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HETEROSIS STUDIES FOR YIELD AND YIELD ATTRIBUTING CHARACTERS IN CHILI (*CAPSISUM ANNUUM* L.) OVER ENVIRONMENTS

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Abstract

Heterosis for dry fruit yield per plant and related characters in chilli was studied in line × tester fashion involving five lines and 6 testers. The hybrids differed significantly for all the characters studied, as evident from their highly significant mean square values. Mean squares due to hybrids × environments were significant for most of the characters which indicated more sensitivity of hybrids to environments. The hybrids LCA 704 x LCA 315, LCA 764 x LCA 315, LCA 712 x LCA 703, LCA 764 x LCA 763 and LCA 710 x LCA 706 exhibited higher magnitude of heterobeltiosis and standard heterosis for dry fruit yield per plant and yield contributing characters. These promising five hybrids could be further evaluated in yield trials over the locations and seasons before recommending for commercial release.

Key words : Chilli, heterosis, yield and environments.

Introduction

Chilli has its unique place in human diet as a spice and vegetable component. It is also a valuable foreign exchange earner. Though, the heterosis has been commercially exploited in several vegetable crops. Very few commercial hybrids are available in chilli. The greater extent of out crossing and large number of viable seeds produced by crossed chilli fruit facilitate for development of commercial hybrids. Therefore, an attempt was made to identify suitable cross combinations from different parents for commercial exploitation of heterosis.

Materials and Methods

The experimental materials were comprised of 11 parents (6 lines and 5 testers) and their 30 F_1s and two checks (Indam-5 and Tejaswini). The parental lines and all the F_1s were evaluated in RBD with three replications during kharif season of 2013-14 at HRS, Lam, HC&RI, V.R.Gudem and HRS, Darsi, AP. Experimental units were consisting of length of 4 m row with 75 × 30 cm spacing. The observations were recorded on five competitive randomly selected plants for several characters *viz*., plant height, plant spread, number of primary branches, number of secondary branches, days to 50% flowering, per cent fruit set, days to first picking, no.of fruits per plant, fruit length, fruit diameter, average dry fruit weight, dry fruit yield per plant, dry fruit recovery, no. of seeds per fruit and seed weight. Heterosis over mid parent, better parent and superiority over checks were calculated as per the standard procedure (Turner (1953) and Hayes *et al*. (1956).

Results and Discussion

Pooled analysis of variance for experimental design revealed significant differences among locations for all the characters studied (table 1). Significant differences for replications × locations were not recorded except for primary branches per plant. The differences among the parents and hybrids were observed to be significant for all the characters studied. The differences among the

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parents vs. hybrids were recorded to be significant except for plant spread, per cent fruit set and fruits per plant. Partitioning of genotypes into lines, testers and lines x testers revealed that the variance differences among lines and testers were observed to be significant for all the characters studied. The effects due to lines x testers were significant for all the traits studied except for days to 50 per cent flowering, fruit diameter, fruit length, average dry fruit weight and number of seeds per fruit. Interaction effects of (parents vs. hybrids) × locations were significant for all the characters except fruit diameter.

Significant variances for parents × locations interaction were per cent fruit set, fruits per plant, dry fruit yield per plant and dry fruit recovery. The effects due to hybrids × locations were significant for all the characters except days to first picking and dry fruit recovery. Further partitioning of hybrids × locations indicated that the interaction of lines × locations was significant for per cent fruit set, no. of fruits per plant, dry fruit yield per plant and dry fruit recovery while that of testers × locations for per cent fruit set, fruits per plant and dry fruit recovery. Interaction effects of lines x testers x locations were significant for per cent fruit set, dry fruit yield and dry fruit recovery.

This indicates the existence of wide variability in the material studied and there is a good scope for identifying promising parents and hybrid combinations, and improving the yield through its components. These results are in conformity with the findings of Prasath and Ponnuswami (2008) and Payakhapaab *et al*. (2012).

In respect of *per se* performance of parents, LCA 764 and LCA 704 were found to be superior for dry fruit yield per plant and for most of the yield contributing characters (tables 2 and 3). Among the hybrids, LCA 704 × LCA 315, LCA 704 × LCA 703, LCA 764 × LCA 315, LCA 704 × G4 and LCA 712 × LCA 703 had high per se performance for dry fruit yield per plant and other important yield contributing characters.

