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HETEROSIS IN BELL PEPPER (*CAPSICUM ANNUUM* L.) FOR YIELD AND YIELD ATTRIBUTING TRAITS

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Abstract

The magnitude of heterosis in 33 crosses derived from line × tester, indicated pronounced hybrid vigour for total fruit yield and yield attributing traits in bell pepper (*Capsicum annuum* L.). The magnitude of heterosis over the commercial check hybrid was high in the desirable direction for all the 12 characters. The findings revealed that the crosses: Arka Mohini × IIHR-4103, Arka Mohini × IIHR-3341, Arka Mohini × IIHR-4107 and Arka Basant × IIHR-4096 were identified as the best heterotic cross combinations. These four productive hybrids had significantly higher *per se* values than the commercial check (Indra) in respect of number of primary branches, number of secondary branches, fruit length, fruit width, average fruit weight and number of fruits per plant. These hybrids also possess desirable fruit length and fruit width. The high heterotic response as observed in these hybrids further supported by the predominant role of non-additive gene action in the inheritance of the characters under study. These cross combinations could be exploited in heterosis breeding programme in future.

Introduction

Bell pepper (*Capsicum annuum* L.) also known as sweet pepper or Simla Mirch is popular among the vegetables for its delicate taste and pleasant flavour coupled with rich ascorbic acid, vitamin-A, other vitamins and minerals. Shimla Mirch has attained a status of high value crop in India in the recent years both for its green as well as colored (red and yellow) fruits. The high market price is due to the heavy demand from the urban consumers and inadequacy of supply due to low productivity, which can be attributed to lack of high yielding adaptable varieties and hybrids. As the required goals of increasing productivity in the quickest possible time can be achieved by utilizing heterosis breeding, which is feasible in this crop (Joshi and Singh 1980, Sood and Kumar 2010, Mulge 1992). Information on the magnitude of heterosis in different cross combinations is a basic requisite to assess for identifying crosses that exhibit high amount of exploitable heterosis. The present investigation describes the extent and nature of heterosis in hybrids for plant growth, earliness and fruit yield and its components.

Materials and Methods

Three lines (Female parents) Arka Mohini (L_1), Arka Gaurav (L_2) and Arka Basant (L_3) and 11 testers (Male parents) IIHR-4096 (T_1), IIHR-4103 (T_2), IIHR-3338 (T_3), IIHR-3341 (T_4), IIHR-3342 (T_5), IIHR-4104 (T_6), IIHR-4105 (T_7), IIHR-4106 (T_8), IIHR-4034 (T_9), IIHR-4033 (T_{10}), and IIHR-4107 (T_{11}) developed and maintained at Indian Institute of Horticultural Research (IIHR), Bangalore were used as parental materials in this experiment. Parents were selected on the basis of the diverse morphological characters, fruit size and shape and yield potential of the lines. Male and female parents were mated in line × tester fashion during August to December, 2012 at

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Vegetable crops research farm, IIHR, Hessarghatta lake post, Bangalore-65, India. Thirty three F_1 hybrids along with their 14 parents were evaluated in randomized block design with two replications using Indra (Syngenta Seeds Pvt. Ltd., Bima nagar, Bangalore-75, India) as a commercial hybrid check during February to June, 2013 at IIHR Bangalore. Recommended agronomic practices and need based plant protection measures were taken. Data was recorded on five random plants for 12 yield and yield attributing traits. Replication wise mean values were then subjected to analysis of variance and calculated the heterobeltiosis and standard heterosis.

Results and Discussion

Analysis of variance (ANOVA) revealed that mean sum of squares due to genotypes, parents, hybrids and parents *vs* hybrids were highly significant (at p = 0.05) for all traits except primary branches, secondary branches, fruit width (cm), average no. of locules/fruit, pericarp thickness (mm) indicating the presence of considerable amount of diversity among the genotypes. However, comparison of parents *vs* crosses were significant for fruit number, yield per plant, fruit length, average fruit weight and number of locules per fruit suggesting the presence of hybrid vigour for yield and most of the yield attributing traits. Estimation of heterobeltiosis and standard heterosis for various characters studied. From practical point of view for the breeder the cross showing heterosis for the maximum number of characters over commercial check (CC) is desirable and real potentiality of the hybrid and reliability of the parents for deriving superior hybrids estimated by the better parent (BP) heterosis. In the present investigation the standard heterosis over commercial check (CC) and heterobeltiosis over better parent (BP) of best performed F_1 hybrids among 33 F_1 hybrids were presented in Table 1.

