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Heterosis for fruit yield and its yield attributing traits in brinjal (*Solanum melongena* L.)

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Abstract
As heterosis is widely utilized for the selection of superior cross combinations with this study was conducted in brinjal to estimate the magnitude of heterosis for fruit yield and yield attributing characters. The 24 F1 generated by Line x Tester fashion along with 10 Parents (6 Females and 4 Males) and 2 checks (Kashi Taru and Phule Arjun) were evaluated in randomized block design. The experiment was carried out during *kharif* 2018 at experimental farm of Department of Agricultural Botany, VNMKV, Parbhani. Appreciable heterosis was found over mid, better and standard parent for all the traits studied in desirable direction. For the traits like Days to 50% flowering and Days to first picking negative heterosis is desirable for this the cross combination DBR-8 x JKGEH-6012 exhibited highest significant heterosis over mid parent (-12.10%) and better parent (-17.79%). For the yield attributing characters *viz.*, Fruit length (DBR-8 x DMU-1), Fruit girth (NBJ-19 x DMU-1), Fruit weight (DBR-8 x JB- 18). For the trait fruit yield per plant The maximum positive and significant heterosis over mid parent (75.50) over the better parent (67.76%), over Check-1 (50.68%) and Check-2 (66.49%) observed in the cross JB-9 x JKGEH-6012. The heterosis for fruit yield was ranged from (- 19.51 to 75.50) mid- parent, (-28.94 to 67.76) over better parents, (-32.19 to 50.68), (-25.08 to 66.49) and standard checks respectively.

Keywords: Brinjal, heterosis, line x tester, fruit yield

Introduction
Brinjal (*Solanum melongena*.L) is one of the most popular and major vegetable crop in India and some other parts of the world. Brinjal originated in India, which is also considered as a centre of diversity (Genabus, 1963) [3]. It is being grown extensively in India, Bangladesh, Pakistan, China, Japan, Philippines, France, Italy and U.S.A. India is the second major producer of brinjal in the world after China (Ravali *et al.*, 2017) [4]. Brinjal fruits are a fairly good source of calcium, phosphorus, iron and vitamins, particularly `B' group. Analysis of edible parts of fruit (except stalk and calyx) gave the following values (per 100 g fresh weight): moisture (92.7%), protein (1.4 g), fat (0.3 g) minerals (0.3g), carbohydrates (4 g), and fibre (1.3 g). (Aykroyd, 1963) [1]. and also excellent remedy for those suffering from liver troubles (Shukla and Naik, 1993) [5] and high blood cholesterol (Singh and Kalda, 2001) [6].
In recent years, brinjal breeding has concentrated on increased fruit yield, earliness, fruit quality as well as pests and disease resistance.
The productivity of F1 hybrids in brinjal has been reported to be high as compared to open pollinated varieties. Several workers have also reported the existence of considerable heterosis for economic characters in brinjal.
The crop is also highly suitable for exploitation of hybrid vigour owing to the existence of large bud size, higher percentage of crossed fruit set and production of more number of seeds per fruit (Chadha *et al.*, 1990) [2]. Therefore, nature and magnitude of heterosis is one of the important aspects for selection of the right parents for crosses and also help in identification of superior cross combinations that may produce desirable transgressive segregates in advanced generations.

Materials and methods
The present investigation was undertaken to study the magnitude of heterosis for fruit yield and its components in brinjal involving twenty four hybrids, ten parents and two checks. All the six male parents DMU -1, JKGEH - 6012, CO -11, B.deoria, DBR-31, JB -18 as (Testers) were crossed with the four female parents DBR8, JB-9, NBJ-19, Bhagya Mati (Lines), and made 24 hybrids by using Line X Tester fashion. The crossing programme was carried during late *kharif* 2017-18 at experimental farm of Department of Agricultural Botany, VNMKV, Parbhani. At the same time, the male and female parents were selfed to obtain pure seeds of parents for the experiment.

Each hybrid and parents represented single rows of six meter length spaced at 90 cm between rows and 60 cm between plants. Recommended agronomic practices and plant protection operations were followed to raise good crop. Observations were recorded for days to 50% flowering, days to first picking, fruit length (cm), fruit girth (cm), fruit weight (g), number of fruits per plant, number of fruits per cluster, number of branches per plant, plant height (cm), fruit yield per plant (Kg). Significance of heterosis worked out over mid-parent, better parents and Commercial checks (Phule Arjun), (Kashi Taru).

Results and Discussion

The analysis of variance showed highly significant differences among the genotypes for all the traits except for number of primary branches.

The genotypic variance was further partitioned into parents (lines, testers and Lines *vs* Testers), hybrids and parents *vs.* hybrids. The differences among parents and hybrids were found highly significant for all the characters under investigation except for number of primary branches in parents and for plant height in hybrids.

Differences between parents *vs* hybrids were also found significant for all the characters except days to first picking, number of fruits per plant, per cluster, stem girth and number of primary branches. The estimates of heterosis of F1 hybrids are presented in (Table 1).

