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Exploitation of heterosis for different quantitative characters in cucumber (*Cucumis sativus* L.)

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Abstract

The experimental material for the present study comprised of F_1 population of twenty four crosses, developed by crossing four female parents *viz.* Sheetal, Shubhangi, Himangi, and Punakhira of cucumber with six male parents *viz.*, AAUC-2, DC-2, AAUC-1, VRC-19, DARL-103 and Fansu local. The experiment was laid out with 24 F1s, 4 females 6 males and one check Konkan kakadi in Randomized Block Design (RBD) with two replications during the *kharif* 2017. Observations were recorded on thirteen different quantitative characters. Higher yield is the basic objective of all crop improvement programmes. The best five hybrids were identified with respect to marketable yield per vine based on significant highest appreciable positive heterosis were *viz.*, Sheetal x Fansu local, Sheetal x VRC-19, Puna khira x VRC-19, Puna khira x Fansu local and Sheetal x AAUC-2.

Keywords: cucumber, F_1 hybrids, heterosis and yield characters

Introduction

Cucumber (*Cucumis sativus* L) is an important member of the family cucurbitaceae. It is chiefly grown for its edible tender fruits, preferred salad ingredient, pickles, and desert fruit and as a cooked vegetable. It is also consumed by diabetic patients and known as fat reducing food. Heterosis or hybrid vigor is an important biological phenomenon refers to the manifested superiority of the F_1 hybrid resulting from cross of genetically dissimilar homozygous parents over either of the parents. Heterosis or hybrid vigor can play a vital role in increasing the yield quality of cucumber. Based on the information, the present study was undertaken to assess the parental diversity and heterosis in cucumber. The very basic problem in cucumbers is concerning with the low marketable yield. The lack of progress in increased fruit yield of cucumber might be partially due to the meager breeding effort relative to other crop or lack of variability for yield (Wehner *et. al.*, 1989) [21]. Today, hybrid varieties of cucumber are very uncommon among the farmers because farmers are purchasing the hybrid seed from private companies which are charging exorbitantly. To tide over the situation, there is a need to develop location specific high yielding hybrids having desirable traits and to make available their seeds to the farmers at reasonable prices.

Materials and Methods

The experimental material for the present study comprised of F_1 population of twenty four crosses, developed by crossing four females (lines) *viz.*, Sheetal, Shubhangi, Himangi, and Puna khira of cucumber with six males (testers) *viz.*, AAUC-2, DC-2, AAUC-1, VRC-19, DARL-103 and Fansu local. were used in this experiment. All the lines used as female parents were crossed to each of the tester by hand pollination in a line x tester model and thus line x tester full-sib crossed true to type seeds was produced at the Educational Experimental Botany Farm, at Department of Agriculture Botany, College of Agriculture, Dapoli during *Kharif* 2017. The experiment was laid out with $24F_1$s, 4 females 6 males and one check Konkan kakadi in Randomized Block Design (RBD) with two replications. The unit plot size was 3.0 m X 6.0 m accommodating 10 plants in each plot with spacing of 3.0 m X 0.60 m. All the recommended agronomic practices were adopted to raise a good crop. Data on 13 quantitative characters: *viz*. Days to first male flower appearance, days to first female flower appearance, nodal position of first female flower, days to first picking, fruit length (cm), fruit diameter (cm), average fruit weight (g), number of marketable fruits vine^{-1}, marketable yield vine^{-1} (kg), harvest duration, number of primary branches plant^{-1}, vine length (m), total soluble solids (^{0}Brix) were recorded. The collected data were statistically analyzed. Analysis of variance for each of the character was performed. The data for each character was analyzed by using standard statistical procedure (Panse and Sukhatme, 1985) [12]. Heterosis expressed as per cent, increase or decrease in the mean value of F_1 hybrids over better parent (heterobeltiosis) and over standard check (standard heterosis). In the present study standard heterosis and heterobeltiosis was calculated for various characters procedure given by Fonseca and Patterson (1968) [5].