Mackey (1976) described genetic principles of expression of heterosis superior to the better parent, which may result from one or two of the following situations: (i) the accumulated action of favourable dominant or semi-dominant genes dispersed amongst two parents *i.e.* dominance; (ii) the complementary interaction of additive dominant on recessive genes at different loci i.e. non-allelic interaction or epistasis; (iii) favourable interaction between two alleles at the same locus *i.e.* intra locus or inter allelic interactions referred to as over dominance. It will be possible to recover homozygous lines as good as heterotic hybrids if either or both of the first two situations are the cause of heterosis, although the case with which such lines can be recovered will depend on linkage relationship of the genes involved and the ability to identify the recombinants as and when they arise. This will be particularly difficult with close linkage and when heterosis is expressed by a slight improvement in each of main yield components. If the heterosis is due to inter allelic interactions of dominant types, it is not possible to fix such heterosis in homozygous condition in subsequent generations. The superiority of hybrids, particularly over better parent, is more useful in determining the feasibility of commercial exploitation of heterosis and also identifying the parental combinations capable of producing the highest level of transgressive segregants. Investigation on degree of heterosis is, however, important as it may be of value in deciding the directions of future breeding programme. Kaladee (1988) pointed out that overdominance or heterosis of hybrids was due to the heterozygosity in self pollinated crops.

The range of heterosis, number of desirable significant heterotic crosses and best heterotic crosses over mid, better parent and standard variety for 15 traits are presented in table 4. Heterotic effects in negative direction are desirable for days to 50% flowering and days to first picking. Hybrids LCA 718 × LCA 763 (-19.87%) and LCA 704 × LCA 703 (-19.45%) exhibited significant and the highest negative heterobeltiosis (HB) and standard heterosis (SH) respectively for days to 50% flowering. For days to first picking, the hybrid LCA 704 × G4 and LCA 764 × LCA 763 showed significant and highest negative HB and SH, respectively. The cross LCA 704 × LCA 315 exhibited maximum significant SH for dry fruit yield per plant (55.42%), average dry fruit weight (52.72%), fruit length (40.43%), number of seeds per fruit (34.38%), seed weight (25.77%) and plant height (19.86%) and the hybrid LCA710 × LCA 703 expressed significant heterosis over better parent for dry fruit yield per plant (64.77%). The above results are in agreement with the findings of Prasath and Ponnuswami (2008), Choudhary *et al*. (2013), Hasanuzzaman *et al*. (2013) and Mendes *et al*. (2014) who observed high heterotic effects in positive direction in chilli.

The cross LCA 764 × LCA 706 exhibited greater magnitude of standard heterosis for plant spread and per cent fruit set. The cross LCA 704 × LCA 703 flowered earlier and has highest number of fruits per plant over the best check Tejaswini. The crosses LCA 764 × LCA 763 and LCA 764 × LCA 315 showed highest heterotic effects for number of primary branches per plant and dry fruit weight respectively. For fruit diameter, the hybrid LCA 704 × LCA 763 expressed highest standard heterosis

Table 1 : Analysis of variance for fifteen characters in chilli.

	Df	Plant height (cm)	Plant spread (cm)	No. of primary branches/plant	No. of secondary branches/plant	Days to 50% flowering	Fruit set (%)	Days to first picking	No. of fruits per plant
Replications	2.00	7.77	32.48	0.14	0.34	13.08*	36.41	57.23**	2174.63
Locations	2.00	13590.84**	37088.52**	10.82**	92.21**	90.89**	2150.57**	90.89**	1032572.63**
Rep x Locations	4.00	27.70	26.65	0.66*	1.24	0.91	22.23	0.96	983.47
Treatments	40.00	748.23**	1786.61**	1.69**	9.61**	56.22**	432.71**	412.02**	30040.14**
Parents	10.00	1007.98**	2448.06**	3.38**	20.71**	50.98**	316.90**	584.87**	26466.02**
Lines	5.00	697.41**	2183.29**	1.41**	19.50**	76.21**	278.96**	404.08**	24114.53**
Testers	4.00	1365.45**	3325.04**	2.43**	20.21**	28.59**	257.23**	363.72**	11663.24**
Line x Tester	1.00	1130.91**	263.99*	17.04**	28.72**	14.43	745.30**	2373.41**	97434.65**
Hybrids	29.00	172.40**	175.30**	0.76**	3.91**	57.89**	486.76**	365.24**	32177.40**
Parents vs hybrids	1.00	14849.72**	41900.44	11.41**	63.80**	60.18**	23.34	40.22*	3800.72
Parents x locations	20.00	4.13	4.18	0.07	0.72	2.28	127.63**	2.28	15160.42**
Lines x location	10.00	4.62	2.23	0.09	0.52	2.43	161.48**	2.43	21527.49**
Testers x locations	8.00	4.06	5.56	0.07	0.82	2.57	95.89**	2.57	10276.57**
(Lines x Testers) x locations	2.00	1.98	8.38	0.01	1.40	0.35	85.41*	0.35	2860.45
(Parents vs. hybrids) x locations	2.00	4755.30**	14053.77**	6.89**	26.37**	26.39**	1136.94**	26.39*	176706.48**
Hybrids x locations	58.00	122.14**	160.37**	0.74**	5.11**	9.46**	146.17**	9.46	10014.29**
Error	240.00	28.00	43.43	0.21	0.96	4.18	23.73	8.58	1210.79