Table 1: Analysis of variance for experimental design of different characters in brinjal

Source	D.F.	Days to 50% flowering	Days to 1st Picking	Fruit length (cm)	Fruit girth (cm)	Fruit weight (gm)	Fruit yield per plant (Kg)
		1	2	3	4	5	6
Replications	1	4.520	22.79	0.07	0.051	0.08	0.016
Treatments	33	49.76**	52.17**	8.03**	0.85**	121.84**	1.71**
parents	9	79.03**	102.63**	5.50**	0.62**	232.51*	1.30**
Lines	3	65.72**	95.63**	0.82**	0.28*	451.99**	0.54**
Testers	5	46.08**	41.53*	6.09**	0.68**	146.43**	2.02**
crosses	23	39.38**	33.58*	9.34**	0.91**	82.05**	1.88**
Lines x Testers	1	283.68**	429.08**	16.06**	1.34**	4.50	0.00
Parents vs Hybrids	1	25.30**	25.54	0.49**	1.51**	40.85*	1.53**
Error	33	3.85	15.00	0.13	0.12	19.56	0.11

Table 1: Contd…

Source	D.F.	Number of fruits per plant	Number of fruits per cluster	Number of primary branches	Stem girth (cm)	Plant height (cm)
		7	8	9	10	11
Replications	1	0.60	0.001	0.22	0.013	32.82
Treatments	33	10.22**	0.16**	0.17	0.79**	55.42*
parents	9	20.23**	0.31**	0.16	1.15**	86.48**
Lines	3	16.38**	0.36**	0.054	0.61**	122.97**
Testers	5	26.58**	0.35**	0.25**	0.49**	60.23*
crosses	23	6.70*	0.19**	0.18*	0.44**	42.28
Lines x Testers	1	0.042	0.11**	0.004	6.01**	108.28**
Parents *vs* Hybrids	1	1.33	0.00	0.06	5.78**	77.97**
Error	33	2.56	0.031	0.09	0.02	24.60

** Significant at 5 and 1 per cent levels, respectively

Day to 50 per cent flowering

Significantly negative heterosis over mid parent and better parent was observed in respect of days to 50% flowering (Table 2). Negative heterosis for this trait indicates earliness which is desirable. The maximum and significant negative heterosis over mid parent (-12.10%) and better parent (-17.79%) was observed in the cross DBR - 8 x JKGEH - 6012. None of the crosses were significantly early in days to 50 per cent flowering to both the commercial checks. Out of 24 crosses, seven crosses over mid parent, 18 crosses over better parent and none of the crosses over commercial check shown significant negative heterosis for days to 50 per cent flowering.

Table 2: Per cent heterosis for yield and its components over mid parent (MP) over better parent (BP), Kashi Taru (C-1) and Phule Arjun (C-2)

Sr. No.	Crosses	Days to 50% flowering				Days to first picking			
		MP	BP	Kashi Taru	Phule Arjun	MP	BP	Kashi Taru	Phule Arjun
1.	DBR8 x DMU-1	4.14*	-0.61	34.55**	23.85**	1.09	-4.41	19.02**	14.69**
2.	DBR8 x JKGEH-6012	-12.10**	-17.79**	11.30**	2.45	-11.64**	-18.01**	2.09	-1.63
3.	DBR8 x CO-11	0.45	-4.47*	29.32**	19.04**	-2.61	-7.82*	14.78**	10.60**
4.	DBR8 x B.deoria	-2.18	-7.97**	24.58**	14.68**	-3.37	-10.02**	12.04**	7.96*
5.	DBR8 x DBR-31	0.06	-11.10**	20.35**	10.78**	-2.13	-12.44**	9.03*	5.06
6.	DBR8 x JB-18	-7.15**	-17.23**	12.04**	3.13	-6.22	-16.39**	4.11	0.32
7.	JB-9 x DMU-1	-2.87	-7.03**	25.08**	15.14**	-3.06	-8.60*	14.47**	10.31**
8.	JB-9 x JKGEH-6012	3.25	-3.14	30.32**	19.95**	5.31	-2.54	22.07**	17.62**
9.	JB-9 x CO-11	-4.85**	-9.25**	22.09**	12.39**	4.21	-9.58*	13.25**	9.13*
10.	JB-9 x B.deoria	-10.89**	-15.92*	13.12**	4.13*	-9.69**	-16.13**	5.04	1.22
11.	JB-9 x DBR-31	1.87	-9.25**	22.09**	12.39**	-2.52	-13.02**	8.94*	4.97

