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Heterosis studies for yield and yield traits in Brinjal

AB Bagade, JD Deshmukh and SV Kalyankar

Abstract
Diallel method of analysis was followed involving eight parents IBH-2, Utkal Keshari, IBH-3, SBJH-631, Sep-034, Sep-034, A. Nerkanth and BH-2 to study of heterosis for yield characters. The F_1 were evaluated during late *kharif /rabi* 2018-19 for the present study in randomized block design for two replications. Significant and positive heterosis was observed for most of the characters. The percentage of heterotic crosses showing heterosis over better parent were total number of fruits/plant (52.73), total yield of fruits per plant (71.06), fruit length (8.29), fruit weight (85.60), fruit diameter (43.27), fruit cluster per plant (3.77), plant height (27.45), days to 50% flowering (-19.72), High heterosis was observed in the cross 4 x 5 (SBJH-631 x Sep-034) for total yield of fruits per plant (kg/plant).

Keywords: Heterosis, studies, yield traits, Brinjal

Introduction
It is important vegetable crop cultivated throughout the warmer region of the world and has its centre of origin as India (Thompson *et al.* 1957) [9]. It is one of the major vegetable crops grown in Maharashtra after onion occupying an area of 26000 ha and have production of 548000 MT (Hort. Glance 2017) [4]. In Maharashtra, the crop is grown during all season *viz*., *Kharif*, *Rabi* and *Summer*, usually under irrigated condition except at higher altitudes. Brinjal is an important year round widely consumed vegetable in tropical and subtropical regions of globe. It is grown extensively in India, Bangladesh, Pakistan, China and Philippines. In India, it is one of the most common, popular and principal vegetable crop grown in the country. It is a versatile crop adapted to different agroclimatic regions and can be grown throughout the year. It is a perennial but grown commercially as an annual crop. A number of cultivars are grown in India based on consumer preference for fruit colour, size, shape and taste. The productivity of brinjal crop is low in some areas. The reasons for low yield are, growing of low yielding cultivars and the problems of diseases like phomopsis blight, little leaf, leaf spot and bacterial wilt and insect pests like fruit and shoot borer, jassids and epilachna beetles. Therefore, identification of good combiner and specific cross combinations and exploitation of heterosis is in need.

Materials and Methods
The present investigation entitled "Heterosis and Combining Ability Studies in Brinjal (*Solanum melongena* L.)" was conducted at Experimental farm of Department of Agricultural Botany, College of Agriculture, and V.N.M.K.V. Parbhani during *kharif* 2018. Twenty eight crosses were made during late *Kharif /rabi* 2017-18 using genetically diverse parents. Thus, eight parents, two check and 28 hybrids were evaluated during late *kharif /rabi* 2018-19 for the present study. A set of 38 genotypes comprising of 8 parents and their 28 F_1 and standard checks Manjarigota and Panchaganga were sown in Randomized Block Design with two replications. Fertilizers were applied at the rate of 100 kg N/ha, 50 kg P_2O_5/ha and 50 kg K_2O/ha. P_2O_5 and K_2O were applied as basal dose with 50 kg of nitrogen before one week of transplanting, while, remaining 50 kg of nitrogen was top dressed at the time of flowering.

Result and Discussion
The analysis of variance showed significant differences among treatments for the characters studied (Table 1). Heterosis (%) over mid parent (MP), better parent (BP) and standard checks (SC1, SC2) was calculated for yield. The results obtained are presented in Table 2, which are discussed below.

A. Plant height: Among the cross combinations, minimum plant height was observed in IBH-2 x BH-2. For plant height three and fifteen hybrids exhibited the significant negative

heterosis over mid parent, better parent respectively. Whereas two each of hybrids showed significant negative heterosis over standard check first and standard check second, respectively. Positive heterosis for this trait has also been reported by Chezhian *et al.* (2000) [2], Kumar and Pathania (2003) [5].

B. Days to 50 per cent flowering: The cross combination Utkal Keshari x IBH3 was observed earliest in flowering with respect to mean performance of crosses. For this trait, six, nine, one and one hybrids exhibited the significant positive heterosis over mid parent, better parent and standard check one and standard check two, respectively. Early flowering in hybrids has also been reported by Rai *et al.* (2005) [6].

C. Fruit diameter (cm): Among the cross combinations, maximum fruit diameter was observed in cross IBH-3 x BH-2. For fruit diameter eight, four, six and eight hybrids exhibited the significant positive heterosis over mid parent, better parent and standard check one and standard check two, respectively. Positive heterosis for this trait has also been reported by Shafeeq *et al.* (2007) [8].

