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Effect of Heterosis on Growth, Earliness and Yield Characters of Brinjal (*Solanum melongena* L.)

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Abstract

The present study was conducted to estimate the magnitude of heterosis for thirteen characters in brinjal. The analysis of variance revealed that the genotype selected were having sufficient amount of genetic variability amongst them to carry out further genetic analysis. Forty five F_1 hybrids (generated by line x tester mating design using diverse fifteen lines and three testers) along with 18 parents and standard check hybrid (Punjab Sadabahar) were evaluated in a randomized block design with three replications at The Research Farm of Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Highest heterotic value for fruit yield per plant was observed in cross combinations HE-100 x H-8 (42.27%) followed by HE-100 x HLB-12 (40.97%), HE-106 x BR-112 (37.54%) and HE-101 x BR-112 (36.46%). The cross combinations HE-100 x BR-112 followed by HE-100 x H-8 and HE-100 x HLB-12 showed earliness among all the crosses.

Key words : Heterosis, brinjal, genotype, hybrids.

Brinjal or eggplant (*Solanum melongena* L.) is an important Solanaceous crop of sub tropics and tropics which can be grown throughout the year. In India, it is one of the most common, popular and principal vegetable crops grown throughout the country except higher altitudes. It is cultivated in an area of about 669 thousand hectare with a production of 12.4 lakh metric tonnes in India (Anonymous, 2017). It is an important vegetable crop grown in almost all parts of the country, which being a centre of origin has a huge genetic divergence and offers much scope for improvement through heterosis breeding. The required goal of increasing the productivity in the quickest possible time can be achieved only through heterosis breeding (Kakizaki, 1931). Heterosis is the exploitation of hybrid vigour in brinjal and has been recognized as a practical tool for providing the breeder a means of increasing yield and other economic traits. Brinjal, often a self-pollinated crop that also shows some degree of crossing and therefore, it has the advantages of easy crossing, production of large number of seeds per cross and low seed requirement per unit area which facilitates its hybrid seed production for exploitation of heterosis.

Material and Methods

The present experiment was carried out at The Research Farm of Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar located at 29° 10 latitude North, 75° 46 longitude East and 215.2 m above mean sea level with semi-arid subtropical climate during spring-summer and rainy season of 2017. The experimental material comprised of 18 parents: 15 as lines (HE-100, HE-101, HE-102, HE-103, HE-104, HE-105, HE-106, HE-107, HE-108, HE-109, HE-110, HE-111, HE-112, HE-113 & HE-114) and 3 as testers {BR-112, Hisar Shyamal (H 8) and HLB-12} of brinjal along with 45 cross combinations and standard check.

Seeds of eighteen genotypes (15 lines and 3

testers) were sown on 18th November, 2016 in nursery bed and seedlings of these genotypes were transplanted on 23rd January, 2017 for making crosses in a line x tester mating fashion. Forty-five F_1 crosses were made by crossing 15 lines with 3 testers and seeds of 45 F_1 hybrids along with self-seeds of 18 parents were harvested separately. Forty five F_1 crosses along with 15 parents and one standard check were sown on 15th June, 2017. Thirty five days old seedlings were planted at spacing of 75 x 60 cm on 20th July 2017 with 3 replications accommodating 15 plants in each treatment in Randomized Block Design. Five competitive plants were selected randomly in each genotypes replication for recording the observations (Plant height (cm), Number of branches plant^{-1}, Days to 50 per cent flowering, Days to first fruit harvest, Number of flowers cluster^{-1}, Number of fruits cluster^{-1}, Fruit length (cm), Fruit diameter (cm), Fruit length to fruit diameter ratio, Number of fruits plant^{-1}, Average fruit weight (g), Fruit yield plant^{-1} (kg) and Fruit yield hectare^{-1} (q). All the recommended cultural practices of the crop were adopted for raising the crop successfully. The magnitude of heterosis was estimated in relation to mid parent, better parent and commercial check, as percentage increase or decrease of F_1s over the respective mid parental value or better parental value or commercial check, respectively.