12.	JB-9 x JB-18	6.28**	-5.00*	27.82**	17.66**	-4.56	-15.13**	6.30	2.43
13.	NBJ-19 x DMU-1	-11.02**	-12.97**	11.96**	3.06	-11.44**	-13.37**	0.46	-3.19
14.	NBJ-19 x JKGEH-6012	4.58*	-8.58**	17.61**	8.26**	-2.77	-6.71	8.18*	4.25
15.	NBJ-19 x CO-11	11.16**	-13.42**	11.38**	2.52	-5.95	-7.88*	6.83	2.94
16.	NBJ-19 x B.deoria	8.23**	-11.55**	13.79**	4.74*	-3.81	-7.37*	7.42*	3.51
17.	NBJ-19 x DBR-31	4.86**	-4.71*	22.59**	12.84**	4.33	-6.32	11.77**	7.70*
18.	NBJ-19 x JB-18	-0.53	-9.29**	16.69**	7.42**	1.44	-6.62	8.28*	4.34
19.	Bhagya Mati x DMU-1	0.80	-2.56	19.85**	10.32**	-1.83	-4.18	6.30	2.43
20.	Bhagya Mati x JKGEH-6012	-2.32	-3.59	13.62**	4.59*	-2.81	-3.23	3.11	-0.64
21.	Bhagya Mati x CO-11	-7.71**	-10.47**	9.30**	0.61	-4.72	-7.11	3.29	-0.47
22.	Bhagya Mati x B.deoria	-7.05**	-8.83**	8.80**	0.15	-4.57	-5.35	1.63	-2.07
23.	Bhagya Mati x DBR-31	2.71	-1.59	12.96**	3.98	8.28*	4.51	10.40**	6.39
24.	Bhagya Mati x JB-18	1.27	-2.60	11.79**	2.91	4.64	0.62	6.30	2.43
	S.E.	1.72	1.99	1.99	1.99	3.05	3.53	3.53	3.53
	CD at 5%	3.54	4.09	4.09	4.09	6.28	7.27	7.27	7.27
	CD at 1%	4.81	5.58	5.58	5.58	8.54	9.88	9.88	9.88

** Significant at 5 and 1 per cent levels, respectively

Table 2: Contd…

Sr. No.	Crosses	Fruit length (cm)				Fruit girth (cm)			
		MP	BP	Kashi Taru	Phule Arjun	MP	BP	Kashi Taru	Phule Arjun
1.	DBR8 x DMU-1	39.58**	24.27**	40.69**	111.99**	-3.60**	-13.48**	17.86**	-14.76**
2.	DBR8 x JKGEH-6012	-30.26**	-35.38**	-33.05**	0.88	-1.45**	-7.40**	26.15**	-8.76**
3.	DBR8 x CO-11	2.46**	-14.89**	13.74**	71.38**	0.35	-5.24**	29.08**	-6.64**
4.	DBR8 x B.deoria	-0.91**	-5.40**	-16.39**	25.98**	-11.30**	-15.82**	14.67**	-17.07**
5.	DBR8 x DBR-31	-7.33**	-12.97**	-12.41**	31.97**	30.46**	13.30**	54.34**	11.62**
6.	DBR8 x JB-18	-16.13**	-17.12**	-24.99**	13.03**	10.65**	7.61**	55.10**	12.18**
7.	JB-9 x DMU-1	15.26**	-3.00**	9.81**	65.47**	14.84**	6.32**	35.20**	-2.21**
8.	JB-9 x JKGEH-6012	-7.59**	-19.30**	-16.39**	25.98**	4.03**	1.00**	28.44**	-7.10**
9.	JB-9 x CO-11	-15.31**	-33.15**	-10.66**	34.61**	31.76**	28.59**	63.52**	18.27**
10.	JB-9 x B.deoria	9.32**	7.26**	-13.79**	29.90**	14.72**	12.54**	43.11**	3.51**
11.	JB-9 x DBR-31	-3.73**	-14.87**	-14.32**	29.10**	9.53**	-2.01**	24.62**	-9.87**
12.	JB-9 x JB-18	54.30**	43.08**	29.50**	95.12**	-25.15**	-29.56**	1.53**	-26.57**
13.	NBJ-19 x DMU-1	-17.65**	-30.13**	-20.90**	19.18**	42.34**	33.78**	64.67**	19.10**
14.	NBJ-19 x JKGEH-6012	-24.01**	-33.08**	-30.66**	4.48**	19.33**	17.72**	44.90**	4.80**
15.	NBJ-19 x CO-11	-36.85**	-49.78**	-32.89**	1.12**	17.66**	16.68**	43.62**	3.87**
16.	NBJ-19 x B.deoria	-4.93**	-5.81**	-24.30**	14.07**	8.94**	8.60**	33.67**	-3.32**
17.	NBJ-19 x DBR-31	-24.88**	-33.00**	-32.57**	1.60**	29.68**	17.72**	44.90**	4.80**
18.	NBJ-19 x JB-18	-0.66*	-7.03**	-15.86**	26.78**	-2.15**	-9.29**	30.74**	-5.44**
19.	Bhagya Mati x DMU-1	-20.33**	-28.12**	-18.62**	22.62**	10.69**	-3.26**	40.05**	1.29**
20.	Bhagya Mati x JKGEH-6012	-3.00**	-8.86**	-5.57**	42.29**	1.74**	-7.05**	34.57**	-2.68**
21.	Bhagya Mati x CO-11	-15.72**	-29.14**	-5.31**	42.69**	-11.04**	-18.33**	18.24**	-14.48**
22.	Bhagya Mati x B.deoria	52.85**	43.86**	31.03**	97.44**	0.10	-7.67**	33.67**	-3.32**
23.	Bhagya Mati x DBR-31	25.96**	19.98**	20.74**	81.93**	-14.67**	-27.75**	4.59**	-24.35**
24.	Bhagya Mati x JB-18	47.36**	46.88**	33.79**	101.60**	-26.18**	-26.34**	6.63**	-22.88**
	S.E.	0.30	0.34	0.34	0.34	0.28	0.33	0.33	0.33
	CD at 5%	0.61	0.70	0.70	0.70	0.57	0.67	0.67	0.67
	CD at 1%	0.84	0.95	0.95	0.95	0.78	0.92	0.92	0.92

