



ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(9): 1504-1510
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www.thepharmajournal.com
Received: 02-07-2021
Accepted: 19-08-2021

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Estimating the extent of heterosis for yield and yield contributing characters in Bitter gourd

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Abstract

Out 40 crosses many of the crosses had shown significant heterosis over their respective better parent and also over standard check for the traits studied. As yield is the important trait for crop production. The ideal hybrid or parent producing high fruit yield per hectare will be the one having traits like higher fruit weight and fruit yield per vine. The hybrids like IC-085618 X Phule green gold and IC-085618 X CO-1 performed significant heterosis.

Keywords: Bitter gourd, heterosis, hybrid, yield, fruit

1. Introduction

Bitter gourd is recognized as a healthy vegetable from the past twenty years. There are however, problems related to the production of bitter gourd. Many farmers are experiencing many difficulties cultivation technology to supply stock of stable bitter gourd yearly. The yield potential of bitter gourd in India is very low due to poor yielding varieties and high incidence of pests and diseases. One of the methods to improve yield and quality is heterosis breeding. The importance of heterosis breeding has been recognized widely in many vegetable crops. The term heterosis was first coined by Shull (1910) ^[9] using two Greek words, 'hetero' means different and 'oisis' means condition. It refer to the phenomenon in which F₁ hybrid obtained by crossing the two genetically dissimilar homozygous individuals, shows increased vigour over the parental values. After the discovery of phenomenon of heterosis by Shull (1914) ^[10], heterosis breeding has been one of the important tools of crop improvement for the plant breeders. However, selection of suitable parents for hybridization plays an important role in heterosis breeding programme.

2. Details Experimental

A field experiment for Estimating the extent of heterosis for yield and yield contributing characters in Bitter gourd was conducted in Horticulture Research Scheme (Vegetable), V.N.M.K.V, Parbhani with an objective of finding out the most desirable F₁ s in bitter gourd. The results obtained along with relevant discussion are presented in this paper.

3. Results and Discussion

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Table 1: Magnitude of heterosis in the bitter gourd hybrids over mid parent, better parent and standard check for Fruit length (cm)

Genotypes	Mean	Mid Parent	Better Parent	Standard Checks	
				Check-1	Check-2
IC-085620 X Phule Hirkani	15.41	26.56 **	22.49 **	57.49 **	37.99 **
IC-085620 X CO-1	16.14	22.08 **	16.45 **	64.95 **	44.52 **
IC-085620 X Konkan Tara	15.21	25.73 **	20.90 **	55.45 **	36.20 **
IC-085620 X Phule green gold	16.39	14.15 **	1.59	67.47 **	46.73 **
IC-085620 X Arka Harit	11.97	4.33	-4.87	22.31 **	7.16
IC-505639 X Phule Hirkani	12.74	5.24	2.41	30.21 **	14.09
IC-505639 X CO-1	15.89	20.78 **	14.59 **	62.33 **	42.23 **
IC-505639 X Konkan Tara	14.38	19.56 **	15.59 **	46.97 **	28.77 **
IC-505639 X Phule green gold	14.21	-0.55	-11.92 **	45.20 **	27.22 **
IC-505639 X Arka Harit	11.41	0.03	-8.33	16.55 *	2.12
IC-85647 X Phule Hirkani	12.66	8.22	7.50	29.33 **	13.31
IC-85647 X CO-1	12.90	1.26	-6.95	31.81 **	15.49 *
IC-85647 X Konkan Tara	12.76	9.87	9.87	30.42 **	14.26
IC-85647 X Phule green gold	11.82	-14.83 **	-26.76 **	20.74 *	5.79
IC-85647 X Arka Harit	13.51	22.93 **	16.30 *	38.04 **	20.95 **
IC-085617 X Phule Hirkani	14.23	21.46 **	20.89 **	45.44 **	27.42 **
IC-085617 X CO-1	16.27	27.45 **	17.34 **	66.21 **	45.63 **
IC-085617 X Konkan Tara	13.39	15.03 **	14.80 *	36.82 **	19.87 **
IC-085617 X Phule green gold	14.74	6.06	-8.64	50.61 **	31.96 **
IC-085617 X Arka Harit	12.61	14.53 *	8.15	28.88 **	12.92
IC-085616 X Phule Hirkani	13.79	8.68	1.37	40.91 **	23.46 **
IC-085616 X CO-1	13.20	-3.91	-4.81	34.84 **	18.14 *
IC-085616 X Konkan Tara	12.49	-0.93	-8.16	27.66 **	11.85
IC-085616 X Phule green gold	15.08	1.42	-6.53	54.09 **	35.00 **
IC-085616 X Arka Harit	13.73	14.58 **	0.93	40.29 **	22.92 **
IC-085618 X Phule Hirkani	12.33	-0.71	-5.61	25.99 **	10.38
IC-085618 X CO-1	17.03	26.47 **	22.82 **	73.98 **	52.43 **
IC-085618 X Konkan Tara	12.85	4.16	-1.61	31.34 **	15.07 *
IC-085618 X Phule green gold	17.86	22.37 **	10.72 *	82.53 **	59.92 **
IC-085618 X Arka Harit	13.59	16.05 **	4.06	38.90 **	21.70 **
IC-505629 X Phule Hirkani	11.59	-4.87	-7.94	18.39 *	3.73
IC-505629 X CO-1	15.27	15.46 **	10.15	56.03 **	36.71 **
IC-505629 X Konkan Tara	14.62	20.81 **	16.15 **	49.39 **	30.89 **
IC-505629 X Phule green gold	15.43	7.45	-4.36	57.66 **	38.14 **
IC-505629 X Arka Harit	12.50	8.96	-0.66	27.76 **	11.94
IC-470535 X Phule Hirkani	12.51	6.94	6.29	27.86 **	12.03
IC-470535 X CO-1	14.23	11.64 *	2.64	45.40 **	27.39 **
IC-470535 X Konkan Tara	12.54	7.92	7.85	28.17 **	12.29
IC-470535 X Phule green gold	14.48	4.33	-10.23 *	47.99 **	29.66 **
IC-470535 X Arka Harit	12.64	14.91 *	8.66	29.12 **	13.13
S.E.		0.30	0.35	0.35	
CD.95.%		0.61	0.71	0.71	
CD.99.%		0.81	0.94	0.94	