Results and Discussion

The analysis of variance for different characters was computed in brinjal among 64 genotypes described in Table 1. It reveals that the mean sum of squares for all the 13 characters were highly significant. The analysis of variance was carried out by using the randomized block design (RBD) and the line x tester mating design separately for the different characters to be observed on the selected plants. The analysis of variance reveals that the genotype selected for the current investigations were having sufficient amount of genetic variability among the genotypes to carry out further genetical analysis. Wide range of heterosis was observed among all the characteristics as shown in Table 2.

Growth characters : The maximum heterosis for plant height was observed in cross combination HE-100 x BR-112 (42.82%) followed by the cross combination HE-100 x H-8 (38.12%), HE-101 x BR-112 (35.77%) and HE-101x H-8 (32.55%). The range of heterosis over the standard check for number of branches per plant varied from -34.18 to 54.43%. The maximum heterosis was showed by the cross HE-100 x HLB-12 (54.43%) followed by the crosses HE-100 x BR-112 (45.57%), HE-101 x HLB-12 (20.25%) and HE-111 x H-8 (17.72%). Heterosis for number of branches per plant has also been reported earlier by Dharwad et al. (2012), Venkata-Naresh *et al.* (2014), Balwani *et al*. (2017), Kumar *et al*. (2017) and Sivakumar *et al.* (2017).

Table 1. Analysis of variance for various characters in a line x tester set of brinjal

Characters	Mean sum of square		
	Replication	Genotypes	Error
Degree of freedom	2	62	124
Plant height (cm)	4.797	285.741*	5.164
No. of branches plant^{-1}	0.083	6.842*	0.053
Days to 50% flowering	1.342	142.42*	2.538
Days to first fruit harvest	2.222	182.051*	4.488
No. of flowers cluster^{-1}	0.032	3.502*	0.044
No. of fruits cluster^{-1}	0.045	1.072*	0.035
Fruit length (cm)	0.078	29.821*	0.083
Fruit diameter (cm)	0.007	3.231*	0.036
Fruit length to fruit diameter ratio	0.021	4.114*	0.031
Number of fruits plant^{-1}	0.704	135.568*	1.005
Average fruit weight (g)	2.345	1,301.29*	6.882
Fruit yield plant^{-1} (kg)	0.003	0.176*	0.011
Fruit yield hectare^{-1} (q)	164.378	8,702.44*	529.685