Table 2: Contd…

Sr. No.	Crosses	Fruit Weight (gm)				Fruit yield per plant (Kg)			
		MP	BP	Kashi Taru	Phule Arjun	MP	BP	Kashi Taru	Phule Arjun
1.	DBR8 x DMU-1	1.54	-2.87	-10.05*	-15.35**	15.77**	10.52**	13.11**	24.97**
2.	DBR8 x JKGEH-6012	16.17**	14.74**	-0.54	-6.40	0.80**	-9.27**	-7.14**	2.59**
3.	DBR8 x CO-11	-1.55	-9.73	-8.47	-13.86**	-8.73**	-12.52**	-10.47**	-1.08**
4.	DBR8 x B.deoria	2.02	-1.25	-10.79*	-16.04**	0.55	-21.89**	-20.06**	-11.68**
5.	DBR8 x DBR-31	-2.79	-13.92**	-5.61	-11.17	9.04**	2.09**	19.77**	32.32**
6.	DBR8 x JB-18	17.02**	15.80**	0.00	-5.89	19.47**	12.62**	15.26**	27.35**
7.	JB-9 x DMU-1	16.73**	8.73	0.70	-5.23	3.05**	1.26**	-5.77**	4.11**
8.	JB-9 x JKGEH-6012	13.31**	8.89	-5.61	-11.17*	75.50**	67.76**	50.68**	66.49**
9.	JB-9 x CO-11	-3.14	-13.40**	-12.19*	-17.36**	-18.38**	-20.13**	-25.05**	-17.19**
10.	JB-9 x B.deoria	7.32	1.13	-8.63	-14.01**	9.15**	-11.00**	-20.06**	-11.68**
11.	JB-9 x DBR-31	-10.83*	-22.92**	-15.48**	-20.46**	-19.51**	-28.94**	-16.63**	-7.89**
12.	JB-9 x JB-18	6.91	2.93	-11.11*	-16.35**	16.92**	16.42**	5.48***	16.54**
13.	NBJ-19 x DMU-1	1.05	-9.26	5.61	-0.61	-6.90**	-11.36**	-17.51**	-8.86**
14.	NBJ-19 x JKGEH-6012	3.58	-9.63	5.18	-1.02	-5.36**	-6.62**	-21.43**	-13.19**
15.	NBJ-19 x CO-11	-2.37	-8.66	6.31	0.05	23.04**	16.68**	9.49**	20.97**
16.	NBJ-19 x B.deoria	-0.49	-11.63	2.86	-3.20	-3.68**	-19.41**	-32.19**	-25.08**

17.	NBJ-19 x DBR-31	-4.03	-6.81	8.47	2.08	8.89**	-6.50**	9.69**	21.19**
18.	NBJ-19 x JB-18	-0.71	-13.53**	0.65	-5.28	1.68**	-1.94**	-11.15**	-1.84**
19.	Bhagya Mati x DMU-1	0.20	0.00	-7.01	-12.49**	15.17**	6.20**	-1.17**	9.19**
20.	Bhagya Mati x JKGEH-6012	1.23	-2.20	-9.06	-14.42**	-9.27**	-11.11**	-27.20**	-19.57**
21.	Bhagya Mati x CO-11	3.66	-7.66	-6.36	-11.88**	3.41**	-5.00**	-10.86**	-1.51**
22.	Bhagya Mati x B.deoria	6.85	5.33	-2.05	-7.82	18.81**	2.24**	-19.67**	-11.24**
23.	Bhagya Mati x DBR-31	-15.36**	-21.79**	-14.24**	-19.29**	14.69**	-4.25**	12.33**	24.11**
24.	Bhagya Mati x JB-18	11.15*	7.19	-0.32	-6.19	14.98**	7.30**	-2.74**	7.46**
	S.E.	4.13	4.77	4.77	4.77	0.30	0.34	0.34	0.34
	CD at 5%	8.50	9.82	9.82	9.82	0.61	0.70	0.70	0.70
	CD at 1%	11.59	13.38	13.38	13.38	0.84	0.95	0.95	0.95