3.1 Fruit length (cm)

On consideration, heterotic effects of heterosis over mid parent ranged from -14.83 per cent to 27.45 per cent among 40 hybrids, 19 hybrids were found to be positively significant for heterotic effect. Hybrid IC-085617 X CO-1 (27.45%) showed maximum positive significant heterosis. Heterosis over better parent ranged from -26.76 per cent to 22.82 per

cent. Among 40 hybrids, 12 hybrids were found to be positively significant. Hybrid IC-085618 X CO-1 (22.82%) had shown maximum positively significant heterosis. Check parent-1 heterosis was ranged from 16.55 per cent to 82.53 per cent. Positive Heterotic effect for fruit length was also reported by Bhatt *et al.* (2017) [2] and Resmi and Sreelathakumary (2017) [8].

Table 2: Magnitude of heterosis in the bitter gourd hybrids over mid parent, better parent and standard check for Fruit weight (gm)

Genotypes	Mean	Mid Parent	Better Parent	Standard Checks	
				Check-1	Check-2
IC-085620 X Phule Hirkani	81.13	67.13 **	63.97 **	33.40 **	55.65 **
IC-085620 X CO-1	70.23	30.37 **	20.54 *	15.48	34.75 **
IC-085620 X Konkan Tara	71.67	48.53 **	44.85 **	17.85 *	37.50 **
IC-085620 X Phule green gold	79.20	58.94 **	57.82 **	30.23 **	51.96 **
IC-085620 X Arka Harit	51.30	4.47	3.69	-15.64	-1.57
IC-505639 X Phule Hirkani	78.16	63.34 **	62.51 **	28.52 **	49.96 **
IC-505639 X CO-1	71.62	34.67 **	22.92 *	17.76 *	37.41 **
IC-505639 X Konkan Tara	74.36	56.34 **	54.60 **	22.27 *	42.66 **
IC-505639 X Phule green gold	77.42	57.56 **	54.28 **	27.31 **	48.55 **

