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HETEROSIS IN CGMS AND GMS BASED CHILLI (*CAPSICUM ANNUUM* L.) HYBRIDS FOR GREEN FRUIT YIELD, ITS COMPONENTS AND QUALITY TRAITS

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ABSTRACT

Chilli (*Capsicum annuum*L.) is an important commercial spice cum vegetable crop of Solanaceae family. Due to wide variability, it holds potential for further improvement. The present investigation on chilli comprised of 5 females (2 CGMS and 3 GMS), 8 males, 40 F_1 hybrids and two standard check hybrids GAVCH 1 and ARCH-228. The experiment was laid out in randomized block design with 3 replications at Main Vegetable Research Station, Anand Agricultural University, Anand Campus, Anand, during *kharif-rabi* 2011-2012. This results suggested that differences in performance of parents and hybrids for majority of the traits leading to evidence for manifestation of heterosis for green fruit yield and majority of its components. On the bases on estimates of heterosis, the hybrids ACMS 4 X 9955-15R, CCA-4759 X LCA 206 and CCA-4759 X RHRC PENDT were found to be most promising for green fruit yield and other desirable traits, hence could be further evaluated to exploit the heterosis for commercial cultivation or utilize in future breeding programme to obtain desirable segregants for the development of superior genotypes.

INTRODUCTION

Capsicum annuum L. is a dicotyledonous flowering plant commonly known as hot pepper, chili, chilli or chile pepper, sweet pepper and bell pepper.Though chilli is classified under self pollinated crops, natural cross pollination takes place up to the extent of 7 to 60 % (Aiyadurai, 1996). In the world, the production of chilli in green form is about 7 to 8 million tons (MT) and 2 to 3 million tons in dry form. India is the largest producer of chilli in the world accounting for 1.1 million tons of production annually followed by China with a production of around 0.4 million tonnes. In India, the crop is extensively cultivated in about 9.30 lakh hectares with a production of 11-12 lakh tones (Anon., 2010).

Male sterility, GMS and CGMS sources are widely used on both experimental and commercial basis in the hybrid seed industry. The uses of genetic male sterility, controlled by a single monogenic recessive gene can greatly help in making a F_1 hybrid seed, as tedious and costly hand emasculation of individual flower bud can be avoided. However, because of more tedious maintenance process and non-availability of suitable marker genes in GMS, commercial exploitation of heterosis would not be possible (Patel *et al*., 2004). With the availability of stable male sterile sources, it has become possible now to reduce the cost of hybrid seeds. In CGMS system, the use of male parents with restorer gene as well as known superior genetic potential ensures much better success. It requires extensive and detailed genetic assessment of existing germplasm as well as newly evolved promising lines which could be used in the future breeding program or could be directly released as cultivars after proper testing.

In heterosis breeding, identification of cross combinations for yield is first step followed by minimization of cost of hybrid seed production through uses of male sterility mechanism and manipulation of plant geometry and cultural practices for increased production of hybrid seeds(Stuber, 1994).

Among the several methods, line x tester analysis provides a systematic approach for identification of superior parents and crosses, which is the basic material on which the success of a breeding program rests (Ramesh *et al*, 2014). An added advantage of the line x tester analysis is that it provides overall genetic picture of the experimental material in single generation.

Keeping in view the economic importance of chillies and the need for their improvement in development of hybrids through male sterility, the present investigation was planned to study the performance of parents and hybrids on the basis of *per se* performance,the magnitude of heterosis for green fruit yield and its components as well as quality parameters.