Table 2: Contd…

Sr. No.	**Crosses**	**Number of fruits per plant**				**Number of fruits per cluster**			
		MP	**BP**	**Kashi Taru**	**Phule Arjun**	**MP**	**BP**	**Kashi Taru**	**Phule Arjun**
1.	DBR8 x DMU-1	4.68**	-3.57*	5.29**	1.10	-6.13**	-13.65**	-6.69**	-10.67**
2.	DBR8 x JKGEH-6012	1.23	-14.23**	13.56**	9.05**	3.02**	-9.46**	8.40**	3.78**
3.	DBR8 x CO-11	3.81*	2.00	-6.21**	-9.93**	-6.80**	-10.59**	-18.87**	-22.33**
4.	DBR8 x B.deoria	3.93*	-0.68	0.23	-3.75*	8.09**	6.05**	-3.77**	-7.88**
5.	DBR8 x DBR-31	3.42*	-4.83**	3.68*	-0.44	8.62**	3.42**	3.77**	-0.66**
6.	DBR8 x JB-18	16.86**	13.50**	4.37*	0.22	6.09**	3.78**	-5.83**	-9.85**
7.	JB-9 x DMU-1	4.88**	-0.37	20.92**	16.11**	1.39**	-1.21**	12.52**	7.72**
8.	JB-9 x JKGEH-6012	-5.07**	-9.02**	20.46**	15.67**	-7.49**	-9.74**	8.06**	3.45**
9.	JB-9 x CO-11	-14.66**	-26.13**	-10.34**	-13.91**	8.17**	-6.33**	6.69**	2.13**
10.	JB-9 x B.deoria	-6.92**	-14.77**	3.45*	-0.66	-5.20**	-16.27**	-4.63**	-8.70**
11.	JB-9 x DBR-31	-6.57**	-11.17**	7.82**	3.53*	4.24**	-1.96**	11.66**	6.90**
12.	JB-9 x JB-18	-6.74**	-20.17**	-2.99	-6.84**	2.91**	-9.34**	3.26**	-1.15**
13.	NBJ-19 x DMU-1	3.71*	2.73	12.18**	7.73**	-3.88**	-7.62**	-0.17**	-4.43**
14.	NBJ-19 x JKGEH-6012	-20.15**	-27.77**	-4.37*	-8.17**	-18.22**	-25.07**	-10.29**	-14.12**
15.	NBJ-19 x CO-11	5.39**	-3.64*	3.22	-0.88	-2.34**	-10.33**	-10.63**	-14.45**
16.	NBJ-19 x B.deoria	5.30**	1.28	8.51**	4.19*	2.02**	-4.30**	-4.63**	-8.70**
17.	NBJ-19 x DBR-31	2.54	-3.57*	5.52**	1.32	-8.75**	-9.06**	-8.75**	-12.64**
18.	NBJ-19 x JB-18	7.71**	-2.57	4.37*	0.22	10.76**	3.61**	3.26**	-1.15**
19.	Bhagya Mati x DMU-1	-5.48**	-11.15**	-2.99	-6.84**	-2.10**	-15.08**	-8.23**	-12.15**
20.	Bhagya Mati x JKGEH-6012	-20.92**	-31.77**	-9.66**	-13.25**	-12.15**	-26.93**	-12.52**	-16.26**
21.	Bhagya Mati x CO-11	4.22**	0.23	-3.68*	-7.51**	8.33**	5.76**	-11.84**	-15.60**
22.	Bhagya Mati x B.deoria	2.45	0.00	0.92	-3.09	13.99**	8.84**	-4.97**	-9.03**
23.	Bhagya Mati x DBR-31	2.23	-3.99*	5.06**	0.88	1.53**	-9.06**	-8.75**	-12.64**
24.	Bhagya Mati x JB-18	0.37	-4.54	-8.28**	-11.92**	11.87**	7.12**	-7.03**	-11.00**
	S.E.	1.41	1.63	1.63	1.63	0.15	0.17	0.17	0.17
	CD at 5%	2.90	3.35	3.35	3.35	0.31	0.35	0.35	0.35
	CD at 1%	3.95	4.57	4.57	4.57	0.39	0.47	0.47	0.47