IC-505639 X Arka Harit	60.54	25.04 *	24.22 *	-0.45	16.15
IC-85647 X Phule Hirkani	67.18	32.01 **	24.00 *	10.47	28.89 **
IC-85647 X CO-1	66.37	18.05 *	13.91	9.13	27.33 **
IC-85647 X Konkan Tara	62.61	23.72 *	15.56	2.95	20.12
IC-85647 X Phule green gold	68.61	31.49 **	26.65 **	12.83	31.64 **
IC-85647 X Arka Harit	50.33	-2.18	-7.09	-17.23	-3.43
IC-085617 X Phule Hirkani	82.02	72.03 **	71.76 **	34.88 **	57.37 **
IC-085617 X CO-1	74.95	41.39 **	28.63 **	23.24 **	43.80 **
IC-085617 X Konkan Tara	76.53	61.49 **	60.26 **	25.84 **	46.83 **
IC-085617 X Phule green gold	72.95	48.98 **	45.37 **	19.96 *	39.97 **
IC-085617 X Arka Harit	62.01	28.54 **	27.24 *	1.97	18.98
IC-085616 X Phule Hirkani	75.08	48.27 **	39.89 **	23.47 **	44.06 **
IC-085616 X CO-1	72.45	29.44 **	24.34 *	19.13 *	39.00 **
IC-085616 X Konkan Tara	74.32	47.60 **	38.46 **	22.20 *	42.59 **
IC-085616 X Phule green gold	68.54	32.00 **	27.70 **	12.71	31.51 **
IC-085616 X Arka Harit	57.83	12.95	7.75	-4.90	10.96
IC-085618 X Phule Hirkani	81.44	57.53 **	45.96 **	33.92 **	56.26 **
IC-085618 X CO-1	84.86	48.79 **	45.64 **	39.54 **	62.81 **
IC-085618 X Konkan Tara	74.28	44.48 **	33.13 **	22.14 *	42.52 **
IC-085618 X Phule green gold	85.37	61.11 **	53.00 **	40.38 **	63.80 **
IC-085618 X Arka Harit	66.73	27.68 **	19.59 *	9.73	28.03 **
IC-505629 X Phule Hirkani	71.14	50.42 **	49.43 **	16.98	36.49 **
IC-505629 X CO-1	65.95	25.32 **	13.19	8.44	26.53 *
IC-505629 X Konkan Tara	63.14	34.32 **	34.26 **	3.82	21.14 *
IC-505629 X Phule green gold	75.55	55.51 **	50.55 **	24.23 **	44.95 **
IC-505629 X Arka Harit	53.35	11.48	9.48	-12.27	2.37
IC-470535 X Phule Hirkani	77.36	62.62 **	62.49 **	27.20 **	48.42 **
IC-470535 X CO-1	71.42	35.01 **	22.58 *	17.44 *	37.02 **
IC-470535 X Konkan Tara	65.45	38.44 **	37.71 **	7.63	25.58 *
IC-470535 X Phule green gold	76.19	55.95 **	51.83 **	25.29 **	46.19 **
IC-470535 X Arka Harit	53.37	10.88	9.51	-12.24	2.40
S.E.		3.60	4.15	4.15	
CD.95.%		7.16	8.27	8.27	
CD.99.%		9.50	10.97	10.97	

3.2 Fruit weight (gm)

Considering the heterotic effects the heterosis over mid parent ranged from -2.18 per cent to 72.03 per cent among 40 hybrids, 35 hybrids were found to be positively significant for heterotic effect. Hybrid IC-085617 X Phule Hirkani (72.03%) showed maximum positive significant heterosis when compare with check-1 and 2. Heterosis over better parent

ranged from -7.09 per cent to 71.76 per cent. Among 40 hybrids, 32 hybrids were found to be positively significant. Hybrid IC-085617 X Phule Hirkani (71.76%) had shown maximum positively significant heterosis as compare to check-1 and 2 respectively. Check parent-2 heterosis was ranged from -3.43 per cent to 63.80 per cent.

Table 3: Magnitude of heterosis in the bitter gourd hybrids over mid parent, better parent and standard check for Number of female flowers per vine