MATERIALS AND METHODS

Table 1: Analysis of variance (mean squares) for various characters in chilli

Source of variation	df	Plant height	Primary branches	Secondary branches per plant	Fruits per plant	Fruit length	Fruit weight	Pericarp thickness	Green fruit yield per plant	Capsaicin content	Vitamin Ccontent
Replications	2	2.34	0.15	0.80**	1280.23**	0.10	2.07**	0.04	419.35	0.001	12.50
Genotypes	54	155.99**	0.17**	1.11**	1826.71**	2.12**	2.56**	0.07**	54453.68**	0.08**	5044.89**
(1) Parents	12	148.39**	0.15**	1.88**	106.67	1.74**	1.65**	0.21**	3866.11*	0.05**	881.72**
a) Females	4	172.73**	0.01	0.31*	104.77	0.45	2.39**	0.009	5624.38*	0.03**	1606.84**
b) Males	7	134.05**	0.23**	2.40**	62.57	2.72**	1.02**	0.36**	3342.41	0.06**	336.89**
c) F *vs* M	1	151.41**	0.17	4.54**	422.96*	0.01	3.02**	0.05	499.06	0.02**	1795.03**
(2) Hybrids	39	162.39**	0.15**	0.75**	1439.96**	2.11**	2.97**	0.03	61893.46**	0.09**	6057.58**
P *vs* H	1	229.10**	0.30*	7.65**	26780.75**	10.79**	2.08*	0.16*	340811.20**	0.008**	14033.44**
C *vs* H	1	18.22	0.11	0.26	10074.20**	0.0006	0.17	0.009	94514.14**	0.37**	12119.00**
Between checks	1	45.37	0.80**	0.33	322.66	0.06	0.19	0.002	539.22	0.01**	1990.35**
Error	108	17.31	0.06	0.10	92.80	0.28	0.36	0.03	1943.33	0.001	7.89

*, ** significant at 5 and 1 % levels of significance, respectively.

Table 2: Magnitude Relative heterosis (RH), Better parent (BH) and Standard heterosis (SH) in per cent.