Highest standard heterosis for plant height recorded by $L_2 \times T_2$ (15.99%) and heterobeltiosis by $L_1 \times T_{11}$ (11.48%). The maximum heterobeltiosis for number of primary branches shown by $L_3 \times T_6$ (16.28%) and the standard heterosis by $L_3 \times T_6$ (20.00%). The hybrid $L_3 \times T_6$ showed both standard heterosis (33.33%) and heterobeltiosis (7.81%) for the trait number of secondary branches. These results were in agreement with earlier reports of Prabhudeva (2003), Singh and Chaudhary (2005) and Mulge (1992).

Early flowering is generally an indication of early yield, take advantage of early market. Days to 50% flowering desirable highest standard heterosis was exhibited by $L_3 \times T_7$ (–5.15%) and heterobeltiosis by $L_3 \times T_4$ (–5.80%). The highest desirable standard heterosis (–3.96%) and heterobeltiosis (–5.22%) exhibited by $L_1 \times T_2$ for the trait days to first harvest. These results were in conformity with Bhagyalaksmi *et al.* (1991) and Patel *et al.* (1997).

For the trait fruit length (cm) $L_3 \times T_1$ showed both highest standard heterosis (8.35%) and heterobeltiosis (20.76%). For the trait fruit width (cm) maximum standard heterosis shown by $L_1 \times T_1$ (19.05%) and heterobeltiosis by $L_1 \times T_5$ (2.38%). For the trait number of locules per fruit maximum standard heterosis shown by $L_3 \times T_{11}$ (7.69 %) and heterobeltiosis by $L_1 \times T_4$ (16.50 %).

The hybrid $L_1 \times T_4$ showed maximum standandard heterosis (43.72%) and heterobeltosis (85.21%) for the trait average fruit weight (g). For fruit pericarp thickness (mm) hybrid $L_1 \times T_7$ showed maximum standard heterosis (11.11%) and heterobeltiosis (16.67%). These results coincided with Sood and Kumar (2010). Similar findings obtained by Saritha *et al.* (2005) for yield per plant, Jagadeesha and Wali (2005) for average fruit weight (g) and number of fruits per plant.

The range for mean performance of parents, crosses and various heterotic effects for heterobeltiosis and standard heterosis as well as the heterotic crosses identified on the basis of standard heterosis were narrated in Table 2. The maximum range in performance of the parents for the traits suggesting that considerable amount of genetic variability is present, which is one of the

Table 1. Estimates of per cent heterosis over better parent (BP) and commercial check Indra (CC) for important hybrids in bell pepper.

Hybrids	Plant height (cm)		Primary branches		Secondary branches		Days to 50% flowering		Days to first harvest		No. of fruits/plant	
	BP	CC	BP	CC	BP	CC	BP	CC	BP	CC	BP	CC
$L_1 \times T_1$	–4.86	6.76	–5.67**	13.20**	–8.417**	22.11**	0.00	–2.94*	–3.06*	–2.20	61.70**	72.73**
$L_1 \times T_2$	–13.26**	4.24	0.00	20.00**	0.00	33.33**	0.00	–2.94*	–5.22**	–3.96**	–10.64**	–4.55**
$L_1 \times T_4$	–1.16	–4.90	0.00	20.00**	0.00	33.33**	–3.62**	–2.21	–1.32	–1.32	44.68**	54.55**
$L_1 \times T_5$	–11.22**	10.47**	–8.33**	10.00**	–16.667**	11.11**	–4.35**	–2.94*	–1.76	–1.76	–31.92**	–27.27**
$L_1 \times T_7$	–9.40**	0.87	–8.33**	10.00**	–11.167**	18.44**	–1.47	–1.47	–2.66*	–3.08*	6.38**	13.64**
$L_1 \times T_{11}$	11.48**	7.27*	–19.50**	–3.40**	–19.50**	7.33**	0.00	–0.74	–0.45	–2.64*	65.96**	77.27**
$L_2 \times T_2$	–3.48	15.99**	–15.00**	2.00**	–16.667**	11.11**	3.08**	–1.47	–2.61*	–1.32	2.33	0.00
$L_3 \times T_1$	–5.80	5.70	0.00	20.00**	0.00	33.33**	–0.76	–4.41**	–3.93**	–3.08*	–23.53**	18.18**
$L_3 \times T_4$	–19.60**	–17.97**	0.00	3.20**	–1.25**	22.11**	–5.80**	–4.41**	–3.97**	–3.96**	–23.53**	18.18**
$L_3 \times T_6$	–4.80	0.73	16.28**	20.00**	7.81**	33.33**	–2.96*	–3.68**	0.00	–2.20	–50.00**	–22.73**
$L_3 \times T_{11}$	4.93	7.07*	–6.40**	–3.40**	–13.74**	6.67**	1.48	0.74	7.98**	1.32	–11.77**	36.36**
SEm±	2.39	2.39	0.12	0.12	0.22	0.22	0.78	0.78	0.87	0.87	0.83	0.83
CD at 5%	6.80	6.80	0.34	0.34	0.61	0.61	2.23	2.23	2.47	2.47	2.35	2.35