Genotypes	Mean	Mid Parent	Better Parent	Standard Checks	
				Check-1	Check-2
IC-085620 X Phule Hirkani	60.69	37.09 **	29.29 **	28.24 **	37.63 **
IC-085620 X CO-1	58.44	29.52 **	24.51 **	23.49 **	32.54 **
IC-085620 X Konkan Tara	60.85	28.43 **	27.25 **	28.58 **	38.00 **
IC-085620 X Phule green gold	60.87	34.81 **	29.69 **	28.63 **	38.06 **
IC-085620 X Arka Harit	66.41	39.04 **	36.69 **	40.33 **	50.60 **
IC-505639 X Phule Hirkani	56.13	29.94 **	25.30 **	18.61 *	27.30 **
IC-505639 X CO-1	53.22	20.82 **	18.81 *	12.47	20.71 *
IC-505639 X Konkan Tara	53.86	16.31 *	12.63	13.81	22.15 **
IC-505639 X Phule green gold	56.65	28.51 **	26.47 **	19.72 *	28.49 **
IC-505639 X Arka Harit	60.64	29.87 **	24.81 **	28.13 **	37.52 **
IC-85647 X Phule Hirkani	58.31	38.14 **	36.16 **	23.22 **	32.25 **
IC-85647 X CO-1	53.30	23.75 **	23.07 **	12.62	20.87 *
IC-85647 X Konkan Tara	50.12	10.58	4.80	5.90	13.66
IC-85647 X Phule green gold	60.87	41.23 **	40.34 **	28.62 **	38.04 **
IC-85647 X Arka Harit	63.85	39.69 **	31.42 **	34.92 **	44.80 **
IC-085617 X Phule Hirkani	60.65	39.52 **	33.77 **	28.15 **	37.54 **
IC-085617 X CO-1	57.98	30.81 **	27.88 **	22.51 **	31.49 **
IC-085617 X Konkan Tara	58.77	26.17 **	22.90 **	24.19 **	33.29 **
IC-085617 X Phule green gold	59.78	34.77 **	31.85 **	26.32 **	35.57 **
IC-085617 X Arka Harit	59.13	25.92 **	21.71 **	24.95 **	34.10 **
IC-085616 X Phule Hirkani	60.35	41.53 **	38.16 **	27.53 **	36.87 **

IC-085616 X CO-1	57.84	32.98 **	32.41 **	22.22 **	31.17 **
IC-085616 X Konkan Tara	56.57	23.64 **	18.29 *	19.53 *	28.29 **
IC-085616 X Phule green gold	56.95	30.84 **	30.38 **	20.34 **	29.16 **
IC-085616 X Arka Harit	60.21	30.52 **	23.94 **	27.24 **	36.56 **
IC-085618 X Phule Hirkani	63.93	42.37 **	32.62 **	35.08 **	44.98 **
IC-085618 X CO-1	67.82	48.23 **	40.70 **	43.32 **	53.82 **
IC-085618 X Konkan Tara	59.34	23.59 **	23.10 **	25.39 **	34.58 **
IC-085618 X Phule green gold	69.20	51.13 **	43.55 **	46.22 **	56.93 **
IC-085618 X Arka Harit	58.70	21.29 **	20.82 **	24.03 **	33.12 **
IC-505629 X Phule Hirkani	57.17	26.15 **	16.58 *	20.81 **	29.66 **
IC-505629 X CO-1	68.54	48.44 **	39.76 **	44.84 **	55.45 **
IC-505629 X Konkan Tara	55.83	15.28 *	13.84	17.98 *	26.62 **
IC-505629 X Phule green gold	60.36	30.64 **	23.08 **	27.56 **	36.90 **
IC-505629 X Arka Harit	57.01	16.79 **	16.24 *	20.47 **	29.29 **
IC-470535 X Phule Hirkani	61.86	49.33 **	48.71 **	30.72 **	40.30 **
IC-470535 X CO-1	59.16	39.92 **	36.61 **	25.01 **	34.17 **
IC-470535 X Konkan Tara	53.56	20.26 **	12.01	13.19	21.48 *
IC-470535 X Phule green gold	59.07	39.59 **	36.19 **	24.82 **	33.96 **
IC-470535 X Arka Harit	62.31	38.72 **	28.26 **	31.68 **	41.32 **
S.E.		1.95	2.25	2.25	
CD.95.%		3.88	4.48	4.48	
CD.99.%		5.15	5.94	5.94	

3.3 Number of female flowers per vine

Considering the heterotic effects, heterosis over mid parent ranged from -10.58 per cent to 51.13 per cent among 40 hybrids, 39 hybrids were found to be positively significant for heterotic effect. Hybrid IC-085618 X Phule green gold (51.13%) showed maximum positive significant heterosis when compare with check-1. Heterosis over better parent ranged from 4.80 per cent to 48.71 per cent. Among 40

hybrids, 36 hybrids were found to be positively significant. Hybrid IC-4705335 X Phule Hirkani (48.71%) had shown maximum positively significant heterosis as compare to check-1 and 2 respectively. Check parent-2 heterosis was ranged from 13.66 per cent to 56.93 per cent. The above results are similar with the findings of Mohanty and Prusti (2002) ^[4] in pumpkin.