Hybrids	Plant height			Primary branches per plant			Secondary branches per plant		
	RH	BPH	SH2	RH	BPH	SH2	RH	BPH	SH2
CCA-4759 X PBC 142	-5.89*	-7.29*	-11.78**	11.43**	8.33**	-17.02**	20.00**	20.00**	0
CCA-4759 X ACG 12	-1.01	-8.97**	3.23	24.32**	21.05**	-2.13**	30.51**	28.33**	6.94**
CCA-4759 X 9955-15R	-13.1**	-17.61**	-12.50**	8.33**	8.33**	-17.02**	26.83**	23.81**	8.33**
CCA-4759 X LCA 206	14.77**	3.81	22.13**	6.67**	2.56**	-14.89**	26.98**	21.21**	11.11**
CCA-4759 X LCA 436	-19.65**	-23.38**	-19.60**	0	-2.63**	-21.28**	-3.39**	-5.00**	-20.83**
CCA-4759 X RHRC PENDT	13.39**	10.33**	10.99**	7.14**	-6.25**	-4.26**	6.49**	-12.77**	13.89**
CCA-4759 X JCA 283	6.01*	5.53	0.43	2.63**	-2.50**	-17.02**	11.11**	-4.76**	11.11**
CCA-4759 X G-4	10.43**	4.98	10.86**	0	0	-23.40**	13.11**	11.29**	-4.17**
CCA-4758 X PBC 142	-1.54	-4.3	-11.64**	9.86**	5.41**	-17.02**	22.81**	16.67**	-2.78**
CCA-4758 X ACG 12	-6.98*	-17.75**	-6.72	6.67**	5.26**	-14.89**	-1.79**	-5.17**	-23.61**
CCA-4758 X 9955-15R	-5.22	-13.72**	-8.36*	15.07**	13.51**	-10.64**	16.24**	7.94**	-5.56**
CCA-4758 X LCA 206	-4.53	-16.89**	-2.24	0	-2.56**	-19.15**	23.33**	12.12**	2.78**
CCA-4758 X LCA 436	-14.95**	-22.14**	-18.33**	1.33**	0	-19.15**	5.36**	1.72**	-18.06**
CCA-4758 X RHRC PENDT	-4.36	-10.75**	-10.22**	-3.53**	-14.58**	-12.77**	1.35**	-20.21**	4.17**
CCA-4758 X JCA 283	-3.33	-6.99*	-12.28**	9.09**	5.00**	-10.64**	28.99**	5.95**	23.61**
CCA-4758 X G-4	-11.67**	-19.39**	-14.87**	-6.85**	-8.11**	-27.66**	6.90**	0	-13.89**
ACMS 4 X PBC 142	7.77**	4.09	3.16	28.57**	25.00**	-4.26**	14.05**	13.11**	-4.17**
ACMS 4 X ACG 12	6.53*	-0.19	13.18**	0	-2.63**	-21.28**	12.61**	9.84**	-6.94**
ACMS 4 X 9955-15R	-18.20**	-20.94**	-16.02**	5.56**	5.56**	-19.15**	6.45**	4.76**	-8.33**
ACMS 4 X LCA 206	0.84	-7.11*	9.27**	-4.00**	-7.69**	-23.40**	3.94**	0	-8.33**
ACMS 4 X LCA 436	0.4	-2.38	2.4	5.41**	2.63**	-17.02**	26.05**	22.95**	4.17**
ACMS 4 X RHRC PENDT	-5.2	-5.91	-5.34	7.14**	-6.25**	-4.26**	-9.68**	-25.53**	-2.78**
ACMS 4 X JCA 283	-1.72	0.78	-4.97	2.63**	-2.50**	-17.02**	-10.34**	-22.62**	-9.72**
ACMS 4 X G-4	0.36	-2.73	2.73	0	0	-23.40**	15.45**	14.52**	-1.39**