Table 2: Contd…

Sr.	Crosses	Stem girth (cm)				Number of primary branches			
No.		MP	BP	Kashi Taru	Phule Arjun	MP	BP	Kashi Taru	Phule Arjun
1.	DBR8 x DMU-1	-10.34**	-24.77**	77.50**	25.94**	-1.65**	-1.97**	-1.97**	-2.13**
2.	DBR8 x JKGEH-6012	-46.38**	-49.93**	18.13**	-16.19**	2.10**	-0.33	-0.33	-0.49
3.	DBR8 x CO-11	-2.39**	-26.89**	72.50**	22.39**	0.53*	-6.56**	-6.56**	-6.71**
4.	DBR8 x B.deoria	-42.35**	-55.10**	5.94**	-24.83**	3.31**	1.91**	4.75**	4.58**
5.	DBR8 x DBR-31	-19.75**	-31.13**	62.50**	15.30**	-8.21**	-8.36**	-8.36**	-8.51**
6.	DBR8 x JB-18	-15.71**	-32.85**	58.44**	12.42**	-2.52**	-4.75**	-4.75**	-4.91**
7.	JB-9 x DMU-1	-42.72**	-51.68**	12.50**	-20.18**	-0.75**	-2.31**	-2.95**	-3.11**
8.	JB-9 x JKGEH-6012	-16.57**	-21.61**	82.50**	29.49**	-4.62**	-5.11**	-8.69**	-8.84**
9.	JB-9 x CO-11	-32.74**	-49.40**	17.81**	-16.41**	3.24**	-2.30**	-5.98**	-6.14**
10.	JB-9 x B.deoria	-14.41**	-33.02**	55.94**	10.64**	-6.84**	-9.81**	-7.30**	-7.45**
11.	JB-9 x DBR-31	-42.77**	-50.60**	15.00**	-18.40**	2.34**	0.58**	0.25	0.08
12.	JB-9 x JB-18	-9.98**	-27.92**	67.81**	19.07**	0.26	-0.17	-3.93**	-4.09**
13.	NBJ-19 x DMU-1	-50.04**	-59.21**	3.12**	-26.83**	5.37**	4.46**	3.77**	3.60**
14.	NBJ-19 x JKGEH-6012	-19.26**	-26.95**	84.69**	31.04**	0.30	-0.92**	-3.28**	-3.44**
15.	NBJ-19 x CO-11	-40.59**	-56.49**	10.00**	-21.95**	-9.25**	-14.69**	-16.72**	-16.86**
16.	NBJ-19 x B.deoria	-19.84**	-39.06**	54.06**	9.31**	-11.98**	-14.20**	-11.80**	-11.95**
17.	NBJ-19 x DBR-31	-48.44**	-56.98**	8.75**	-22.84**	-2.37**	-3.37**	-3.69**	-3.85**
18.	NBJ-19 x JB-18	-11.70**	-31.40**	73.44**	23.06**	-4.29**	-5.37**	-7.62**	-7.77**
19.	Bhagya Mati x DMU-1	-26.52**	-29.37**	22.50**	-13.08**	2.17**	-0.83**	-1.48**	-1.64**
20.	Bhagya Mati x JKGEH-6012	-9.42**	-16.34**	71.25**	21.51**	-1.65**	-1.97**	-4.43**	-4.58**
21.	Bhagya Mati x CO-11	-17.51**	-30.81**	20.00**	-14.86**	2.10**	-0.33	-12.79**	-12.93**
22.	Bhagya Mati x B.deoria	6.56**	-6.31**	62.50**	15.30**	0.53*	-6.56**	-3.28**	-3.44**

23.	Bhagya Mati x DBR-31	-41.97**	-42.70**	-0.63**	-29.49**	3.31**	1.91**	-0.33	-0.49
24.	Bhagya Mati x JB-18	-6.68**	-15.68**	46.25**	3.77**	-8.21**	-8.36**	-1.89**	-2.05**
	S.E.	0.12	0.14	0.14	0.14	0.24	0.28	0.28	0.28
	CD at 5%	0.24	0.28	0.28	0.28	0.49	0.57	0.57	0.57
	CD at 1%	0.33	0.39	0.39	0.39	0.67	0.78	0.78	0.78

Table 2: Contd…

Sr. No	Characters	Plant height (cm)			
	Crosses	MP	BP	Kashi Taru	Phule Arjun
1	DBR8 x DMU-1	-5.91	-12.77*	-14.01*	-12.50*
2	DBR8 x JKGEH-6012	6.75	0.12	-3.76	-2.06
3	DBR8 x CO-11	2.34	-1.76	-10.08	-8.50
4	DBR8 x B.deoria	9.01	7.51	-9.48	-7.89
5	DBR8 x DBR-31	-0.46	-6.53	-10.38	-8.80
6	DBR8 x JB-18	0.88	-0.14	-14.19*	-12.68*
7	JB-9 x DMU-1	-5.06	-5.14	-6.50	-4.85
8	JB-9 x JKGEH-6012	-2.27	-3.39	-4.95	-3.28
9	JB-9 x CO-11	3.99	0.36	-1.25	0.49
10	JB-9 x B.deoria	6.72	-2.24	-3.82	-2.12
11	JB-9 x DBR-31	-15.04**	-16.12**	-17.47**	-16.02**
12	JB-9 x JB-18	-6.31	-12.24*	-13.66*	-12.14*
13	NBJ-19 x DMU-1	9.89*	-2.84	-4.23	-2.55
14	NBJ-19 x JKGEH-6012	3.26	-7.69	-11.27*	-9.71
15	NBJ-19 x CO-11	4.24	-4.76	-12.82*	-11.29*
16	NBJ-19 x B.deoria	25.99**	21.27**	-0.72	1.03
17	NBJ-19 x DBR-31	5.63	-5.47	-9.36	-7.77
18	NBJ-19 x JB-18	16.86**	9.92	-5.55	-3.88
19	Bhagya Mati x DMU-1	9.81*	2.60	1.13	2.91
20	Bhagya Mati x JKGEH-6012	8.53	2.61	-1.37	0.36
21	Bhagya Mati x CO-11	13.36**	9.71	0.42	2.18
22	Bhagya Mati x B.deoria	5.87	3.55	-11.33*	-9.77
23	Bhagya Mati x DBR-31	-7.88	-12.81*	-16.40**	-14.93*
24	Bhagya Mati x JB-18	9.14	8.95	-6.38	-4.73
	S.E.	4.65	5.36	5.36	5.36
	CD at 5%	9.62	11.08	11.08	11.08
	CD at 1%	13.05	15.04	15.04	15.04