Table 4: Magnitude of heterosis in the bitter gourd hybrids over mid parent, better parent and standard check for Number of fruits per vine

Genotypes	Mean	Mid Parent	Better Parent	Standard Checks	
				Check-1	Check-2
IC-085620 X Phule Hirkani	38.63	64.97 **	62.60 **	55.80 **	59.09 **
IC-085620 X CO-1	34.41	36.64 **	26.09 **	38.78 **	41.72 **
IC-085620 X Konkan Tara	35.78	55.13 **	55.05 **	44.29 **	47.34 **
IC-085620 X Phule green gold	35.30	45.07 **	37.97 **	42.34 **	45.35 **
IC-085620 X Arka Harit	41.40	82.93 **	79.39 **	66.94 **	70.47 **
IC-505639 X Phule Hirkani	31.33	36.64 **	31.85 **	26.33 **	29.00 **
IC-505639 X CO-1	30.76	24.58 **	12.71 *	24.06 **	26.68 **
IC-505639 X Konkan Tara	29.61	31.19 **	28.46 **	19.42 **	21.95 **
IC-505639 X Phule green gold	33.86	42.04 **	32.35 **	36.55 **	39.44 **
IC-505639 X Arka Harit	36.23	63.64 **	63.31 **	46.09 **	49.18 **
IC-85647 X Phule Hirkani	35.09	56.30 **	47.69 **	41.51 **	44.50 **
IC-85647 X CO-1	30.45	25.75 **	11.58 *	22.81 **	25.41 **
IC-85647 X Konkan Tara	30.00	35.78 **	30.15 **	21.00 **	23.56 **
IC-85647 X Phule green gold	37.23	59.36 **	45.52 **	50.14 **	53.32 **
IC-85647 X Arka Harit	38.55	77.98 **	73.79 **	55.48 **	58.76 **
IC-085617 X Phule Hirkani	35.02	53.69 **	47.40 **	41.24 **	44.23 **
IC-085617 X CO-1	35.35	43.98 **	29.53 **	42.57 **	45.59 **
IC-085617 X Konkan Tara	34.11	52.02 **	47.95 **	37.55 **	40.45 **
IC-085617 X Phule green gold	35.67	50.49 **	39.41 **	43.84 **	46.88 **
IC-085617 X Arka Harit	33.98	54.44 **	53.16 **	37.02 **	39.92 **
IC-085616 X Phule Hirkani	37.95	59.65 **	59.60 **	53.03 **	56.27 **
IC-085616 X CO-1	34.96	36.92 **	28.10 **	41.00 **	43.98 **
IC-085616 X Konkan Tara	33.01	40.99 **	38.85 **	33.14 **	35.95 **
IC-085616 X Phule green gold	32.89	33.27 **	28.56 **	32.64 **	35.44 **
IC-085616 X Arka Harit	34.22	48.90 **	43.91 **	37.99 **	40.91 **
IC-085618 X Phule Hirkani	38.67	52.03 **	42.64 **	55.95 **	59.25 **
IC-085618 X CO-1	43.24	58.96 **	58.43 **	74.38 **	78.06 **
IC-085618 X Konkan Tara	35.40	41.13 **	30.57 **	42.75 **	45.77 **
IC-085618 X Phule green gold	44.16	67.60 **	62.88 **	78.08 **	81.84 **
IC-085618 X Arka Harit	34.32	39.26 **	26.61 **	38.42 **	41.35 **
IC-505629 X Phule Hirkani	34.35	48.37 **	44.56 **	38.51 **	41.44 **
IC-505629 X CO-1	41.50	66.56 **	52.05 **	67.36 **	70.90 **

IC-505629 X Konkan Tara	31.35	37.51 **	35.97 **	26.41 **	29.09 **
IC-505629 X Phule green gold	36.08	49.96 **	41.04 **	45.52 **	48.59 **
IC-505629 X Arka Harit	34.08	52.39 **	51.18 **	37.42 **	40.33 **
IC-470535 X Phule Hirkani	36.34	57.82 **	52.95 **	46.55 **	49.65 **
IC-470535 X CO-1	36.06	45.44 **	32.12 **	45.42 **	48.50 **
IC-470535 X Konkan Tara	30.57	34.83 **	32.61 **	23.28 **	25.89 **
IC-470535 X Phule green gold	33.44	39.71 **	30.72 **	34.87 **	37.72 **
IC-470535 X Arka Harit	36.57	64.43 **	64.03 **	47.47 **	50.58 **
S.E.		1.25	1.44	1.44	
CD. 95%		2.49	2.88	2.88	
CD. 99%		3.31	3.82	3.82	