ACMS 6 X PBC 142	-1.46	-10.88**	1.72	11.11**	5.26**	-14.89**	3.28**	1.61**	-12.50**
ACMS 6 X ACG 12	-6.04*	-6.34	6.90*	23.68**	23.68**	0	30.00**	25.81**	8.33**
ACMS 6 X 9955-15R	-5.91*	-9.18**	3.66	-5.41**	-7.89**	-25.53**	7.20**	6.35**	-6.94**
ACMS 6 X LCA 206	-0.5	-1.98	15.29**	14.29**	12.82**	-6.38**	18.75**	15.15**	5.56**
ACMS 6 X LCA 436	-1.42	-5.4	7.97*	7.89**	7.89**	-12.77**	20.00**	16.13**	0
ACMS 6 X RHRC PENDT	-9.71**	-15.07**	-3.06	-11.63**	-20.83**	-19.15**	6.41**	-11.70**	15.28**
ACMS 6 X JCA 283	-2.77	-11.22**	1.34	5.13**	2.50**	-12.77**	1.37**	-11.90**	2.78**
ACMS 6 X G-4	-8.87**	-12.27**	0.13	0	-2.63**	-21.28**	27.42**	27.42**	9.72**
ACMS 8 X PBC 142	-2.08	-5.9	-5.79	-2.86**	-5.56**	-27.66**	40.54**	30.00**	8.33**
ACMS 8 X ACG 12	-7.63**	-13.04**	-1.38	-8.11**	-10.53**	-27.66**	26.61**	18.97**	-4.17**
ACMS 8 X 9955-15R	-8.38**	-11.00**	-5.49	0	0	-23.40**	17.54**	6.35**	-6.94**
ACMS 8 X LCA 206	-9.22**	-15.98**	-1.16	4.00**	0	-17.02**	35.04**	19.70**	9.72**
ACMS 8 X LCA 436	-6.58*	-8.71*	-4.22	13.51**	10.53**	-10.64**	13.76**	6.90**	-13.89**
ACMS 8 X RHRC PENDT	0.06	-0.17	0.43	-7.14**	-18.75**	-17.02**	-2.07**	-24.47**	-1.39**
ACMS 8 X JCA 283	6.76*	3.66	3.78	10.53**	5.00**	-10.64**	18.52**	-4.76**	11.11**
ACMS 8 X G-4	3.5	0.82	6.47	0	0	-23.40**	32.74**	20.97**	4.17**
Range Min.	-19.65	-23.38	-19.6	-1.63	-20.83	-27.66	-10.34	-25.33	-23.61
Max.	14.77	10.33	22.13	28.57	25	0	40.54	30	23.61
SE +	2.98	3.45	3.45	0.17	0.19	0.19	0.23	0.26	0.26

The crosses were made during *Kharif* - *Rabi* 2010-11 through Line x Tester mating design. The 40 hybrids along with 8 male parents, 5 female parents (3 GMS and 2 CGMS (maintainer) lines) and two standard check hybrids (ARCH-228 and GAVCH-1) were evaluated in a randomized block design with three replications during *kharif-Rabi* 2011-2012. Analysis of variance technique suggested by Panse and Sukhatme (1967) was followed to test the significant differences between the genotypes for all the characters.Heterosis expressed as per cent increase or decrease of hybrid (F_1) over mid parent value(Turner, 1953), its better parent (Fonseca and Patterson, 1968) as well as hybrid checks ARCH-228 and GAVCH-1 (Meredith and Bridge, 1972) were computed.