Results and Discussion

Analysis of variance for the experimental design

The analysis of variance for parents and hybrids was computed in the table 1for *kharif* 2017 for different characters.The results revealed that the variance of mean squares due to parents for all the characters were found significant. This indicated existence of considerable amount of genetic variability in parents. The mean squares due to females and males were also found highly significant for the most of the characters under study this indicating large variation among the females and males. Similar results have also been reported by Munshi *et al.* (2007) [11].

The mean square due to females Vs. males was found to be significant for all the characters. This was confirmed that the magnitude of mean squares due to females was higher which implied major contribution of females to total parental variation. The mean squares due to hybrids were also found highly significant for all the characters under study some traits indicated existence of considerable amount of genetic variability among parents and hybrids. Similar findings observed by Verma (2000) [20].

The analysis of variance for parents vs. hybrids was found significant for most of the characters and had higher magnitude which revealed large variation in hybrids except some traits.

Magnitude of heterosis

Heterosis breeding has played a important role in improving the yield and component traits of self as well as cross-pollinated species. In literature, most of the research work on heterosis refers to average heterosis and heterobeltiosis only. However, it is the standard heterosis, which is of practical interest to the breeders as well as growers. Therefore, the present study was carried out to find out the superior heterotic cross combinations. In comparison to heterobeltiosis and standard heterosis over Konkan kakadi (standard check). The heterotic response of best hybrids for various traits under study over better parent and standard check has been presented in the table 2.

Table 1: Analysis of variance (mean squares) for different quantitative characters in L X T of cucumber

Sr. No	Source of variance	D.F.	Days to first male flower appearance	Days to first female flower appearance	Nodal position of first female flower	Days to first picking	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of marketable fruits vine^{-1}
1	Replications	1	5.3088	5.308	0.0147	10.720	0.903	0.522	36.911	0.0072
2	Parents	9	15.088**	26.45**	1.050	47.688**	1.998**	0.283	776.86**	0.573
3	Females	3	25.458**	49.00**	0.447	61.833**	0.154	0.290	808.71*	0.135
4	Males	5	18.483**	5.88**	1.270	5.000	1.976**	0.330	827.86**	0.386
5	Females Vs. Males	1	39.67**	45.63**	1.752	218.70**	7.641**	0.031	426.396	2.821*
6	Hybrids	23	39.339**	17.21**	3.159**	18.586**	1.454**	0.579**	624.299**	15.468**
7	Parents Vs. Hybrids	1	45.108**	40.40**	124.25**	18.806*	112.44**	8.986**	5168.925**	13.237**
8	Error	33	2.18	1.79	0.0147	10.720	0.522	0.522	203.68	0.0072

Table 1: Cont……

Sr. No	Source of variance	D.F.	Marketable yield vine^{-1} (kg)	Harvest duration	Number of primary branches plant^{-1}	Vine length (m)	Total soluble solids (^{0}Brix)
1	Replications	1	0.010	3.764	0.0119	3.926	0.0177
2	Parents	9	0.292*	8.111	0.391**	9.080**	0.244**
3	Females	3	0.096	1.125	0.458**	0.929	0.023
4	Males	5	0.453**	13.883	0.181**	6.407**	0.362**
5	Females Vs. Males	1	0.079	0.208	1.240**	46.900**	0.320**
6	Hybrids	23	1.087**	29.855**	0.654**	0.356	0.496**
7	Parents Vs. Hybrids	1	3.437**	2.450	hf	48.955**	0.709**
8	Error	33	0.099	0.099	hfgh	1.628	0.028

*, ** significant at 5 and 1percent probability level respectively

Table 2: Estimates of heterosis (%) over better parent (BP) and standard check (SC) for different quantitative characters in L X T of cucumber