Table 1 contd…

	Df	Fruit length (cm)	Fruit diameter (cm)	Average dry fruit weight (g)	Dry fruit yield (g/plant)	Dry fruit recovery (%)	No. of seeds per fruit	Seed weight (g/1000 seed)
Replications	2.00	1.77**	0.022	0.034	120.99	17.85	92.12	0.774
Locations	2.00	9.53**	0.076**	0.432**	227979.58**	955.65**	5631.15**	119.334**
Rep x Locations	4.00	0.30	0.010	0.011	211.04	54.32*	16.66	0.312
Treatments	40.00	5.89**	0.054**	0.144**	13569.71**	108.69**	971.38**	3.689**
Parents	10.00	8.83**	0.069**	0.253**	18384.38**	268.82**	1400.48**	5.833**
Lines	5.00	1.39**	0.087**	0.166**	20034.45**	200.10**	2025.48**	6.536**
Testers	4.00	20.15**	0.063**	0.421**	11028.67**	146.24**	969.05**	5.090**
Line x Tester	1.00	0.80	0.001	0.020	39556.88**	1102.72**	1.15	5.288**
Hybrids	29.00	4.32**	0.043**	0.095**	12234.75**	43.77**	535.17**	2.644**
Parents vs hybrids	1.00	21.96**	0.237**	0.457**	4136.78**	390.21**	9330.63**	12.568**
Parents x locations	20.00	0.08	0.002	0.006	3097.61**	202.33**	4.22	0.063
Lines x location	10.00	0.03	0.002	0.005	4061.23**	223.71**	6.21	0.104
Testers x locations	8.00	0.11	0.002	0.008	211.30	175.67**	2.51	0.027
(Lines x Testers) x locations	2.00	0.19	0.003	0.000	9824.76**	202.14**	1.11	0.005
(Parents vs. hybrids) x locations	2.00	3.04**	0.019	0.285**	46100.83**	859.87**	2030.27**	3.311**
Hybrids x locations	58.00	0.87**	0.012*	0.023**	2694.33**	13.81	242.21**	1.085**
Error	240.00	0.33	0.008	0.011	333.49	20.92	49.47	0.464

*, ** Significant at 5 and 1% level.

Table 2 : Mean performance of parents and hybrids for various characters in chilli (pooled over environments).