RESULTS AND DISCUSSION

The hybrids differed significantly among themselves for all the characters except pericarp thickness as their mean square values were highly significant. The parents v/s hybrids contrast comparisons were significant for most of the attributes suggesting that parents and hybrids differed statistically for these traits included in the investigation.In the present investigation significant and higher estimates of relative heterosis, heterobeltiosis and standard heterosis were observed for various components for green fruit yield and its quality attributes as well. High degree of heterosis of various kinds recorded for these attributes clearly indicated the presence of large genetic diversity among males as well as females. The magnitude of estimates of various heterosis was moderate to high in respect to most of the characters in both the directions.

The results on relative heterosis, heterobeltiosis and standard heterosis for various characters revealed that the estimates and magnitude of various heterotic effects varied with cross combinations and characters. The results revealed that crosses ACMS 4 x 9955-15R, ACMS 8 x RHRC PENDT and CCA 4759

Table 2: Cont....

Hybrids	Fruits per plant			Fruit length		
	RH	BPH	SH2	RH	BPH	SH2
CCA-4759 X PBC 142	44.9**	40.57**	-28.62**	9.22**	8.78**	-2.69**
CCA-4759 X ACG 12	15.48**	7.84	-45.24**	19.75**	18.28**	4.95**
CCA-4759 X 9955-15R	28.57**	11.67*	-43.30**	-3.70**	-15.48**	-0.73
CCA-4759 X LCA 206	121.68**	120.22**	13.32*	13.93**	12.56**	2.33**
CCA-4759 X LCA 436	17.19**	12.59*	-42.82**	9.39**	8.94**	-2.55**
CCA-4759 X RHRC PENDT	72.96**	59.26**	-19.13**	14.38**	13.44**	0.65
CCA-4759 X JCA 283	-7.23	-7.25	-52.90**	18.00**	16.31**	3.20**
CCA-4759 X G-4	20.00**	1.51	-48.45**	-7.32**	-7.51**	-17.60**
CCA-4758 X PBC 142	16.97**	12.35*	-46.36**	-2.40**	-3.33**	-13.53**
CCA-4758 X ACG 12	21.73**	21.61**	-46.42**	11.66**	10.90**	-2.69**
CCA-4758 X 9955-15R	37.44**	27.21**	-44.06**	-8.91**	-20.43**	-6.55**
CCA-4758 X LCA 206	7.6	-0.23	-48.66**	-5.23**	-6.88**	-15.35**
CCA-4758 X LCA 436	17.53**	13.98*	-46.65**	-1.09**	-2.03**	-12.36**
CCA-4758 X RHRC PENDT	13.53*	11.93*	-50.78**	4.63**	4.35**	-8.44**
CCA-4758 X JCA 283	14.13**	6.5	-45.95**	10.47**	9.49**	-3.93**
CCA-4758 X G-4	29.21**	16.22**	-48.89**	-4.17**	-4.90**	-15.27**
ACMS 4 X PBC 142	93.62**	72.47**	-17.65**	6.74**	2.47**	-0.36
ACMS 4 X ACG 12	74.72**	61.34**	-28.91**	28.37**	21.32**	17.96**
ACMS 4 X 9955-15R	105.99**	105.67**	-23.02**	13.48**	3.72**	21.82**
ACMS 4 X LCA 206	97.88**	70.68**	-12.17*	5.22**	1.80**	-1.02*
ACMS 4 X LCA 436	44.08**	29.47**	-39.40**	7.83**	3.52**	0.65
ACMS 4 X RHRC PENDT	68.78**	58.07**	-32.45**	3.90**	-1.42**	-4.15**
ACMS 4 X JCA 283	51.27**	31.24**	-33.39**	14.99**	8.45**	5.45**
ACMS 4 X G-4	104.23**	98.26**	-26.02**	9.13**	4.56**	1.67**
ACMS 6 X PBC 142	86.81**	60.86**	-23.19**	9.20**	7.48**	-0.73
ACMS 6 X ACG 12	51.14**	34.72**	-40.64**	13.98**	10.39**	1.96**
ACMS 6 X 9955-15R	44.75**	39.06**	-47.95**	-2.25**	-12.69**	2.55**
ACMS 6 X LCA 206	149.31**	108.19**	7.13	9.29**	8.43**	0.15
ACMS 6 X LCA 436	32.56**	15.11*	-46.12**	6.80**	5.12**	-2.91**
ACMS 6 X RHRC PENDT	82.67**	65.03**	-29.47**	20.16**	16.85**	7.93**
ACMS 6 X JCA 283	48.27**	24.51**	-36.81**	11.61**	7.87**	-0.36
ACMS 6 X G-4	87.98**	86.24**	-34.57**	-0.84*	-2.60**	-10.04**
ACMS 8 X PBC 142	46.25**	38.40**	-33.92**	33.02**	28.48**	23.35**
ACMS 8 X ACG 12	74.09**	71.24**	-24.55**	14.02**	8.41**	4.07**
ACMS 8 X 9955-15R	22.09**	14.66*	-51.13**	-12.98**	-20.93**	-7.13**
ACMS 8 X LCA 206	12.66**	2.98	-47.01**	3.11**	0.38	-3.64**
ACMS 8 X LCA 436	15.75**	10.58	-48.25**	15.92**	11.97**	7.49**
ACMS 8 X RHRC PENDT	102.9**	102.62**	-13.41*	11.51**	6.44**	2.18**
ACMS 8 X JCA 283	18.69**	9.18	-44.59**	-2.83**	-7.80**	-11.49**
ACMS 8 X G-4	98.1**	80.71**	-22.99**	-6.09**	-9.47**	-13.09**
Range Min.	-7.23	-7.25	-52.9	-12.98	-20.93	-17.6
Max.	149.31	120.22	13.32	33.02	28.48	23.35
SE +	5.1	5.88	5.88	0.37	0.43	0.43