*Significant at 5% level of significance

Table 2. Estimation of Standardheterosisfor different characters in brinjal

Cross	Plant height	No. of branches plant^{-1}	Days to 50% flowering	Days to first fruit harvest	No. of flowers cluster^{-1}	No.of fruits cluster^{-1}	Fruit length	Fruit diameter	Fruit length to fruit diameter ratio	No. of fruits plant^{-1}	Av. fruit weight	Fruit yield plant^{-1}	Fruit yield ha^{-1}
HE-100 x BR-112	42.82**	45.57**	-32.46**	-24.17**	46.81**	93.33**	10.53**	36.36**	13.85**	-8.23**	48.33**	36.12**	36.12**
HE-100 x H-8	38.12**	5.06*	-26.97**	-16.21**	53.19**	113.33**	-24.34**	9.09*	-2.58	9.88**	29.48**	42.27**	42.27**
HE-100 x HLB-12	29.77**	54.43**	-25.22**	-10.85**	78.72**	186.67**	12.50**	6.06	48.99**	58.02**	-10.79**	40.97**	40.97**
HE-101 x BR-112	35.77**	15.19**	25.88**	16.35**	19.15**	6.67	-30.92**	57.57**	-38.42**	-29.63**	93.92**	36.46**	36.46**
HE-101 x H-8	32.55**	7.59**	31.70**	21.27**	21.28**	-6.67	-36.18**	45.45**	-38.37**	3.70	29.33**	34.12**	34.12**
HE-101 x HLB-12	28.30**	20.25**	17.98**	11.58**	42.55**	46.67**	-26.32**	15.15**	-10.12**	23.87**	7.29*	32.90**	32.90**
HE-102 x BR-112	15.10**	-10.13**	-11.18**	-4.05	17.02**	60.00**	-53.29**	36.36**	-51.88**	-16.46**	40.43**	17.31**	17.31**
HE-102 x H-8	12.76**	3.80	-3.29	0.43	29.79**	53.33**	-65.79**	42.42**	-66.26**	-2.88	8.81**	5.68	5.68
HE-102 x HLB-12	6.16**	-2.53	-6.14*	-2.03	42.55**	80.00**	-28.95**	9.09*	-8.51**	7.41*	10.79**	19.00**	19.00**
HE-103 x BR-112	7.19**	-10.13**	9.21**	8.83**	4.25	33.33**	-42.11**	115.15**	-62.20**	-30.45**	75.08**	21.76**	21.76**
HE-103 x H-8	2.79	-29.11**	10.53**	16.64**	14.89**	46.67**	-57.24**	39.39**	-56.91**	-12.76**	31.16**	14.42**	14.42**
HE-103 x HLB12	-2.05	-6.33**	7.89**	14.62**	31.92**	100.00**	-39.47**	18.18**	-28.06**	-2.06	2.74	0.62	0.62
HE-104 x BR-112	10.18**	-13.92**	-13.60**	-5.64*	8.51*	40.00**	-51.97**	57.58**	-57.19**	-17.28**	37.39**	13.64**	13.64**
HE-104 x H-8	6.89**	-7.60**	-7.24**	1.01	12.77**	53.33**	-44.08**	48.48**	-47.10**	9.47**	10.18**	20.61**	20.61**
HE-104 x HLB-12	0.00	-25.32**	-8.55**	-4.05	36.17**	86.67**	-40.79**	6.06	-21.58**	5.76*	-15.35**	-10.47*	-10.47*
HE-105 x BR-112	26.69**	8.86**	-6.79**	-6.22**	-4.25	33.33**	-28.95**	42.42**	-29.92**	-18.52**	58.97**	29.53**	29.53**
HE-105 x H-8	20.82**	-10.13**	4.61	4.34*	21.28**	73.33**	-39.47**	36.36**	-37.65**	-1.65	9.57**	7.77	7.77
HE-105 x HLB-12	9.82**	6.33**	4.39	1.88	44.68**	106.67**	-19.74**	12.12**	0.56	9.05**	-7.45*	0.93	0.93
HE-106 x BR-112	6.75**	-13.92**	20.39**	15.19**	-12.77**	13.33	-46.05**	87.88**	-59.67**	-25.51**	84.65**	37.54**	37.54**
HE-106 x H-8	-6.45**	-6.33**	2.63	5.35*	-17.02**	6.67	-51.97**	66.67**	-59.52**	-22.22**	60.49**	24.82**	24.82**
HE-106 x HLB-12	3.96	-22.78**	15.57**	18.52**	12.77**	40.00**	-37.50**	18.18**	-25.71**	1.23	24.32**	25.85**	25.85**
HE-107 x BR-112	-2.93	-26.58**	27.63**	20.26**	29.78**	73.33**	-9.87**	15.15**	9.95**	12.76**	3.19	16.36**	16.36**
HE-107 x H-8	-13.93**	-20.25**	21.05**	16.64**	42.55**	106.67**	-25.66**	6.06	-1.54	31.69**	-14.29**	12.87**	12.87**
HE-107 x HLB-12	-4.99*	-12.66**	8.99**	10.56**	59.57**	146.67**	-1.32	9.09*	27.07**	87.65**	-36.02**	20.06**	20.06**
HE-108 x BR-112	-0.44	3.80	-1.75	3.62	21.28**	33.33**	-36.18**	66.67**	-46.22**	4.53	16.87**	22.16**	22.16**

Table 2. Contd.