*, ** indicates significant at 5% and 1% respectively.

Table 3: Heterosis range for different growth characters in L x T mating design and Number of crosses with desired performance

Sl. No.	Character	Mid parent	Number of crosses with desirable heterosis	Better parent	Number of crosses with desirable heterosis	Kashi Taru (check-1)	Number of crosses with desirable heterosis	Phule Arjun (check-2)	Number of crosses with desirable heterosis
1	Days to 50% flowering	-12.10 to 11.16	7	-17.7 to -1.59	18	8.80 to 34.55	0	0.15 to 23.85	0
2	Days to first Picking	6-11.64 to 8.28	3	-18.01 to 4.51	13	0.46 to 22.07	0	-1.63 to 14.69	0
3	Fruit length (cm)	-30.26 to 54.30	8	-49.78 to 46.88	6	-33.05 to 40.69	7	0.88 to 111.9	23
4	Fruit girth (cm)	-26.18 to 42.34	14	-29.56 to 33.78	11	1.53 to 64.67	24	-26.57 to 19.10	9
5	Fruit weight (gm)	-15.36 to 17.02	5	-21.79 to 15.80	2	-14.24 to 8.47	0	-19.29 to 2.08	0
6	Fruit yield per plant (Kg)	-19.51 to 75.50	16	-28.94 to 67.76	9	-32.19 to 50.68	7	-25.08 to 66.49	12
7	Number fruits per plant	-20.92 to 16.86	11	-31.77 to 13.50	1	-10.34 to 20.92	13	-13.91 to 16.11	6
8	Number fruits per cluster	-18.22 to 13.99	14	-26.93 to8.84	7	-18.87 to 12.52	8	-22.33 to 7.72	5
9	Number of primary branches	-11.98 to 5.37	10	-14.69 to 4.46	4	-16.72 to 4.75	2	-16.86 to 4.58	2
10	Stem girth (cm)	-50.04 to 6.56	1	-59.21 to -6.31	0	-0..63 to 84.69	24	-29.49 to 31.04	13
11	Plant height (cm)	-15.04 to 25.99	5	-16.12 to 21.27	1	-17.47 to 1.13	0	-16.02 to 2.91	0

Day to first picking

The negative heterosis for this trait indicates earliness which is desirable for this character (3). The maximum and significant negative heterosis (-11.64%) over mid parent and (-18.01%) over better parent was observed in the cross DBR-8 x JKGEH-6012.The significant and negative heterosis was observed in three crosses over mid parent, 13 crosses over the better parent out of 24 crosses, none of the crosses over commercial check shown significant negative heterosis for days to first picking (Table 3).

Fruit length (cm)

The heterosis over mid parent, better parent and the Kashi Taru (check-1) was significant in both positive and negative directions, whereas the heterosis over the (Phule Arjun) check-2 was significant in positive direction only (Table 2). The maximum positive and significant heterosis over mid parent (54.30%) and better parent (46.88%) was noticed in the crosses JB-9 x JB-18 and Bhagya Mati x JB-18 respectively. The cross DBR-8 x DMU- 1exhibited maximum heterosis over the check-1 (40.69%) and check-2 (111.99%). Of 24 crosses, 8 crosses over mid parent, 6 crosses over better parent, seven over commercial check- 1 and 23 cross over the check-2 recorded positive and significant heterosis for fruit length (Table 3).

Fruit girth (cm)

Heterosis over mid parent, over better parent and the

commercial check-2 was significant in both the directions whereas heterosis and commercial check-1 was significantly positive (Table 2). The cross NBJ-19 x DMU-1maximum significant positive heterosis over mid parent (42.34%), over better parent (33.78%), over commercial check-1(64.67%) and over commercial check-2 (19.10%) Out of 24 crosses, 14 crosses over mid parent, 11 crosses over better parent, 24 crosses over commercial check-1 and nine crosses over commercial check-2 showed significant and positive heterosis for fruit girth.

Fruit weight (gm)

The heterosis over mid parent, the better parent and the commercial checks was significant in positive as well as in negative directions (Table 2). The maximum positive and significant heterosis over mid parent (17.02%) and over the better parent (15.80%) was observed in the cross DBR-8 x JB-18. None of the crosses recorded positive significant standard heterosis over Kashi Taru (check-1) and Phule Arjun (check-2). Significant and positive heterosis was observed in 5 crosses over mid parent, two crosses over better parent. None of the crosses registered over both the checks.