D. Fruit cluster per plant: Among the cross combinations, maximum fruit cluster per plant was observed in SBJH-631 x Sep-034. None of hybrid in mid parent and better parent was recorded as significant positive heterosis for fruit cluster per plant. Eleven and nineteen hybrids exhibited the significant positive heterosis over standard check one and standard check two, respectively. Positive heterosis for this trait has also been reported by Aswani and Khandelwal (2005) [1].

E. Number of fruits per plant: maximum fruit per plant was observed in SBJH631 x Sep-034. For number of fruits per plant twenty seven, thirteen, twenty eight and twenty four hybrids exhibited the significant positive heterosis over mid parent, better parent and standard check one and standard check two, respectively. Singh *et al.* (2012) [9].

F. Fruit yield (kg): Among the cross combinations, maximum fruit yield was observed in cross SBJH-631 x Sep-034. With respect to mean performance it revealed that, twenty, eleven, twenty eight and twenty eight hybrids showed significant positive heterosis over mid parent, better parent and standard check.

G. Fruit borer infestation: Twenty seven hybrids showed significant negative heterosis which ranged from -89.39 percent (SBJH-631 x Sep-034.) to 0.26 percent (IBH -2 x A. Nerkanth)

Table 1: Analysis of variance (mean square) for different characters in Brinjal

Source of variation	D.F	Plant height	Days to 50% flowering	Fruit diameter	Fruit cluster/ plant	No of fruits per plant	Fruit yield per plant	No of fruits / cluster	Fruit borer infestation
Replication	1	0.238	1.798	0.924	0.0012	1.068	0.028	0.0001	0.031
Genotype	35	106.093**	46.635**	17.086**	1.006**	75.319**	1.147**	0.162**	30.952**
Parents	7	282.779**	68.338**	26.328**	1.679**	85.845**	1.099**	0.377**	21.290**
Hybrids	27	62.868**	42.405**	15.322**	0.857**	54.567**	0.785**	0.112**	26.549**
Parents vs	1	36.343	8.938	0.0006	0.335	561.938**	11.279**	0.0034	217.47**
Hybrids Error	35	21.588	8.527	0.457	0.268	2.587	0.082	0.0300	0.347
SE±		4.64	2.92	0.67	0.51	1.60	0.28	0.17	0.58

*Significant at 5 % and at 1% level

Table 2: Heterosis in percentage over mid parent (MP), better parent (BP) and standard checks (SC1, SC2) for various characters in Brinjal