Cross	Plant height	No. of branches plant^{-1}	Days to 50% flowering	Days to first fruit harvest	No. of flowers cluster^{-1}	No.of fruits cluster^{-1}	Fruit length	Fruit diameter	Fruit length to fruit diameter ratio	No. of fruits plant^{-1}	Av. fruit weight	Fruit yield plant^{-1}	Fruit yield ha^{-1}
HE-108 x H-8	-6.45**	-31.65**	1.32	6.66**	34.04**	73.33**	-30.92**	30.30**	-25.53**	20.99**	1.98	23.38**	23.38**
HE-108 x HLB-12	-9.53**	-10.13**	10.96**	8.83**	65.96**	120.00**	-2.63*	39.39**	-1.88	71.60**	-25.08**	28.57**	28.57**
HE-109 x BR-112	9.82**	-26.58**	-15.79**	-15.05**	8.51*	20.00*	-52.63**	69.69**	-60.79**	-14.40**	58.51**	35.68**	35.68**
HE-109 x H-8	-4.99*	-15.19**	-13.60**	-3.91	25.53**	66.67**	-65.79**	42.42**	-66.26**	0.00	32.37**	32.37**	32.37**
HE-109 x HLB-12	8.80**	-3.80	-10.31**	-4.34*	40.43**	86.67**	-42.76**	15.15**	-30.18**	26.34**	-4.41	20.77**	20.77**
HE-110 x BR-112	15.69**	-30.38**	-2.19	6.51**	-4.26	26.67**	-55.92**	54.54**	-59.94**	-0.82	23.86**	22.84**	22.84**
HE-110 x H-8	-2.35	-21.52**	7.02**	14.18**	21.28**	53.33**	-57.24**	39.39**	-56.91**	16.87**	9.27**	27.71**	27.71**
HE-110 x HLB-12	23.31**	-34.18**	10.75**	12.15**	29.79**	86.67**	-44.74**	0.00	-22.37**	20.16**	-2.13	17.61**	17.61**
HE-111 x BR-112	10.26**	12.66**	-8.55**	-5.64*	25.53**	73.33**	-28.29**	24.24**	-18.92**	4.53	5.78*	10.56*	10.56*
HE-111 x H-8	-3.08	17.72**	-14.25**	-9.41**	31.92**	80.00**	-35.53**	36.36**	-33.59**	13.58**	-10.49**	1.67	1.67
HE-111 x HLB-12	10.56**	-1.26	-7.46**	-1.74	51.07**	100.00**	-15.13**	15.15**	3.53	44.86**	-25.23**	8.31	8.31
HE-112 x BR-112	27.86**	-6.33**	-13.82**	-4.63*	10.64**	26.67**	-7.24**	72.73**	-24.56**	-24.28**	72.64**	30.73**	30.73**
HE-112 x H-8	3.08	-13.92**	-21.49**	-12.88**	27.66**	46.67**	-12.50**	45.45**	-15.50**	-10.29**	31.46**	17.93**	17.93**
HE-112 x HLB-12	30.65**	2.53	-9.21**	-1.16	38.30**	73.33**	5.92**	12.12**	32.70**	3.29	18.09**	21.97**	21.97**
HE-113 x BR-112	6.75**	-1.26	2.63	3.91	6.38*	26.67**	-48.03**	30.30**	-43.97**	-18.52**	30.40**	6.25	6.25
HE-113 x H-8	-10.26**	-12.66**	-18.42**	-11.29**	10.64**	53.33**	-43.42**	18.18**	-32.75**	0.82	19.15**	20.13**	20.13**
HE-113 x HLB-12	1.32	-2.53	-5.92*	0.43	27.66**	80.00**	-37.50**	-3.03	-9.46**	29.63**	-8.21**	18.99**	18.99**
HE-114 x BR-112	9.68**	12.66**	-19.52**	-18.81**	0.00	20.00*	-50.66**	93.94**	-64.26**	-10.29**	50.00**	34.57**	34.57**
HE-114 x H-8	0.15	2.53	-15.35**	-0.58	8.51*	40.00**	-47.37**	72.73**	-57.20**	-15.23**	22.49**	3.84	3.84
HE-114 x HLB-12	-13.34**	16.46**	-20.61**	0.58	25.53**	66.67**	-40.13**	9.09*	-22.91**	18.93**	3.80	23.45**	23.45**
Max.	42.82	54.43	31.80	21.27	78.72	186.67	12.50	115.15	48.99	87.65	93.92	42.27	42.27
Min.	-13.93	-34.18	-32.46	-24.17	-17.02	-6.67	-65.79	-3.03	-66.26	-30.45	-36.02	-10.47	-10.47
SE	1.90	0.19	1.27	1.69	0.17	0.14	0.23	0.15	0.12	0.83	2.09	0.09	19.17
CD at 5%	3.16	0.31	2.12	2.81	0.29	0.24	0.38	0.25	0.20	1.38	3.47	0.14	31.86
CD at 1%	4.15	0.45	3.02	4.01	0.41	0.34	0.54	0.36	0.28	1.97	4.94	0.20	45.42