Fruit yield per plant (Kg)

The significantly positive and negative heterosis over mid parent, better parent and the commercial checks was observed for the character fruit yield per plant (Table 2). The maximum positive and significant heterosis over mid parent (75.50%), over the better parent (67.76%), over Check-1 (50.68%) and Check-2 (66.49%) observed in the cross JB-9 x JKGEH-6012. Among twenty four crosses studied, sixteen crosses over mid parent, nine crosses over better parent, seven crosses over Kashi Taru (check-1) and twelve crosses over Phule Arjun (check-2) showed positive and significant heterosis for number of fruit yield per plant (Table 3).

Number of fruits per plant

The estimated heterosis observed was significantly positive as well as negative over mid parent, better parent and the commercial checks (Table 2). The heterosis over mid parent (16.86%) and the better parent (13.50%) was significantly positive from the cross DBR-8 x JB-18. Among F1 the cross JB-9 x JKGEH-6012 exhibited maximum standard heterosis over CC-1(20.92%) and CC-2(16.11%) respectively. Out 24 crosses studied, significantly positive heterosis was observed in 11 crosses over mid parent, one cross over better parent, 13 crosses over Kashi Taru (check-1) and six crosses over Phule Arjun (check-2) for the character fruits per plant.

Number of fruits per cluster

The heterosis over mid parent, better parent and the commercial checks was significant in both positive and negative directions (Table 2). The maximum and significant positive heterosis (13.99%) over mid parent and over the better parent (8.84%) was observed in the cross Bhagya Mati x B.deoria. The cross JB-9 xDMU-1 recorded maximum significant heterosis over Kashi Taru (12.52%) and Phule Arjun (7.72%) followed by the cross JB-9 x DBR-31 for heterosis over commercial check-1(11.66%) and commercial check-2 (6.90%). The significant and positive heterosis was observed in 14 crosses over mid parent, seven crosses over the better parent, 8 crosses over the check-1 and 5 crosses over the check-2 for number of fruits per cluster.

Stem girth

Magnitude of heterosis over mid parent, better parent and the commercial check-2 was highly significant in both the directions and commercial check-1 in significant positive direction only (Table 2). The maximum positive heterosis over mid parent (6.56%) was observed in the cross Bhagya Mati x B.deoria, none of the cross exhibited positive heterosis over better parent. The maximum significant and positive standard heterosis over the two checks was exhibited by the cross NBJ-19 x JKGEH-6012 over Check-1 (84.69%) and Check- 2 (31.04%) followed by JB-19 x JKGEH-6012 over Check-1 (82.50%) and Check-2 (29.49%). Out of 24 crosses studied, one crosses over mid parent, none of the crosses over the better parent, 24 crosses over the commercial check-1 and 13 crosses over the commercial check-2 exhibited positive and significant heterosis for stem girth (Table 3).

Number of primary branches per plant

The average heterosis, heterobeltosis and standard heterosis was significant in both directions (Table 2). F1 progeny from a parental combination of NBJ-19 x DMU-1exhibited highest significant heterobeltosis of (4.46%) and highest average heterosis (5.37%) followed by cross JB-9 x CO-11(3.24%) showed significant and positive heterosis over mid parent. The cross DBR-8 x B.deoria exhibited positive and significant standard heterosis over Kashi Taru (4.75%) and Phule Arjun (4.58%). The positive and significant heterosis was observed in 10 crosses for average heterosis, four crosses for heterobeltosis, and two crosses for standard heterosis over check-1 and check-2, respectively for number of primary branches per plant.

Plant height

Magnitude of heterosis over the mid parent, the better parent, and the commercial checks was significant in both the directions. Maximum significant positive heterosis over mid parent (25.99%), better parent (21.27%), was observed in the cross NBJ-19 x B.deoria, followed by the cross NBJ-19 x JB-18 over the mid parent (16.86%), and the none of the cross over the commercial check 1 and check 2.Out of 24 crosses studied, five crosses over mid parent, one crosses over the better parent, none over the commercial check-1 and over the commercial check-2 exhibited positive and significant heterosis for plant height (Table 3).

Summary and Conclusion

Among the cross combination DBR-8 x JB-18 exhibited significant negative heterosis over better parent for days to fifty percent flowering, and days to first picking. The cross combinations JB-9 x JB-18 and Bhagya Mati x JB-18 exhibited significant and positive heterosis for fruit length. For the character of fruit girth NBJ-19 x DMU-1 exhibited desirable heterosis over mid parent, better parent, Kashi Taru (check - 1) and Phule Arjun (check - 2).

The cross JB-9 x JKGEH-6012 exhibited significant and positive heterosis over mid parent, better parent and over commercial checks, followed by NBJ-19 x CO-11, DBR-8 x JB-18 and JB-9 x JB-18 respectively for the character of fruit yield per plant.

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