(Contd.)

(Contd.)

Hybrids	Yield/plant (kg)		Fruit length (cm)		Fruit width (cm)		Average no. of locules/ fruit		Average fruit weight (g)		Pericarp thickness (mm)	
	BP	CC	BP	CC	BP	CC	BP	CC	BP	CC	BP	CC
$L_1 \times T_1$	100.00**	74.24**	–0.37	10.28**	–33.33**	19.05**	–20.88**	–2.62**	24.15	–19.95	8.33**	3.17**
$L_1 \times T_2$	35.65**	18.18**	–7.93**	4.14**	–2.74**	4.76**	–13.63**	6.31**	72.46**	11.20	0.00	–4.76**
$L_1 \times T_4$	166.09**	131.82**	–6.54**	3.45**	0.00	7.14**	16.50**	7.54**	85.21**	43.72**	8.33**	3.17**
$L_1 \times T_5$	69.28**	47.47**	–4.98**	5.17**	2.38**	2.38**	–25.00**	–7.69**	39.41**	–10.11	–8.33**	–12.70**
$L_1 \times T_7$	8.70**	–5.30**	–5.55**	4.55**	0.00	0.00	–14.29**	–7.69**	18.64	–23.50	16.67**	11.11**
$L_1 \times T_{11}$	35.65**	18.18**	–11.78**	–2.34**	2.38**	0.00	–18.75**	0.00	-11.86	–43.17**	0.00	–4.76**
$L_2 \times T_2$	–12.00**	–16.67**	–16.76**	–1.72**	–8.71**	2.38**	–25.00**	–7.69**	-7.85	–26.23*	0.00	–4.76**
$L_3 \times T_2$	14.71**	–1.52**	5.18**	18.97**	–22.64**	–16.67**	–28.13**	–11.54**	39.65**	–13.39	–8.33**	–12.70**
$L_3 \times T_4$	30.00**	11.62**	–3.47**	7.59**	–13.32**	–16.67**	0.00	–7.69**	7.04	–16.94	9.09**	-4.76**
$L_3 \times T_5$	–25.00**	–35.61**	2.10**	13.79**	–15.60**	–9.52**	–28.13**	–11.54**	5.61	–43.44**	–16.67**	–20.63**
$L_3 \times T_6$	–25.00**	–35.61**	–0.50	10.90**	–13.32**	–9.52**	–12.50**	–19.23**	9.47	–14.75	9.09**	–4.76**
$L_3 \times T_{11}$	5.88**	–9.09**	2.10**	13.79**	–13.32**	0.00	–12.50**	7.69**	–4.64	–49.45**	0.00	–12.70**
SEm±	0.14	0.14	0.36	0.36	0.61	0.61	0.17	0.17	8.98	8.98	0.34	0.34
CD at 5%	0.40	0.40	1.01	1.01	1.72	1.72	0.48	0.48	25.53	25.53	0.96	0.96

*and** indicate significance of values at p = 0.05 and p = 0.01%, respectively.