Cross combinations	Plant height (cm)	Plant spread (cm)	No. of primary branches/plant	No. of secondary branches/plant	Days to 50% flowering	Fruit set (%)	Days to first picking	No. of fruits per plant
Lines								
LCA 625	110.50	105.17	3.96	9.92	32.56	34.70	88.44	233.58
LCA 764	89.81	101.08	4.63	11.58	33.56	46.68	77.78	313.18
LCA 704	90.53	112.88	4.61	11.23	27.56	38.03	93.44	306.11
LCA 710	86.24	70.84	3.88	8.50	29.78	30.17	88.89	217.93
LCA 718	99.48	100.44	3.75	8.72	33.22	39.00	79.78	353.09
LCA 712	97.53	113.08	4.47	11.87	27.00	40.58	78.00	306.11
Mean	**95.04**	**100.55**	**4.35**	**10.72**	**30.39**	**37.53**	**84.61**	**246.78**
Testers								
LCA 315	84.83	74.68	2.81	7.71	31.33	24.38	71.67	256.29
LCA 706	109.08	110.00	3.42	9.29	29.11	32.60	85.89	265.89
LCA 763	97.28	87.33	2.98	8.61	34.11	38.88	71.56	181.07
LCA 703	103.74	123.18	4.12	11.70	31.22	32.27	71.11	200.53
G4	117.42	91.32	3.59	8.80	31.11	35.29	72.56	222.87
Mean	**102.47**	**97.30**	**3.38**	**9.22**	**31.38**	**32.68**	**74.56**	**225.33**
Parental mean	**98.76**	**98.93**	**3.86**	**10.32**	**30.88**	**35.11**	**79.58**	**236.05**
Crosses								
LCA 625 x LCA 315	82.90	73.20	3.19	9.24	31.22	31.33	70.44	188.12
LCA 625 x LCA 706	88.39	82.08	3.36	9.24	27.22	33.44	85.44	247.24
LCA 625 x LCA 763	89.52	78.90	3.43	8.17	35.11	27.78	78.89	206.71
LCA 625 x LCA 703	89.43	81.77	2.89	9.31	27.44	34.56	87.56	250.24
LCA 625 x G4	89.82	75.75	3.42	8.19	30.11	43.00	77.22	205.60
LCA 764 x LCA 315	87.72	69.84	2.80	8.66	30.78	39.44	70.56	382.36
LCA 764 x LCA 706	90.50	83.03	3.36	9.68	28.00	49.44	73.00	276.11
LCA 764 x LCA 763	84.96	81.84	3.93	9.80	36.00	48.67	69.00	252.29
LCA 764 x LCA 703	81.63	75.04	3.58	10.03	29.00	40.78	74.33	232.60

Table 2 continued....

Table 2 continued....

Cross combinations	Plant height (cm)	Plant spread (cm)	No. of primary branches/plant	No. of secondary branches/plant	Days to 50% flowering	Fruit set (%)	Days to first picking	No. of fruits per plant
LCA 764 x G4	78.42	74.96	3.29	8.97	30.78	34.11	80.56	212.47
LCA 704 x LCA 315	74.70	72.62	3.34	8.84	32.00	39.00	72.33	379.18
LCA 704 x LCA 706	90.01	80.94	3.78	9.06	28.33	36.89	83.33	303.24
LCA 704 x LCA 763	82.30	74.85	3.70	9.56	30.22	47.33	77.78	275.07
LCA 704 x LCA 703	82.60	81.30	3.78	9.84	26.22	39.44	87.11	433.07
LCA 704 x G4	81.07	76.93	3.52	8.84	33.56	38.44	69.78	269.00
LCA 710 x LCA 315	77.21	68.06	3.24	8.32	30.11	44.44	71.22	262.29
LCA 710 x LCA 706	82.10	72.41	3.30	8.80	29.22	46.67	71.11	238.53
LCA 710 x LCA 763	85.94	72.28	3.83	9.94	27.78	25.67	85.22	226.09
LCA 710 x LCA 703	80.33	78.34	3.83	8.88	33.00	20.56	80.67	291.22
LCA 710 x G4	82.83	72.53	3.51	8.48	27.56	39.00	87.44	255.11
LCA 718 x LCA 315	83.92	69.72	3.39	8.83	33.33	36.22	81.33	188.69
LCA 718 x LCA 706	83.41	74.57	3.28	8.52	33.00	42.56	79.33	193.09
LCA 718 x LCA 763	86.11	69.12	3.90	9.37	27.33	34.78	75.00	194.71
LCA 718 x LCA 703	85.37	71.79	3.38	8.54	28.00	29.56	76.33	267.96
LCA 718 x G4	80.00	71.75	3.62	8.66	31.44	29.44	80.89	216.96
LCA 712 x LCA 315	83.63	70.18	3.08	8.18	30.22	29.11	87.44	186.36
LCA 712 x LCA 706	89.57	76.29	3.82	7.98	30.89	31.44	80.78	214.42
LCA 712 x LCA 763	93.18	72.82	3.32	7.10	28.11	25.44	88.56	208.91
LCA 712 x LCA 703	85.09	78.23	3.12	8.78	27.44	38.78	86.56	280.98
LCA 712 x G4	80.86	70.06	3.26	8.39	28.00	30.33	86.00	234.93
Crosses Mean	**84.45**	**75.04**	**3.44**	**8.87**	**30.05**	**36.26**	**79.17**	**252.45**
Checks								
Indam-5	79.38	59.44	3.07	8.63	29.22	39.89	77.78	140.91
Tejaswini	93.21	67.68	2.98	8.37	32.56	39.33	71.44	276.89
Grand Mean	**88.19**	**80.66**	**3.52**	**9.09**	**30.32**	**36.27**	**79.15**	**252.28**
C.D. 5%	**7.93**	**11.31**	**0.54**	**1.26**	**2.11**	**7.02**	**2.70**	**64.07**
S.E.	**2.85**	**4.07**	**0.19**	**0.45**	**0.76**	**2.53**	**0.97**	**23.03**