3.4 Number of fruits per vine

Considering the heterotic effects, the heterosis over mid parent ranged from 24.58 per cent to 82.93 per cent. All 40 hybrids were found to be positively significant for heterotic effect. Hybrid IC-085620 X Arka Harit (82.93%) showed maximum positive significant heterosis when compare with check-1 and 2. Heterosis over better parent ranged from 11.58 per cent to 79.39 per cent. All 40 hybrids were found to be

positively significant. Hybrid IC-085620 X Arka Harit (79.39%) had shown maximum positively significant heterosis as compare to check-1 and 2 respectively. Check parent-2 heterosis was ranged from 21.95 per cent to 81.84 per cent. Standard heterosis for number of fruits per vine was also reported by Thangamani *et al.* (2011) ^[11], Narasannar *et al.* (2014) ^[6] and Bhatt *et al.* (2017) ^[2]. Results are similar with findings of Ahmad Alhariri *et al.* (2018) ^[11].

Table 5: Magnitude of heterosis in the bitter gourd hybrids over mid parent, better parent and standard check for Fruit yield per vine (kg)

Genotypes	Mean	Mid Parent	Better Parent	Standard Checks	
				Check-1	Check-2
IC-085620 X Phule Hirkani	3.52	65.35 **	64.06 **	64.06 **	52.17 **
IC-085620 X CO-1	3.36	56.59 **	53.03 **	57.81 **	46.38 **
IC-085620 X Konkan Tara	3.04	50.41 **	44.44 **	42.19 **	31.88 **
IC-085620 X Phule green gold	3.15	41.35 **	34.29 **	46.87 **	36.23 **
IC-085620 X Arka Harit	2.83	40.50 **	34.92 **	32.81 **	23.19 **
IC-505639 X Phule Hirkani	2.93	35.38 **	33.33 **	37.50 **	27.54 **
IC-505639 X CO-1	3.05	37.88 **	37.88 **	42.19 **	31.88 **
IC-505639 X Konkan Tara	2.96	43.55 **	34.85 **	39.06 **	28.99 **
IC-505639 X Phule green gold	3.42	51.47 **	47.14 **	60.94 **	49.28 **
IC-505639 X Arka Harit	2.84	35.48 **	27.27 **	31.25 **	21.74 **
IC-85647 X Phule Hirkani	2.99	41.73 **	40.62 **	40.62 **	30.43 **
IC-85647 X CO-1	2.86	33.33 **	30.30 **	34.37 **	24.64 **
IC-85647 X Konkan Tara	2.62	30.58 **	25.40 **	23.44 **	14.49
IC-85647 X Phule green gold	3.10	39.85 **	32.86 **	45.31 **	34.78 **
IC-85647 X Arka Harit	2.71	33.88 **	28.57 **	26.56 **	17.39 *
IC-085617 X Phule Hirkani	3.48	68.00 **	64.06 **	64.06 **	52.17 **
IC-085617 X CO-1	3.35	57.48 **	51.52 **	56.25 **	44.93 **
IC-085617 X Konkan Tara	3.04	52.94 **	49.18 **	42.19 **	31.88 **
IC-085617 X Phule green gold	3.53	61.83 **	51.43 **	65.62 **	53.62 **
IC-085617 X Arka Harit	2.90	46.22 **	42.62 **	35.94 **	26.09 **
IC-085616 X Phule Hirkani	3.47	62.79 **	61.54 **	64.06 **	52.17 **
IC-085616 X CO-1	3.22	48.09 **	46.97 **	51.56 **	40.58 **
IC-085616 X Konkan Tara	3.23	57.72 **	49.23 **	51.56 **	40.58 **
IC-085616 X Phule green gold	2.99	33.33 **	28.57 **	40.62 **	30.43 **
IC-085616 X Arka Harit	2.70	31.71 **	24.62 **	26.56 **	17.39 *
IC-085618 X Phule Hirkani	3.41	46.76 **	36.00 **	59.37 **	47.83 **
IC-085618 X CO-1	3.86	63.12 **	53.33 **	79.69 **	66.67 **
IC-085618 X Konkan Tara	3.47	56.39 **	38.67 **	62.50 **	50.72 **
IC-085618 X Phule green gold	3.93	61.38 **	56.00 **	82.81 **	69.57 **
IC-085618 X Arka Harit	3.14	41.35 **	25.33 **	46.87 **	36.23 **
IC-505629 X Phule Hirkani	3.01	42.86 **	40.62 **	40.62 **	30.43 **
IC-505629 X CO-1	3.21	50.00 **	45.45 **	50.00 **	39.13 **
IC-505629 X Konkan Tara	2.62	31.67 **	27.42 **	23.44 **	14.49
IC-505629 X Phule green gold	3.32	51.52 **	42.86 **	56.25 **	44.93 **
IC-505629 X Arka Harit	2.61	30.00 **	25.81 **	21.87 *	13.04
IC-470535 X Phule Hirkani	3.07	55.00 **	45.31 **	45.31 **	34.78 **
IC-470535 X CO-1	3.20	57.38 **	45.45 **	50.00 **	39.13 **
IC-470535 X Konkan Tara	2.83	49.12 **	46.55 **	32.81 **	23.19 **
IC-470535 X Phule green gold	3.26	53.97 **	38.57 **	51.56 **	40.58 **
IC-470535 X Arka Harit	2.66	38.60 **	36.21 **	23.44 **	14.49
S.E.		0.09	0.11	0.11	
CD.95.%		0.19	0.22	0.22	
CD.99.%		0.26	0.30	0.30	