**Significant at 1% & *Significant at 5% level respectively

Earliness characters : Earliness, one of the most desirable characters for brinjal is indicated by days required for 50% flowering and days to 1st harvest and the crosses with negative significant heterosis were considered as desirable for these two traits. Heterotic effects for days to 50% flowering varied from -32.46 to 31.80%. Presence of negative heterosis expressed earliness. The maximum heterosis was recorded in the cross HE-100 x BR-112 (-32.46%), HE-100 x H-8 (-26.97%), HE-100 x HLB-12 (-25.22%), HE-112 x H-8 (-21.49%) and HE-114 x HLB-12 (-20.61%) which expresses earliness over the check. Significant heterosis in negative direction was earlier observed by Makani *et al*. (2013), Dubey *et al*. (2014), Balwani *et al*. (2017), Kumar *et al*. (2017) and Sivakumar *et al*. (2017). Heterosis over the standard check for days to first fruit harvesting varied from -6.59 to 7.92%. The maximum negative heterosis was recorded in cross combination HE-100 x BR-112 (-24.17%) followed by HE-114 x BR-112 (-18.81%) and HE-100 x H-8 (-16.21%) which expresses earliness over the check. The results are in favour of Chowdhury *et al*. (2010), Makani *et al*. (2013), Venkata-Naresh *et al*. (2014) and Balwani *et al*. (2017).

Yield and yield attributing characters : The maximum heterosis for number of flowers per cluster was showed by the cross HE-100 x HLB-12 (78.72%) followed by the crosses HE-108 x HLB-12 (65.96%), HE-107 x HLB-12 (59.57%) and HE-100 x H-8 (53.19%). The maximum heterosis over best parent was shown by cross HE-101 x BR-112 (16.67%). These outcomes are in accordance with the findings of Dharwad *et al*. (2012) and Dubey *et al*. (2014). The maximum heterosis for number of fruits per cluster was showed by the cross HE-100 x HLB-12 (186.67%) followed by the crosses HE-107 x HLB-12 (146.67%), HE-108 x HLB-12 (120.00%) and HE-100 x H-8 (113.33%). Only three cross combination HE-100 x HLB-12

Table 3. Best crosses on the basis of standard heterosis for different characters

Characters	Desirable crosses	Standard check (%)
Plant height	HE-100 x BR-112	42.82
	HE-100 x H-8	38.12
	HE-101 x BR-112	35.77
No. of branches plant^{-1}	HE-100 x HLB-12	54.43
	HE-100 x BR-112	45.57
	HE-101 x HLB-12	20.25
Days to 50% flowering	HE-100 x BR-112	-32.46
	HE-100 x H-8	-26.97
	HE-100 x HLB-12	-25.22
Days to first fruit harvest	HE-100 x BR-112	-24.17
	HE-114 x BR-112	-18.81
	HE-100 x H-8	-16.21
No. of flowers cluster^{-1}	HE-100 x HLB-12	78.72
	HE-108 x HLB-12	65.96
	HE-107 x HLB-12	59.57
No. of fruits cluster^{-1}	HE-100 x HLB-12	186.67
	HE-107 x HLB-12	146.67
	HE-108 x HLB-12	120.00
Fruit length	HE-100 x HLB-12	12.50
	HE-100 x BR-112	10.53
	HE-112 x HLB-12	5.92
Fruit diameter	HE-103 x BR-112	115.15
	HE-114 x BR-112	93.94
	HE-106 x BR-112	87.88
Fruit length to fruit diameter ratio	HE-100 x HLB-12	48.99
	HE-112 x HLB-12	32.70
	HE-107 x HLB-12	27.07
Average fruit weight	HE-101 x BR-112	93.92
	HE-106 x BR-112	84.65
	HE-103 x BR-112	75.08
Number of fruits plant^{-1}	HE-107 x HLB-12	87.65
	HE-108 x HLB-12	71.60
	HE-100 x HLB-12	58.02
Fruit yield plant^{-1}	HE-100 x H-8	42.27
	HE-100 x HLB-12	40.97
	HE-106 x BR-112	37.54
Fruit yield ha^{-1}	HE-100 x H-8	42.27
	HE-100 x HLB-12	40.97
	HE-106 x BR-112	37.54