Sr. No.	Treatment	Days to first male flower appearance		Days to first female flower appearance		Nodal position of first female flower		Days to first picking		Fruit length (cm)		Fruit diameter (cm)	
	Hybrids	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC
1	Sheetal x AAUC-2	1.02	0.001	-1.74	0.89	-25.71**	8.33	-6.67**	0.80	37.02**	33.13**	0.001	-1.89
2	Sheetal x DC-2	2.13	-3.03	-4.39	-2.68	-20.00	0.001	-6.52**	3.20	28.01**	26.25**	4.80	3.02
3	Sheetal x AAUC-1	-2.04	-3.03	-6.84**	-2.69	-16.67	25.00	-9.93**	1.60	16.81**	15.41*	7.69	5.66
4	Sheetal x VRC-19	0.001	-1.01	-0.85	3.57	-47.06**	-25.00	-3.50	10.40*	10.11	16.65	6.88	5.47

									*		*		
5	Sheetal x DARL-103	-6.06	-6.06	-2.68	-2.68	-66.67**	-58.33**	-3.68	4.80	18.22**	41.82**	-1.64	2.08
6	Sheetal x Fansu local	-8.00*	-7.07	-13.11**	-5.36*	-40.00**	-25.00	-11.35**	0.00	9.70	16.78*	-6.34	3.21
7	Shubhangi x AAUC-2	1.01	1.01	0.001	5.36*	-42.86**	-16.67	3.68	12.80**	29.58**	25.90**	12.15	13.21
8	Shubhangi x DC-2	-16.16**	-16.16**	-12.71**	-8.04**	-41.94**	-25.00	-8.70	0.80	32.46**	30.64**	16.45*	17.55*
9	Shubhangi x AAUC-1	-14.14**	-14.14**	-12.71**	-8.04**	-61.11**	-41.67**	-10.64**	0.80	21.52**	20.05**	11.03	12.08
10	Shubhangi x VRC-19	-1.01	-1.01	-2.54	2.68	-58.82**	-41.67	-8.39**	4.80	31.41**	40.28**	8.04	9.06
11	Shubhangi x DARL-103	-1.01	-1.01	-9.32**	-4.46	-41.94	-25.00	-3.68	4.80	1.15	21.34**	8.91	13.02
12	Shubhangi x Fansu local	-6.00	-5.05	-7.38**	0.89	-16.13	8.33	-7.09**	4.80	14.55*	21.94**	3.60	14.15
13	Himangi x AAUC-2	-13.27**	-14.14	-11.30**	-8.93**	-48.57**	-25.00	-9.63**	-2.40	20.19**	16.78*	15.64	2.31
14	Himangi x DC-2	-26.09	-31.31**	-10.53**	-8.93**	-29.03*	-8.33	-10.87**	-1.60	22.25**	20.57**	5.18	3.40
15	Himangi x AAUC-1	-27.55**	-28.28**	-13.68**	-9.82**	-44.44**	-16.67	-14.18**	-3.20	33.01**	31.41**	11.91	2.83
16	Himangi x VRC-19	-13.27**	-14.14**	-9.40**	-5.36*	-47.06**	-25.00	-5.59*	8.00**	15.57*	22.12**	18.55*	16.98*
17	Himangi x DARL-103	-11.11**	-11.11**	-0.89	-0.89	-41.94**	-25.00	-5.88*	2.40	9.25	31.07**	31.82**	36.79**
18	Himangi x Fansu local	0.001	1.01	-5.74*	2.68	-16.13	8.33	-2.84	9.60**	12.69*	19.97**	3.94	14.53
19	Punakhira x AAUC-2	-6.12	-7.07*	-5.22*	-2.68	-48.57**	-25.00	-0.74	7.20*	33.08**	26.36**	21.65**	25.09**
20	Punakhira x DC-2	10.87**	3.03	2.63	4.46	-66.67**	-58.33**	-1.45	8.80**	23.91**	22.20**	10.09	13.21
21	Punakhira x AAUC-1	-5.10	-6.06	-3.42	0.89	-50.00**	-25.00	-2.84	9.60**	24.22**	22.72**	22.02**	25.47**
22	Punakhira x VRC-19	-4.08	-5.05	0.85	5.36*	-35.29**	-8.33	-2.80	11.20**	17.95**	24.96**	23.85**	27.36**
23	Punakhira x DARL-103	-12.12**	-12.12**	-8.85**	-8.04**	-51.72**	-41.67**	-0.74	8.00**	-4.09	15.06*	16.91*	21.32**
24	Punakhira x Fansu local	2.00	3.03	-1.64	7.14**	-17.24	0.00	0.71	13.60**	12.77*	20.05**	16.44*	28.30**
	Range of heterosis	-27.55-10.87	-31.31-3.03	-13.68-2.63	-9.82-7.14	-66.67-(-16.13)	-58.33-25.00	-14.18-0.71	-3.20-13.60	-4.09-37.02	15.06 - 41.82	-6.34-31.82	-1.89-36.79
	SE ±		1.479		1.33		0.80		1.67		0.72		0.38
	C.D at 5%		3.059		2.77		1.65		3.46		1.50		0.79
Total No. of significant crosses		09	08	13	11	18	4	12	10	19	24	08	08
No. of Positive significant crosses		01	-	-	3	-	-	-	10	19	24	08	08
No. of Negative significant crosses		08	08	13	8	18	4	12	-	-	-	-	-