Sr. No.	Hybrids		Plant height (cm)			Fruit weight (gm)				Fruit Diameter (cm)			
		MP	BP	SC1	SC2	MP	BP	SC1	SC2	MP	BP	SC1	SC2
1.	IBH-2 x Utkal Keshari	-8.39	-10.98*	16.32*	14.31*	7.45	-10.47**	71.85**	67.11**	-19.31**	-33.14**	2.18	2.99
2.	IBH-2 x IBH-3	-1.34	-12.70*	14.06*	12.09	10.35**	-0.96	90.12**	84.88**	-18.67**	-35.17**	-0.92	-0.13
3.	IBH-2 x SBJH-631	-2.17	-2.66	28.48**	26.26**	-5.36	-17.57**	58.23**	53.87**	-40.74**	-58.86**	-37.12**	-36.62**
4.	IBH-2 x Sep-034	-12.38*	-19.32**	5.41	3.59	43.83**	8.22*	107.75**	102.02**	-3.28	-32.57**	3.06	3.87
5.	IBH-2 x Kavya	-7.70	-20.67**	3.66	1.87	12.42**	-9.01*	74.66**	69.85**	-4.93	-22.86**	17.90**	18.84**
6.	IBH-2 x A.Nerkanth	-4.21	-9.69	18.00**	15.96*	0.65	-1.28	89.50**	84.28**	-1.13	-25.14**	14.41*	15.32*
7.	IBH-2 x BH-2	-13.03	-27.45**	-5.20*	-6.84*	-14.22**	-15.86**	67.92**	63.29**	-28.30**	-34.86**	-0.44	0.35
8.	Utkal Keshari x IBH-3	-4.87	-11.19*	6.47	4.63	47.08**	35.18**	106.28**	100.60**	6.85	1.74	2.18	2.99
9.	Utkal Keshari x SBJH-631	-8.15	-13.23*	17.23**	15.20*	25.63**	19.23**	69.92**	65.12**	-20.22**	-36.52**	-36.24**	-35.74**
10.	Utkal Keshari x Sep-034	-8.27	-17.06**	6.96	5.11	71.00**	50.29**	92.22**	86.93**	41.30**	13.04*	13.54*	14.44**
11.	Utkal Keshari x Kavya	-5.86	-14.83**	2.25	0.48	92.47**	85.60**	137.39**	130.85**	6.25	3.48	3.93	4.75
12.	Utkal Keshari x A.Nerkanth	-12.14*	-4.51	4.99	3.18	17.22**	-0.79	83.16**	78.11**	24.39**	10.87	11.35	12.24*
13.	Utkal Keshari x BH-2	11.79*	-18.49**	17.72*	15.69*	39.98**	14.84**	129.20**	122.89**	-3.10	-12.59*	9.17	10.04
14.	IBH-3 x SBJH-631	-7.47	-5.72	7.59	5.74	1.29	-2.09	49.41**	45.29**	5.81	-12.50	-20.52**	19.89**
15.	IBH-3 x Sep-034	-1.52	6.71	3.66	1.87	53.20**	25.25**	91.14**	85.87**	-13.29	-27.88**	-34.50**	-33.98**
16.	IBH-3 x Kavya	10.34	-0.10	7.31	5.46	54.96**	37.78**	110.26**	104.47**	17.37**	14.68*	9.17	10.04
17.	IBH-3 x A.Nerkanth	6.91	-5.66	15.61*	13.61*	-27.64**	-33.91**	22.01**	18.65*	53.61**	43.27**	30.13**	31.16**
18.	IBH-3 x BH-2	0.98	-11.69*	-5.13*	-6.77*	34.66**	18.82**	137.13**	130.60**	31.17**	13.29**	41.48**	42.61**
19.	SBJH-631 x Sep-034	-3.64	-9.43	16.56*	14.55*	10.91*	-6.80	32.72**	29.06**	-9.49	-10.14	-45.85**	-45.42**
20.	SBJH-631 x Kavya	5.82	-19.93**	19.55**	17.48*	31.40**	20.50**	71.61**	66.88**	-18.87**	-34.13**	-37.29**	-36.80**
21.	SBJH-631 x A.Nerkanth	-14.67**	-19.93**	5.70	3.87	-10.18*	-20.44**	46.87**	42.83**	-16.46*	-26.67**	-42.36**	-41.90**
22.	SBJH-631 x BH-2	-2.33	-18.86*	7.10	5.25	31.17**	12.38**	124.29**	118.11**	-1.42	-27.27**	-9.17	-8.45
23.	Sep-034 x Kavya	2.30	-5.14	4.29	2.49	97.68**	79.49**	13.19**	107.31**	24.49**	1.65	-3.23	-2.46
24.	Sep-034 x A.Nerkanth	2.82	0.26	16.02*	14.02*	-27.89**	-45.02**	1.50	-1.29	-22.01**	-31.11**	-45.85**	-45.42**
25.	Sep-034 x BH-2	8.13	-2.99	6.65	4.81	17.76**	-12.53**	74.57**	69.76**	17.92**	-12.59*	9.17	10.04
26.	Kavya x A.Nerkanth	-5.76	-14.62*	-1.20	-2.90	-15.08**	-30.22**	28.81**	25.26**	5.53	-3.67	-8.30	-7.57
27.	Kavya x BH-2	26.12**	21.68**	14.32*	12.34	56.87**	25.11**	149.70**	142.82**	15.87**	2.10	27.51**	28.52**