(12.50%), HE-100 x BR-112 (10.53%) and HE-112 x HLB-12 (5.92%) had significant positive heterosis over check for fruit length while rest of the cross combinations showed significantly negative heterosis. The crosses HE-103 x BR-112 (115.15%) followed by HE-114 x BR-112 (93.94%) and HE-106 x BR-112 (87.88%) showed the highest heterotic effect for fruit diameter. The range of heterosis over the standard check for average fruit weight varied from 36.02 to 93.92%. The maximum heterosis was observed in cross combination HE-101 x BR-112 (93.92%) followed by the cross combinations HE-106 x BR-112 (84.65%), HE-103 x BR-112 (75.08%) and HE-112 x BR-112 (72.64%). Positive heterosis for average fruit weight was also reported by Venkata-Naresh *et al*. (2014), Balwani *et al*. (2017), Kumar *et al*. (2017) and Sivakumar *et al*. (2017). The heterotic effects of crosses over the standard check for number of fruits per plant varied from -30.45 to 87.65%. Maximum heterosis was observed in cross combination HE-107 x HLB-12 (87.65%) which was followed by HE-108 x HLB-12 (71.60%), HE-100 x HLB-12 (58.02%) and HE-111 x HLB-12 (44.86%). The results are in favour of Makani *et al*. (2013), Venkata-Naresh *et al*. (2014), Balwani *et al*. (2017) and Kumar *et al*. (2017). The heterotic effects of crosses over the standard check for fruit yield plant^{-1} varied from -10.47 to 42.27%. Out of 45 crosses, 36 exhibited significantly positive heterosis. The maximum was observed in cross HE-100 x H-8 (42.27%) which was closely followed by HE-100 x HLB-12 (40.97%), HE-106 x BR-112 (37.54%) and HE-101 x BR-112 (36.46%). These results are matching with the results of Reddy and Patel (2014), Venkata-Naresh *et al*. (2014), Ramani *et al*. (2015), Balwani *et al*. (2017), Patel *et al*. (2017) and Sivakumar *et al*. (2017). The maximum heterosis was observed in cross HE-100 x H-8 (42.27%) for fruit yield per hectare which was closely followed by HE-100 x HLB-12 (40.97%), HE-106 x BR-112 (37.54%) and HE-101 x BR-112 (36.46%). Chowdhury *et al*. (2010) also reported high heterosis for fruit yield hectare^{-1}. Best cross combinations on the basis of standard heterosis are shown in Table No. 3.

Conclusion

The cross combinations HE-100 x BR-112 followed by HE-100 x H-8 and HE-100 x HLB-12 showes earliness as compared to other crosses. These were the good combinations for earliness and also higher yield was obtained in them. Highest heterotic value for fruit yield per plant was observed in cross combinations HE-100 x H-8 (42.27%) followed by HE-100 x HLB-12 (40.97%), HE-106 x BR-112 (37.54%) and HE-101 x BR-112 (36.46%). On the basis of present study, it may be concluded that among 45 crosses, ten hybrids *viz*. HE-100 x H-8 (505.51 q), HE-100 x HLB-12 (500.90 q), HE-106 x BR-112 (488.70 q), HE-101 x BR-112 (484.88 q), HE-100 x BR-112 (483.66 q), HE-109 x BR-112 (482.09 q), HE-114 x BR-112 (478.14 q), HE-101 x H-8 (476.56 q), HE-101 x HLB-12 (472.23 q) and HE-109 x H-8 (470.34 q) have high heterosis and per se performance should be further tested in yield trial based on quality traits to get superior hybrids for evaluation.

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