Table 2: Cont….

Sr. No.	Treatment	Average fruit weight (g)		Number of Marketable fruits vine^{-1}		Marketable Yield vine^{-1} (kg)		Harvest duration		Number of primary branches plant^{-1}		Vine length (m)		Total soluble solids (^{0}Brix)	
	Hybrids	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC
1	Sheetal x AAUC-2	8.93	16.13*	29.32**	40.34**	41.45**	41.19**	17.14	24.24*	8.82	45.10**	-21.89	-22.12	-1.52	-1.52
2	Sheetal x DC-2	10.53	17.83**	4.76	12.50	7.06	6.68	1.33	15.15	11.76*	49.02**	-28.51*	-15.67	0.001	0.001
3	Sheetal x AAUC-1	-10.53	-3.77	13.23	21.59**	-12.27	-12.43	-7.89	6.06	7.35	43.14**	-46.16**	-20.73	7.58	7.58

4	Sheetal x VRC-19	7.59	19.19**	59.79**	71.59**	56.52**	60.30**	-5.71	0.001	5.88	41.18**	-31.62**	-22.32	3.03	3.03
5	Sheetal x DARL-103	-1.87	15.60*	38.62**	48.86**	7.61	31.17*	2.70	15.15	-2.86	33.33**	-18.47	-19.44	-1.52	-1.52
6	Sheetal x Fansu local	8.50	15.66*	64.55**	76.70**	65.09**	93.88**	16.90	25.76*	-5.71	29.41**	-24.70*	-17.76	-29.85**	-28.79
7	Shubhangi x AAUC-2	12.02	11.41	-15.15*	-4.55	11.30	-1.30	17.14	24.24*	14.81*	21.57**	-14.93	-15.18	-1.52	-1.52
8	Shubhangi x DC-2	9.25	14.12*	-26.77**	-17.61*	30.89*	12.43	8.00	22.73*	-18.18**	5.88	-28.26*	-15.38	-30.77**	-31.82**
9	Shubhangi x AAUC-1	6.35	14.39*	-14.14*	-3.14	11.45	-4.27	-19.74*	-7.58	-16.13*	1.96	-42.05**	-14.68	-32.81**	-34.85**
10	Shubhangi x VRC-19	4.23	15.46*	-27.27**	-18.18*	-5.25	-2.97	-11.43	-6.06	-21.21**	1.96	-28.82*	-19.15	1.52	-1.52
11	Shubhangi x DARL-103	-7.60	8.86	-22.22**	-12.50	-14.00	4.82	-2.70	9.09	-28.57**	-1.96	-20.28	-21.23	0.001	-3.03
12	Shubhangi x Fansu local	23.41**	18.58**	-25.25**	-15.91*	-10.74	4.82	-7.04	0.001	-28.57**	-1.96	-22.71	-15.58	-2.99	-1.52
13	Himangi x AAUC-2	19.48**	18.82**	-4.15	5.11	-0.42	-11.13	-13.89	-6.06	-11.11	-5.88	-9.75	-10.02	-8.70	-4.55
14	Himangi x DC-2	15.73**	20.89**	-19.17**	-11.36	16.22	3.71	-1.33	12.12	-27.27**	-5.88	-27.92*	-14.98	-1.45	3.03
15	Himangi x AAUC-1	4.65	12.56*	-13.47*	-5.11	4.16	-7.05	-10.53	3.03	-12.90*	5.88	-44.54**	-18.35	-13.04*	-9.09