3.5 Fruit yield per vine (kg)

Considering the heterotic effects, the heterosis over mid parent ranged from 30.00 per cent to 68.00 per cent all 40 hybrids were found to be positively significant for heterotic effect. Hybrid IC-085617 X Phule Hirkani (68.00%) showed maximum positive significant heterosis when compare with check-1 and 2. Heterosis over better parent ranged from 24.62 per cent to 64.06 per cent. All 40 hybrids were found to be positively significant. Hybrids IC-085617 X Phule Hirkani (64.06%) and IC-085620 X Phule Hirkani (64.06%) had

shown maximum positively significant heterosis as compare to check-2 respectively. Check parent-1 heterosis was ranged from 21.87 per cent to 82.81 per cent.

Total yield per vine is dependent mainly on the number of fruits per vine and average fruit weight. Number of fruits per vine was influenced by the size of the fruit that is fruit length and fruit girth. Results are similar with findings of Ahmad Alhariri *et al.* (2018) ^[1], Doloi *et al.* (2018) ^[3] and Narasannavar *et al.* (2018) ^[7].

Table 6: Magnitude of heterosis in the bitter gourd hybrids over mid parent, better parent and standard check for Fruit yield per hectare (tons)

Genotypes	Mean	Mid Parent	Better Parent	Standard Checks	
				Check-1	Check-2
IC-085620 X Phule Hirkani	21.46	74.71 **	62.17 **	75.76 **	53.91 **
IC-085620 X CO-1	20.46	70.31 **	61.17 **	67.59 **	46.76 **
IC-085620 X Konkan Tara	18.32	63.83 **	61.62 **	50.01 **	31.37 **
IC-085620 X Phule green gold	19.63	57.15 **	43.80 **	60.80 **	40.81 **
IC-085620 X Arka Harit	17.07	48.34 **	46.08 **	39.86 **	22.47 **
IC-505639 X Phule Hirkani	17.69	34.25 **	33.68 **	44.88 **	26.87 **
IC-505639 X CO-1	18.82	45.77 **	43.42 **	54.11 **	34.95 **
IC-505639 X Konkan Tara	18.12	50.11 **	38.14 **	48.43 **	29.98 **
IC-505639 X Phule green gold	21.02	57.00 **	53.93 **	72.13 **	50.73 **
IC-505639 X Arka Harit	17.65	42.28 **	34.53 **	44.55 **	26.58 **
IC-85647 X Phule Hirkani	18.54	46.13 **	40.13 **	51.87 **	32.99 **
IC-85647 X CO-1	17.63	41.96 **	38.88 **	44.42 **	26.46 **
IC-85647 X Konkan Tara	16.24	40.16 **	33.70 **	33.01 **	16.47 **
IC-85647 X Phule green gold	18.81	45.84 **	37.79 **	54.08 **	34.93 **
IC-85647 X Arka Harit	16.95	42.25 **	39.57 **	38.85 **	21.59 **
IC-085617 X Phule Hirkani	21.56	64.58 **	62.95 **	76.60 **	54.65 **
IC-085617 X CO-1	20.49	59.66 **	57.98 **	67.81 **	46.95 **
IC-085617 X Konkan Tara	19.77	64.77 **	52.43 **	61.92 **	41.79 **
IC-085617 X Phule green gold	20.90	57.03 **	53.10 **	71.20 **	49.92 **
IC-085617 X Arka Harit	18.98	53.96 **	46.36 **	55.47 **	36.15 **
IC-085616 X Phule Hirkani	21.26	68.38 **	60.68 **	74.15 **	52.50 **
IC-085616 X CO-1	19.56	58.28 **	54.08 **	60.22 **	40.31 **
IC-085616 X Konkan Tara	20.02	73.68 **	66.48 **	63.94 **	43.56 **