Table 3 : Mean performance of parents and hybrids for various characters in chilli (pooled over environments).

Cross combinations	Fruit length (cm)	Fruit diameter (cm)	Average dry fruit weight (g)	Dry fruit yield per plant (g)	Dry fruit recovery (%)	No. of seeds per fruit	Seed weight (g/1000)
Lines							
LCA 625	9.22	0.97	0.92	219.00	23.39	44.47	8.31
LCA 764	8.64	1.06	1.04	240.11	21.37	54.28	9.09
LCA 704	9.36	0.99	1.13	199.44	20.76	65.67	8.95
LCA 710	8.52	0.77	0.73	108.12	33.23	28.99	7.07
LCA 718	9.14	0.96	0.97	197.84	24.53	66.09	7.19
LCA 712	9.48	1.00	0.94	226.94	21.17	38.54	8.01
Mean	**8.94**	**0.97**	**0.96**	**165.37**	**21.23**	**49.42**	**9.36**
Testers							
LCA 315	10.49	1.06	1.10	159.89	30.83	64.52	8.58
LCA 706	8.15	0.89	0.87	207.44	32.33	54.44	6.99
LCA 763	10.47	1.05	1.31	171.07	35.63	46.36	6.96
LCA 703	7.29	0.89	0.80	113.71	30.56	37.41	7.36
G4	7.99	0.93	0.84	140.06	24.54	44.54	8.30
Mean	**8.88**	**0.96**	**0.98**	**158.43**	**30.78**	**49.46**	**7.64**
Parental Mean	**8.91**	**0.97**	**0.97**	**161.90**	**26.00**	**49.44**	**8.50**
Crosses							
LCA 625 x LCA 315	10.67	1.10	1.16	156.22	30.55	76.23	8.44
LCA 625 x LCA 706	8.99	0.96	1.03	190.16	35.32	59.83	8.23
LCA 625 x LCA 763	9.87	1.07	1.13	157.28	29.23	65.28	8.20
LCA 625 x LCA 703	9.22	1.05	1.03	183.36	31.13	60.25	8.96
LCA 625 x G4	9.86	0.99	1.04	139.39	32.02	66.72	8.60
LCA 764 x LCA 315	10.31	1.11	1.24	262.94	28.83	72.43	9.21
LCA 764 x LCA 706	8.68	1.01	0.95	181.23	30.64	62.89	8.09
LCA 764 x LCA 763	9.93	1.06	1.15	206.72	29.47	60.86	9.00
LCA 764 x LCA 703	8.73	1.01	1.04	204.56	29.02	68.44	8.54

Table 3 continued....