28.	A.Nerkanth x BH-2	3.78	-8.95	5.37	3.55	4.27	0.36	100.31**	94.79**	-4.7	-22.41**	-3.10	-2.33
SE ±		4.02382	4.64631	4.64631		3.01224	3.47824	3.47824		0.58556	0.67615	0. 67615	
C.D at 5 %		8.16873	9.43244	9.43244		6.11514	7.06115	7.06115		1.18874	1.37264	1.37264	
C.D at 1 %		10.9601	12.6557	12.6557		8.20482	9.47410	9.47410		1.59496	1.84170	1.84170	
Sr. No.	**Hybrids**		**Fruit cluster per plant**			**No. of fruits per plant**				**Fruit yield per plant (kg)**			
		MP	**BP**	**SC1**	**SC2**	**MP**	**BP**	**SC1**	**SC2**	**MP**	**BP**	**SC1**	**SC2**
1.	IBH-2 x Utkal Keshari	-4.13	-6.45	19.59	28.89*	23.95**	11.98	66.18**	17.44**	10.13	5.73	60.69**	52.25**
2.	IBH-2 x IBH-3	12.28	3.23	31.96**	42.22**	41.53**	22.49**	81.79**	28.46**	54.45**	29.51**	96.83**	86.50**
3.	IBH-2 x SBJH-631	2.29	-2.90	38.14**	48.89**	32.97**	6.47	162.70**	85.64**	38.19**	16.59*	157.78**	144.25**
4.	IBH-2 x Sep-034	-10.94	-13.64	17.53	26.67*	27.40**	10.39	123.51**	57.95**	-20.24**	-29.41**	39.31**	32.00**
5.	IBH-2 x Kavya	9.57	1.61	29.90**	40.00**	10.60	10.19	64.73**	16.41	2.22	-0.17	51.72**	43.75**
6.	IBH-2 x A.Nerkanth	-9.09	-14.29	23.71**	33.33**	27.08**	25.12**	91.58**	35.38**	-23.25**	13.82	104.22**	93.50**
7.	IBH-2 x BH-2	15.09	-1.61	25.77*	35.56**	36.56**	20.78**	79.25**	26.67**	51.05**	37.15**	89.77**	97.50**
8.	Utkal Keshari x IBH-3	3.60	-2.54	18.56	27.78**	60.25**	52.73**	82.87**	29.23**	56.52**	35.85**	138.26**	80.00**
9.	Utkal Keshari x SBJH-631	1.56	-5.80	34.02**	44.44**	44.16**	7.06	164.15**	86.67**	32.02**	7.76	84.70**	125.75**
10.	Utkal Keshari x Sep-034	-24.80**	-28.79**	-3.09	4.44	32.88**	5.73	114.08**	51.28**	9.55	-6.42	104.49**	75.00**
11.	Utkal Keshari x Kavya	1.79	-3.39	17.53	26.67*	3.35**	25.49**	87.59**	32.56**	43.65**	41.17	78.89**	93.75**
12.	Utkal Keshari x A.Nerkanth	-10.08	-17.14*	19.59	28.89*	34.04**	19.43*	82.87**	29.23**	12.07	-0.29	120.58*	69.50**
13.	Utkal Keshari x BH-2	-12.38	-13.21	20.62	30.00**	28.16**	25.15*	49.85**	5.90	67.20**	57.74**	120.70**	109.00**
14.	IBH-3 x SBJH-631	-19.01*	-28.99**	1.03	8.89	32.58**	-4.56	135.49**	66.41**	40.55**	2.98	127.70**	115.75**
15.	IBH-3 x Sep-034	-13.56	-22.73**	5.15	13.33	33.02**	2.15	16.82**	46.15**	46.22**	11.23	119.53**	108.00**
16.	IBH-3 x Kavya	13.59	-0.85	-5.15	2.22	32.77**	14.56	71.26**	21.03*	42.92**	22.22*	77.04**	67.75**
17.	IBH-3 x A.Nerkanth	-8.20	-20.00*	15.46	24.44*	24.83**	6.64	63.28**	15.38	15.33	-9.26	62.80**	54.25**
18.	IBH-3 x BH-2	0.01	-7.69	-1.03	6.67	38.55**	35.14**	54.21**	8.97	33.67**	24.49**	112.14**	101.00**
19.	SBJH-631 x Sep-034	-2.16	-2.86	46.39**	57.78**	2.15**	20.29**	196.81**	109.74**	86.98**	71.06**	179.68**	165.00**
20.	SBJH-631 x Kavya	2.46	-9.42	28.87*	38.89**	19.41**	-4.12	136.57**	67.18**	16.80*	-3.34	113.72**	102.50**
21.	SBJH-631 x A.Nerkanth	5.19	2.90	40.21**	51.78**	39.38**	12.94**	178.66**	96.92**	34.12	21.48**	168.60**	154.50**
22.	SBJH-631 x BH-2	-3.54	-21.01**	12.37	21.11	11.81*	-18.24**	101.74**	47.56**	31.19**	2.39	126.39**	114.50**
23.	Sep-034 x Kavya	-5.88	-15.15	15.46	24.44*	21.65**	5.73	114.08**	51.28**	33.08**	15.37	127.70**	115.75**
24.	Sep-034 x A.Nerkanth	-6.62	-9.29	30.93**	41.11**	27.14**	11.65	126.05**	59.74**	17.65*	12.30	121.64**	110.00**
25.	Sep-034 x BH-2	-9.09	-24.24**	3.09	11.11	30.20**	1.79	106.10**	54.64**	36.62**	11.23	119.53**	108.00**
26.	Kavya x A.Nerkanth	-0.81	-12.86	25.77*	35.56**	35.49**	33.89**	105.01**	44.87**	38.32**	25.00**	124.27**	112.50**
27.	Kavya x BH-2	13.40	3.77	13.40	22.22	36.27**	20.15**	79.61**	26.92**	58.59**	47.18**	113.19**	102.00**
28.	A.Nerkanth x BH-2	-8.77	-25.71**	7.22	15.56	40.34**	22.46**	87.52**	32.51**	26.61**	7.06	92.08**	82.00**
SE ±		0.44890	0.51834	0.51834		1.39394	1.60843	1.60843		0.24905	0.28758	0.28758	
C.D at 5 %		0.91130	1.05228	1.05228		2.82780	3.26526	3.26526		0.50559	0.58381	0.58381	
C.D at 1 %		1.22272	1.41187	1.41187		3.79412	4.38107	4.38107		0.67836	0.78330	0.78330	