Table 3: Magnitude Relative heterosis (RH), Better parent (BH) and Standard heterosis (SH) in per cent.

Hybrids	Fruit weight			Pericarp thickness			Green fruit yield per plant		
	RH	BPH	SH1	RH	BPH	SH2	RH	BPH	SH2
CCA-4759 X PBC 142	-19.05**	-22.83**	-8.60**	1.44**	-0.2	-1.74**	33.38	32.49	-28.2
CCA-4759 X ACG 12	35.85**	26.60**	35.95**	-1.27**	-1.56**	-2.51**	62.80*	54.28	-17.51
CCA-4759 X 9955-15R	-22.12**	-23.20**	-17.55**	-2.11**	-6.28**	0.87**	4.02	-3.85	-48.6
CCA-4759 X LCA 206	-7.44**	-13.07**	6.30**	2.69**	0.88**	-0.68**	129.64**	113.65**	32.72
CCA-4759 X LCA 436	1.57**	-2.85**	4.31**	15.87**	0.59**	-0.97**	23.62	20.27	-35.7
CCA-4759 X RHRC PENDT	45.15**	26.13**	35.39**	7.09**	6.57**	4.92**	157.58**	124.80**	20.19
CCA-4759 X JCA 283	38.70**	25.42**	34.65**	0.50**	-0.49**	-2.03**	36.69	30.6	-30.18
CCA-4759 X G-4	-9.61**	-9.90**	-3.22**	-2.01**	-2.06**	-3.47**	1.24	0.64	-45.54
CCA-4758 X PBC 142	-22.36**	-24.84**	-11.02**	0.15	-1.94**	-2.51**	-1.43	-1.6	-46.67
CCA-4758 X ACG 12	-5.64**	-13.34**	-3.90**	-3.79**	-3.98**	-4.54**	10.11	3.85	-43.91
CCA-4758 X 9955-15R	-2.13**	-4.98**	5.32**	0.14	-3.68**	3.67**	30.92	20.45	-34.95
CCA-4758 X LCA 206	-18.45**	-22.25**	-4.94**	1.89**	-0.39**	-0.97**	-7.42	-13.47	-46.25
CCA-4758 X LCA 436	-12.58**	-17.64**	-8.69**	13.53**	-1.84**	-2.41**	2.09	-1.16	-46.62
CCA-4758 X RHRC PENDT	9.75**	-5.90**	4.33**	-0.69**	-1.65**	-2.22**	21.8	5.84	-42.84
CCA-4758 X JCA 283	-4.95**	-15.26**	-6.06**	2.36**	0.87**	0.33**	8.49	3.16	-44.29
CCA-4758 X G-4	-1.84**	-3.68**	6.77**	-2.00**	-2.43**	-2.99**	10.38	10.28	-40.33
ACMS 4 X PBC 142	-20.77**	-29.47**	6.98**	1.62**	1.62**	-3.19**	65.21**	52.45	-2.28
ACMS 4 X ACG 12	15.79**	-6.72**	41.51**	6.81**	4.78**	3.76**	99.44**	74.19**	11.65
ACMS 4 X 9955-15R	42.18**	20.00**	82.06**	0.1	-5.65**	1.57**	183.65**	142.21**	55.25*
ACMS 4 X LCA 206	-5.55**	-14.73**	29.39**	5.94**	5.78**	0.77**	98.03**	94.97**	24.97
ACMS 4 X LCA 436	-34.92**	-46.44**	-18.70**	16.23**	2.33**	-2.51**	-6.9	-16.72	-46.62
ACMS 4 X RHRC PENDT	-42.36**	-56.13**	-33.41**	0.85**	-0.30*	-2.80**	-4.7	-22.73	-50.47
ACMS 4 X JCA 283	-44.83**	-56.64**	-34.27**	0.55**	-0.1	-3.57**	-16.05	-26.14	-52.65
ACMS 4 X G-4	-43.55**	-51.93**	-26.98**	2.09**	0.39**	-1.02**	0.7	-7.14	-40.48
ACMS 6 X PBC 142	-25.18**	-25.23**	-11.32**	-2.51**	-3.38**	-6.27**	49.62*	38.44	-24.97
ACMS 6 X ACG 12	-16.09**	-25.23**	-11.29**	-1.23**	-2.24**	-3.21**	23.59	21.3	-41.94
ACMS 6 X 9955-15R	-33.44**	-37.42**	-25.74**	-3.77**	-8.52**	-1.54**	-7.17	-7.9	-57.54*
ACMS 6 X LCA 206	-19.38**	-20.58**	-2.87**	-2.06**	-3.08**	-5.98**	110.97**	83.76**	14.15
ACMS 6 X LCA 436	-40.19**	-45.38**	-35.19**	12.07**	-2.09**	-5.02**	-20.13	-23.66	-61.39*
ACMS 6 X RHRC PENDT	22.13**	1.86**	20.88**	-2.53**	-2.29**	-5.21**	119.13**	104.29**	-5.83
ACMS 6 X JCA 283	14.16**	-1.15*	17.27**	0.15	-0.1	-3.09**	72.78**	68.16*	-18.11
ACMS 6 X G-4	-40.08**	-43.08**	-32.50**	-0.39**	-1.18**	-2.58**	-2.8	-10	-51.3
ACMS 8 X PBC 142	-33.33**	-41.42**	-30.62**	2.51**	1.69**	-1.54**	4.7	-7.64	-49.95
ACMS 8 X ACG 12	26.19**	24.11**	15.14**	8.13**	6.92**	5.91**	115.82**	101.28**	-3.65
ACMS 8 X 9955-15R	-20.81**	-26.38**	-23.15**	-5.38**	-10.13**	-3.30**	-4.56	-8.72	-58.58*
ACMS 8 X LCA 206	-29.16**	-38.60**	-24.89**	-2.57**	-3.49**	-6.56**	-14.97	-29.14	-55.98*
ACMS 8 X LCA 436	2.72**	-1.65**	-3.62**	16.99**	2.29**	-0.98**	17.65	7	-45.89
ACMS 8 X RHRC PENDT	36.89**	28.91**	15.60**	0.84**	0.50**	-2.03**	167.67**	162.62**	8.77
ACMS 8 X JCA 283	48.55**	46.16**	31.11**	-3.34**	-3.49**	-6.56**	78.52**	65.17*	-19.56
ACMS 8 X G-4	-16.71**	-23.35**	-18.23**	3.66**	2.74**	1.25**	41.39	24.81	-32.47
Range Min.	-44.83	-56.64	-35.19	-5.38	-10.13	-6.56	-20.13	-29.14	-61.39
Max.	48.55	46.16	82.06	16.99	6.92	5.91	183.65	162.62	55.25
SE +	0.42	0.48	0.48	0.12	0.14	0.14	24.4	28.18	28.18