IC-085616 X Phule green gold	18.26	42.28 **	33.79 **	49.60 **	31.01 **
IC-085616 X Arka Harit	17.01	43.52 **	41.53 **	39.37 **	22.04 **
IC-085618 X Phule Hirkani	20.94	52.21 **	46.58 **	71.55 **	50.23 **
IC-085618 X CO-1	22.90	69.74 **	60.28 **	87.58 **	64.26 **
IC-085618 X Konkan Tara	21.34	68.61 **	49.36 **	74.80 **	53.07 **
IC-085618 X Phule green gold	24.66	76.50 **	72.57 **	101.97 **	76.86 **
IC-085618 X Arka Harit	19.32	48.78 **	35.25 **	58.29 **	38.61 **
IC-505629 X Phule Hirkani	18.43	54.57 **	39.27 **	50.94 **	32.18 **
IC-505629 X CO-1	19.89	70.68 **	56.68 **	62.93 **	42.67 **
IC-505629 X Konkan Tara	15.86	46.55 **	43.80 **	29.87 **	13.72
IC-505629 X Phule green gold	20.85	71.81 **	52.69 **	70.73 **	49.51 **
IC-505629 X Arka Harit	15.81	41.80 **	35.27 **	29.51 **	13.41
IC-470535 X Phule Hirkani	19.15	54.24 **	44.76 **	56.89 **	37.39 **
IC-470535 X CO-1	20.52	68.89 **	61.64 **	68.09 **	47.19 **
IC-470535 X Konkan Tara	17.37	53.49 **	49.66 **	42.26 **	24.58 **
IC-470535 X Phule green gold	19.93	57.80 **	45.97 **	63.23 **	42.94 **
IC-470535 X Arka Harit	16.98	45.74 **	45.22 **	39.04 **	21.75 **
S.E.		1.14	1.32	1.32	
CD. 95.%		1.28	2.64	2.64	
CD. 99.%		3.03	3.50	3.50	

3.6 Fruit yield per hectare (tons)

Considering the heterotic effects, the heterosis over mid parent ranged from 34.25 per cent to 76.50 per cent all 40 hybrids were found to be positively significant for heterotic effect. Hybrid IC-085618 X Phule green gold (76.50%) showed maximum positive significant heterosis. Heterosis over better parent ranged from 33.68 per cent to 72.57 per cent. All 40 hybrids were found to be positively significant.

Hybrid IC-085618 X Phule green gold (72.57%) had shown maximum positively significant heterosis. Check parent-1 heterosis was ranged from 29.51 per cent to 101.97 per cent. Similar results are in earlier studies reported by Muthaiah *et al.* (2017) ^[5] in ridge gourd. Yield components greatly influence the yield and expression of heterosis for fruit length, fruit weight, number of fruits per vine can greatly contribute for total fruit yield per vine and hectare. For all these traits,

positive heterosis is desirable.

4. Conclusions

Among 40 crosses many of the crosses had shown significant heterosis over their respective better parent and also over standard check for the traits studied. As yield is the important trait for crop production. The ideal hybrid or parent producing high fruit yield per hectare will be the one having traits like higher fruit weight and fruit yield per vine. The hybrids like IC-085618 X Phule green gold and IC-085618 X CO-1 performed significant heterosis. So the exploitation of heterosis in the form of developing hybrids varieties is therefore advocated.

5. References

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