Sr. No.	**Hybrids**		**Fruit Borer Infestation (%)**		
		MP	**BP**	**SC1**	**SC2**
1.	IBH-2 x Utkal Keshari	-32.24**	-35.90**	-31.17**	-13.20
2.	IBH-2 x IBH-3	-20.62**	-28.46**	-23.18**	-3.12
3.	IBH-2 x SBJH-631	-39.77**	-51.69**	-48.12**	-34.57**
4.	IBH-2 x Sep-034	-26.88**	-33.21**	-28.28**	-9.55
5.	IBH-2 x Kavya	-34.77**	-39.52**	-35.06**	-18.10*
6.	IBH-2 x A.Nerkanth	0.47	-13.81*	-7.45	16.72*
7.	IBH-2 x BH-2	-18.02**	-21.35**	-15.54*	6.52
8.	Utkal Keshari x IBH-3	-0.19	-5.20	-9.21	14.49
9.	Utkal Keshari x SBJH631	-30.70**	-41.87**	-44.33**	-29.80**
10.	Utkal Keshari x Sep-034	-37.60**	-40.40**	-42.92**	-28.02**
11.	Utkal Keshari x Kavya	-34.36**	-35.74**	-38.46**	-22.39**
12.	Utkal Keshari A.Nerkanth	-21.17**	-28.86**	-31.88**	-14.09
13.	Utkal Keshari x BH-2	-39.31**	-40.21**	-41.00**	-25.59**
14.	IBH-3 x SBJH-631	52.18**	33.38**	14.03*	44.94**
15.	IBH-3 x Sep-034	-6.19	-6.74	-18.68**	2.55
16.	IBH-3 x Kavya	-36.45**	-38.38**	-43.47**	-28.70**
17.	IBH-3 x A.Nerkanth	-27.88**	-31.78**	-41.22**	-25.87**
18.	IBH-3 x BH-2	-27.86**	-32.43**	-33.32**	-15.91**
19.	SBJH-631 x Sep-034	-75.93**	-79.01**	-81.70**	-76.92**
20.	SBJH-631 x Kavya	11.91	-4.48	-12.36*	10.53
21.	SBJH-631 x A.Nerkanth	-57.06**	-60.40**	-69.57**	-61.62**
22.	SBJH-631 x BH-2	50.34**	24.59**	22.95**	55.06**
23.	Sep-034 x Kavya	-38.79**	-40.31**	-45.23**	-30.93**
24.	Sep-034 x A.Nerkanth	-27.91**	-32.18**	-40.87**	-25.43**
25.	Sep-034 x BH-2	-38.00**	-41.61**	-42.38**	-27.33**
26.	Kavya x A.Nerkanth	45.77**	33.94**	22.89**	54.98**
27.	Kavya x BH-2	-1.55	-5.01	-6.26	18.22**
28.	A.Nerkanth x BH-2	17.37**	4.39	3.02	29.92
	SE ±	0.79	0.92	0.92	
	C.D at 5 %	1.62	1.87	1.87	
	C.D at 1 %	2.17	2.51	2.51	

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