x RHRC PENDT depicted greater magnitude of relative heterosis for green fruit yield per plant. Whereas, in respect to heterobeltiosis crosses ACMS 8 x RHRC PENDT, ACMS 4 x 9955-15R and CCA 4759 x RHRC PENDT registered higher estimates of heterotic effects for green fruit yield per plant. The crosses, which had higher heterotic effects for green fruit yield also depicted significant and desirable heterotic effects for plant height,number of fruits per plant, fruit weight and pericarp thickness. Therefore, heterotic effects for green fruit yield per plant could be outcome of direct and/or indirect effects of various growth attributes and most of the green fruit yield contributing characters. For standard heterosis, only one hybrid ACMS 4 x 9955-15R was found to be significantly superior than better check ARCH 228 for green fruit yield per plant and it had also significant and positive heterotic effect for fruit length and fruit weight. Among the developmental characters, for days to 50 % flowering ACMS 4 x JCA 283 depicted the least estimates of RH. The cross ACMS 4 x PBC 142 exhibited the maximum estimates of RH and HB for number of primary branches per plant. For number of secondary branches per plant cross ACMS 4 x PBC 142 exerted the highest estimates of RH and HB. For quality characters the crosses CCA 4758 X PBC 142 and CCA 4758 X LCA 206 had depicted the maximum estimates of RH and BH for capsaicin content whereas, for vitamin C content the crosses ACMS 4 x G-4 and CCA 4758 X RHRC PENDT had recorded highest estimates of RH and BH. The characters, capsaicin content (high and low) and vitamin c content (high) are the quality parameters for green (fresh) fruits, which determine the acceptance by consumers and traders as well.The estimates of relative heterosis for green fruit yield per plant ranged from -20.13 to 183.65 per cent. Total 13 hybrids exhibited significant heterosis and all those had positive effects. The hybrid ACMS-4 x 9955-15R (183.65%) exerted the highest relative heterosis.

Table 3: Cont....

Hybrids	Capsaicin			Vitamin C		
	RH	BPH	SH2	RH	BPH	SH2
CCA-4759 X PBC 142	15.29**	8.10**	-6.19**	3.03	1.69	2.18
CCA-4759 X ACG 12	-23.80**	-28.70**	-38.11**	-3.94*	-6.29**	-3.57
CCA-4759 X 9955-15R	-16.20**	-16.95**	-26.60**	52.22**	51.46**	49.72**
CCA-4759 X LCA 206	28.30**	18.89**	3.18**	7.81**	5.28*	3.03
CCA-4759 X LCA 436	-20.02**	-20.22**	-30.40**	7.23**	7.11**	5.07**
CCA-4759 X RHRC PENDT	27.25**	16.49**	1.11**	29.27**	24.42**	21.76**
CCA-4759 X JCA 283	8.04**	-5.57**	-18.05**	52.91**	43.23**	60.50**
CCA-4759 X G-4	-14.61**	-18.04**	-22.65**	34.99**	29.09**	38.43**
CCA-4758 X PBC 142	40.19**	34.62**	2.26**	7.43**	5.27*	5.77**
CCA-4758 X ACG 12	8.49**	4.40**	-21.02**	0.97	-2.21	0.63
CCA-4758 X 9955-15R	10.10**	-1.39**	-12.86**	2.13	0.88	-0.28
CCA-4758 X LCA 206	31.63**	27.96**	-5.24**	35.77**	33.53**	28.77**
CCA-4758 X LCA 436	0.54**	-9.43**	-21.00**	12.55**	11.60**	9.47**
CCA-4758 X RHRC PENDT	0.88**	-0.65**	-28.34**	84.25**	78.06**	72.22**
CCA-4758 X JCA 283	-10.04**	-13.25**	-39.35**	42.46**	32.53**	48.51**
CCA-4758 X G-4	-2.66**	-15.27**	-20.02**	2.14	-3.01	4.01*
ACMS 4 X PBC 142	25.05**	22.05**	-2.62**	78.76**	76.99**	81.44**
ACMS 4 X ACG 12	-1.55**	-4.11**	-23.49**	-11.61**	-11.77**	-9.22**
ACMS 4 X 9955-15R	-10.13**	-14.49**	-24.42**	-4.16*	-5.87**	-3.51
ACMS 4 X LCA 206	27.73**	23.15**	-1.75**	16.18**	10.93**	13.72**
ACMS 4 X LCA 436	-15.76**	-19.36**	-29.64**	31.33**	28.49**	31.72**
ACMS 4 X RHRC PENDT	25.10**	19.10**	-4.98**	3.2	-2.83	-0.4
ACMS 4 X JCA 283	24.22**	12.65**	-10.13**	2.83	-1.55	10.32**
ACMS 4 X G-4	1.23**	-6.60**	-11.84**	84.94**	80.87**	93.94**
ACMS 6 X PBC 142	24.95**	22.76**	-6.75**	15.42**	1.94	33.65**
ACMS 6 X ACG 12	-0.05*	-1.59**	-25.55**	-12.92**	-22.29**	1.89
ACMS 6 X 9955-15R	-9.50**	-17.21**	-26.84**	-21.63**	-31.27**	-9.89**
ACMS 6 X LCA 206	6.27**	5.73**	-21.70**	-13.56**	-26.04**	-3.03
ACMS 6 X LCA 436	-23.20**	-29.33**	-38.34**	-28.85**	-37.81**	-18.47**
ACMS 6 X RHRC PENDT	-9.18**	-9.91**	-33.97**	-26.49**	-37.87**	-18.54**
ACMS 6 X JCA 283	-7.15**	-12.45**	-35.84**	-25.56**	-30.97**	-9.50**
ACMS 6 X G-4	-10.91**	-20.86**	-25.30**	-16.03**	-23.68**	0.07
ACMS 8 X PBC 142	-3.29**	-7.89**	-30.03**	63.76**	50.20**	80.87**
ACMS 8 X ACG 12	8.82**	3.87**	-21.44**	-15.85**	-21.97**	-6.04**
ACMS 8 X 9955-15R	-3.00**	-13.77**	-23.80**	21.57**	10.69**	33.29**
ACMS 8 X LCA 206	-8.18**	-11.46**	-34.42**	55.85**	38.28**	66.50**
ACMS 8 X LCA 436	-17.24**	-26.01**	-35.47**	-4.53*	-13.38**	4.30*
ACMS 8 X RHRC PENDT	6.08**	3.60**	-25.28**	-6.36**	-17.98**	-1.24
ACMS 8 X JCA 283	-2.51**	-5.21**	-34.82**	-16.46**	-19.36**	-2.9
ACMS 8 X G-4	-14.88**	-26.44**	-30.55**	7.87**	1.96	22.77**
Range Min.	-23.8	-29.33	-39.35	-28.85	-37.87	-18.54
Max.	40.19	34.62	3.18	84.94	80.87	93.94
SE +	0.02	0.02	0.02	1.94	2.25	2.25