Table 2. The range for mean performance of parents, crosses and various heterotic effects for heterobeltiosis and standard crosses identified on the basis of commercial check (CC).

Characters	Range				Number of hybrids having significant heterosis effect (based on CC)		Best hybrids based on	
	Per se performance		Heterosis					
	Parents	Hybrids	BP	CC	+ve	–ve	BP	CC
Plant height (cm)	66.50 - 107.00	64.15 - 99.75	–33.52 - 11.48	–25.41 - 15.99	6	6	$L_1 \times T_{11}$	$L_2 \times T_2$
Primary branches	2.25 - 3.00	2.00 - 3.00	–33.33 - 16.28	–20.00 - 20.00	27	6	$L_3 \times T_6$	$L_3 \times T_6$
Secondary branches	3.50 - 6.00	3.30 - 6.00	–26.417 - 7.817	–26.67 - 33.33	30	2	$L_3 \times T_6$	$L_3 \times T_6$
Days to 50% flowering	64.00 - 69.50	64.5 - 68.5	–5.80 - 3.08	–5.15 - 0.74	0	17	$L_3 \times T_4$	$L_3 \times T_7$
Days to first harvest	104.00 - 115.00	109.00 - 115.50	–5.22 - 7.98	–3.96 - 1.76	0	12	$L_1 \times T_2$	$L_1 \times T_2$
No. of fruits/plant	4.25 - 9.75	7.50 - 19.50	–50.00 - 65.96	–31.82 - 77.27	18	13	$L_1 \times T_{11}$	$L_1 \times T_{11}$
Yield/plant (kg)	0.85 - 1.88	1.13 - 4.59	–40.00 - 166.09	–43.18 - 131.82	10	23	$L_1 \times T_4$	$L_1 \times T_4$
Fruit length (cm)	4.50 - 8.56	6.38 - 8.76	–23.31 - 8.35	–12.07 - 20.76	23	9	$L_3 \times T_1$	$L_3 \times T_1$
Fruit width (cm)	3.88 - 6.02	4.08 - 6.25	–33.33 - 2.38	–22.29 - 19.05	7	19	$L_1 \times T_5$	$L_1 \times T_1$
Average no. of locules/fruit	2.75 - 4.00	2.13 - 3.50	–45.88 - 16.50	–34.62 - 7.69	6	26	$L_1 \times T_4$	$L_3 \times T_{11}$
Average fruit weight (g)	65.50 - 146.50	90.00 - 263.00	–38.57 - 85.21	–50.82 - 43.72	1	18	$L_1 \times T_4$	$L_1 \times T_4$
Pericarp thickness (mm)	4.50 - 6.00	4.50 - 7.00	–18.18 - 16.67	–28.57 - 11.11	5	28	$L_1 \times T_7$	$L_1 \times T_7$

causes for heterosis. Deviation observed in the *per se* performance of the hybrids compare to that of the parents is also indication of the manifestation of heterosis in the hybrids. Considering the standard heterotic effects, the number of crosses having significant heterosis in desirable direction is more than that of the crosses with heterosis in undesirable direction for most of the traits is strongly suggesting that the genes with desirable effect were dominating. The negative heterosis observed in some of the crosses may be attributed to non-allelic interaction which can either increase or decrease the expression of heterosis.

From the above findings it may be concluded that, $L_1 \times T_2$, $L_1 \times T_4$, $L_1 \times T_{11}$ and $L_3 \times T_1$ were identified as the best heterotic cross combinations. These four productive hybrids had significantly higher *per se* values than the commercial check in respect of number of primary branches, number of secondary branches, fruit length, fruit width, average fruit weight and number of fruits per plant.

These hybrids also possess desirable fruit length and fruit width. Further what is more important is that in respect of days to 50% flowering (earliness) these hybrid combinations are at par with commercial check. From the productivity point of view these promising four hybrids in the order of their importance can be listed as $L_1 \times T_4$ (4.59 kg/ plant), $L_1 \times T_1$ (3.45 kg/ plant), $L_1 \times T_5$ (2.92 kg/ plant), $L_1 \times T_{10}$ (2.52 kg/ plant), $L_1 \times T_2$ and $L_1 \times T_{11}$ (2.34 kg/plant).

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