Cross combinations	Fruit length (cm)	Fruit diameter (cm)	Average dry fruit weight (g)	Dry fruit yield per plant (g)	Dry fruit recovery (%)	No. of seeds per fruit	Seed weight (g/1000)
LCA 764 x G4	9.06	1.02	1.11	166.17	27.50	62.85	8.51
LCA 704 x LCA 315	11.32	1.13	1.28	277.33	27.91	79.47	9.53
LCA 704 x LCA 706	8.88	0.96	0.96	209.22	27.81	62.62	8.13
LCA 704 x LCA 763	9.69	1.17	1.19	199.50	29.95	64.92	9.02
LCA 704 x LCA 703	8.88	1.06	1.10	263.56	30.53	55.57	8.44
LCA 704 x G4	9.23	1.12	1.08	237.22	28.66	66.94	9.19
LCA 710 x LCA 315	9.63	0.96	1.06	184.44	33.07	54.22	8.30
LCA 710 x LCA 706	8.75	0.89	0.86	206.19	34.36	60.98	7.45
LCA 710 x LCA 763	10.25	0.97	1.01	154.56	29.43	52.66	7.72
LCA 710 x LCA 703	8.76	0.94	0.92	187.37	28.96	53.25	7.66
LCA 710 x G4	9.20	0.92	0.85	184.50	29.84	49.97	7.95
LCA 718 x LCA 315	10.18	1.10	1.11	136.78	25.92	66.53	7.99
LCA 718 x LCA 706	9.16	1.01	0.92	136.84	28.91	51.85	7.30

Table 3 continued....

Table 3 continued...

LCA 718 x LCA 763	10.26	1.02	1.13	157.11	26.12	56.23	7.64
LCA 718 x LCA 703	9.04	1.04	1.01	181.23	28.96	64.57	8.30
LCA 718 x G4	9.38	1.00	1.06	173.52	30.12	66.21	8.03
LCA 712 x LCA 315	9.68	0.94	1.06	148.51	26.39	51.22	7.94
LCA 712 x LCA 706	8.53	0.93	0.93	168.94	29.18	56.53	8.32
LCA 712 x LCA 763	10.66	1.07	1.04	187.29	26.32	48.84	8.48
LCA 712 x LCA 703	9.45	1.01	1.02	225.56	28.71	56.13	8.33
LCA 712 x G4	9.54	0.95	0.96	168.92	28.40	53.18	7.78
Crosses Mean	**9.53**	**1.02**	**1.05**	**187.89**	**29.44**	**60.92**	**8.31**
Checks							
Indam-5	8.95	1.30	1.49	145.44	30.58	80.38	9.51
Tejaswini	8.06	0.82	0.84	178.44	35.98	59.14	7.58
Grand Mean	**9.34**	**1.01**	**1.03**	**184.75**	**29.03**	**58.43**	**8.21**
C.D. 5%	**0.60**	**0.09**	**0.11**	**32.26**	**5.51**	**8.97**	**0.70**
S.E.	**0.22**	**0.03**	**0.04**	**11.60**	**1.98**	**3.22**	**0.25**

Table 4 : Range, heterosis and best heterotic crosses for fifteen characters in chilli.

Characters	Range of heterosis (%)			No. of hybrids (Based on SH)		Best heterotic hybrids		
	MP	BP	SH	+Ve	-Ve	MP	BP	SH
Plant height (cm)	-26.23 to 0.46	-33.21 to -4.47	-19.86 to -0.04	0	22	LCA 710 x LCA 763	LCA 764 x G4	LCA 704 x LCA 315
Plant spread (cm)	-35.79 to -6.47	-41.72 to -8.87	0.56 to 22.69	16	0	LCA 718 x LCA 703	LCA 718 x LCA 703	LCA 764 x LCA 706
Number of primary branches	-28.52 to 15.86	-39.57 to 3.88	-5.97 to 32.09	22	0	LCA 718 x LCA 763	LCA 718 x LCA 763	LCA 764 x LCA 763
Number of secondary branches	-30.65 to 16.25	-40.17 to 15.50	-15.14 to 19.92	10	1	LCA 710 x LCA 763	LCA 710 x LCA 763	LCA 764 x LCA 703
Days to 50% flowering	-18.81 to 14.39	-19.87 to 7.86	-19.45 to 10.58	1	18	LCA 718 x LCA 763	LCA 718 x LCA 763	LCA 704 x LCA 703
Per cent fruit set	35.95 to 62.97	-37.29 to 47.33	-35.31 to 25.71	5	13	LCA 710 x LCA 315	LCA 710 x LCA 315	LCA 764 x LCA 706
Days to first picking	-18.63 to 18.42	-25.33 to 13.53	-3.42 to 23.95	21	0	LCA 710 x LCA 706	LCA 704 x G4	LCA 764 x LCA 763
No. of fruits per plant	-25.03 to 70.95	-46.56 to 41.47	-32.70 to 56.40	3	14	LCA 704 x LCA 703	LCA 704 x LCA 703	LCA 704 x LCA 703
Fruit length (cm)	0.30 to 14.61	-10.02 to 8.08	5.85 to 40.43	29	0	LCA 625 x G4	LCA 710 x G4	LCA 704 x LCA 315
Fruit diameter (cm)	-8.06 to 16.27	-10.53 to 12.94	8.97 to 43.48	30	0	LCA 704 x G4	LCA 704 x G4	LCA 704 x LCA 763
Average dry fruit weight (g)	-7.62 to 20.00	-23.04 to 14.58	1.19 to 47.28	25	0	LCA 710 x LCA 703	LCA 710 x LCA 703	LCA 764 x LCA 315
Dry fruit yield per plant (g/plant)	-32.47 to 68.93	-36.35 to 64.77	-23.35 to 55.42	9	8	LCA 710 x LCA 703	LCA 710 x LCA 703	LCA 704 x LCA 315
Dry fruit recovery (%)	-14.51 to 33.65	-26.69 to 30.52	-27.97 to -1.85	0	27	LCA 625 x G4	LCA 625 x G4	LCA 625 x G4