The minimum and maximum values for heterobeltiosis were -29.14 to 162.62 per cent, respectively. Total 11 hybrids depicted significant heterosis and all those had positive effects. The hybrid ACMS-8 x RHRC PENDT (162.62%) exhibited the highest heterobeltiosis. The cross ACMS-8 x LCA 206 (-29.14) had depicted the least heterobeltotic effect. The check hybrid ARCH 228 was higher yielder than GAVCH 1, hence it was considered as a better check for estimating standard heterosis.The estimates of standard heterosis over ARCH 228 ranged from -61.39 to 55.25 per cent. Total 5 hybrids exhibited significant standard heterosis. Among them, only hybrid ACMS-4 x 9955-15R (55.25%) depicted the highest and positive standard heterosis, whereas, the hybrid ACMS-6 x LCA 436 (-61.39%) had the minimum significant estimate of standard heterosis for green fruit yield. ACMS-4 x 9955-15R (55.25%) depicted the highest and positive standard heterosis for green fruit yield and also heterotic over standard check for plant height (-16.02%), fruit length (21.82%), fruit weight (82.06%) and pericarp thickness (1.57%).The results reveal that the estimates of relative heterosis and heterobeltiosis were high with greater magnitude of positive effects, whereas those for standard heterosis were moderate to high in both the directions. The findings confirmed the reports Patel (2004), (RH, BH, SH); Prasath and Ponnuswami(2008), (SH); Reddy *et al.* (2008), (RH, BH, SH); Patel *et al.* (2010), (BH). Whereas, the results differed from the reports of Patel (2002), (RH, BH, SH); and Patel *et al.* (2010) (SH) as they have reported only positive estimates of various heterotic effects.The crosses ACMS 4 X 9955-15R, CCA-4759 X LCA 206 and CCA-4759 X RHRC PENDT had higher estimates of standard heterosis for green fruit yield and other desirable traits. Therefore, above crosses could be directly exploited for commercial cultivation as hybrids.The green fruit yield, most of its component characters and quality parameters are predominantly governed by nonadditive gene effect, which also favors heterosis breeding. Though the chilli is self-pollinated crop, but up to 60 % natural out crossing has been reported. The planting geometry of GMS line and pollen parent (1 GMS : 1 pollen parent) and CGMS line and pollen parent (3 CGMS : 1 pollen parent) could be exploited for commercial hybrid seed production (Patel, 2004; Patel *et al.*, 2004; Anon., 2008), the higher amount seeds produced would offer hybrid seeds at affordable price to the chilli growing farmers.

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