Table 4 continued...

Table 4 continued...

No. of seeds per fruit	-13.97 to 60.39	-21.55 to 49.79	-17.40 to 34.38	10	7	LCA 625 x G4	LCA 625 x G4	LCA 704 x LCA 315
Seed weight (g)	-4.52 to 14.34	-11.07 to 12.78	-3.71 to 25.77	17	0	LCA 625 x LCA 703	LCA 718 x LCA 703	LCA 704 x LCA 315

MP: Mid Parent, **BP:** Better Parent and **SH:** Standard Heterosis.

over Tejaswini. Results are in conformity with the findings of Sharma *et al*. (2013) and Khalil and Hatem (2014) in chilli.

In the pooled analysis, for dry fruit yield per plant 7 hybrids exhibited significant and positive heterobeltiosis and 9 for standard heterosis. A large number of hybrids expressed greater amount of heterotic effects in desired direction for dry fruit yield per plant, plant height, number of primary branches per plant, number of secondary branches per plant and number of fruits per plant. The estimates and magnitude of various heterotic effects were varied with cross combinations and characters. Inconsistent performance of most of the hybrids across the environments for various characters suggested that parental contributions for cross combinations. Different characters were susceptible to environmental fluctuation due to heterosis of the characters changed in different environments due to character x environment interaction.

The crosses which had larger estimates of HB and SH for dry fruit yield, also exerted significant positive heterotic effects for number of fruits per plant and number of primary branches per plant among the yield contributing characters. Therefore, heterotic effects for dry fruit yield were because of direct effect of number of fruits per plant and could be outcome of interaction effects of other yield attributes, like average fruit length and average dry fruit weight. Among developmental characters, early flowering, plant height, number of primary branches and number of secondary branches might have contributed indirectly for heterotic effects of dry fruit yield.

According to Grafius (1959), who had suggested that there could be no separate gene system for yield *per se* as yield is an end product of the multiplicative interactions between its various component characters. Therefore, dry fruit yield per plant could be a result of combinational heterosis. However, positive and negative estimates of heterosis for rest of the characters could have checked each other for exerting heterotic effects. Hence, to obtain maximum advantage of heterotic effects for dry fruit yield, desired level of heterosis of each component characters should be determined to identify superior hybrids in respect to yield and its contributing characters.

Among parents, involved in different cross combinations, the lines LCA 764 and LCA 704 and pollen parents LCA 703 and LCA 315 yielded the best heterotic hybrids. The existence or availability of genetic variability and nature of gene effects impose the selection of breeding methodology. Several hybrids exhibited significant and desirable heterobeltiosis and standard heterosis for various traits studied including dry fruit yield in different environments, which suggest the potentiality of hybrids and scope for heterosis breeding.

A perusal of *per se* performance, heterotic effects and sca effects of hybrids revealed that the hybrids *viz*., LCA 704 × LCA 315, LCA 764 × LCA 315, LCA 712 × LCA 703, LCA 764 × LCA 763 and LCA 710 × LCA 706 found to be promising for all the approaches and could be further evaluated in yield trials over the locations and seasons before recommending for commercial release. The hybrid seed production work can be made easy with male sterile lines by encashing the advantage of natural out crossing, leading to reduction in the cost of hybrid seeds.

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