16	Himangi x VRC-19	0.73	11.59	-21.24**	-13.64	2.17	4.64	-2.78	6.06	-18.18**	5.88	-21.92	-11.31	-34.78**	-31.82**
17	Himangi x DARL-103	-20.23**	-6.02	-1.55	7.95	-11.87	7.42	-18.92*	-9.09	-34.29**	-9.80	-18.98	-19.94	-5.80	-1.52
18	Himangi x Fansu local	20.44**	13.92*	-9.84	-1.14	-17.85	-3.53	12.50.	-4.55	-40.00**	-17.65*	-24.52*	-17.56	-4.35	0.001
19	Puna khira x AAUC-2	4.14	15.60*	37.17**	48.86**	27.62*	31.17*	5.48	16.67	37.04**	45.10**	-23.48	-23.71	0.001	0.001
20	Puna khira x DC-2	1.10	12.22*	-5.38	0.00	-1.62	1.11	-8.00	4.55	12.12*	45.10**	-24.74*	-12.40	-30.77**	-31.82**
21	Puna khira x AAUC-1	-12.18*	-2.51	-19.89	-15.34*	-3.07	-0.37	-22.37*	-10.61	19.35**	45.10**	-37.20**	-7.54	-32.31**	-33.33**
22	Puna khira x VRC-19	-2.30	8.45	47.31**	55.68**	51.99**	56.22**	-16.44	-7.58	6.06	37.25**	-22.01	-11.41	-31.82**	-31.82**
23	Puna khira x DARL-103	-4.18	12.89*	2.15	7.95	-16.29	2.04	-9.46	1.52	-2.86	33.33**	-13.55	-14.58	-29.23**	-30.30**
24	Puna khira x Fansu local	-4.36	6.16	62.37**	71.59**	32.54**	55.66**	5.48	16.67	5.71	45.10**	-21.25	-13.99	10.45*	-9.09
	Range of heterosis	-20.23-23.41	-6.02-20.89	-27.27-64.55	-18.18-76.70	-17.85-65.09	-11.13-93.88	-22.37-17.14	-10.61-25.76	-40.00-37.04	-17.65-49.02	-46.16-(-9.75)	-23.71-(-7.54)	-34.78-10.45	-34.85-7.58
	SE ±		14.27		0.61		0.31		3.07		0.18		1.27		0.17
	C.D at 5%		29.52		1.27		0.65		6.35		0.38		2.63		0.35
Total No. of significant crosses		06	16	16	12	07	07	03	04	15	14	12	-	10	07
No. of Positive significant crosses		04	16	06	08	07	07	-	04	05	13	-	-	01	-
No. of Negative significant crosses		02	-	10	04	-	-	03	-	10	01	12	-	09	07

*, ** significant at 5 and 1percent probability level respectively

Days to first male flower appearance

The heterobeltiosis ranged from 10.87 per cent (Punakhira × DC-2) to -27.55 per cent (Himangi × AAUC-1). The 8 hybrids showed desirable negative significant heterobeltiosis. The hybrids Himangi × AAUC-1(-27.55%) recorded maximum negative heterosis over better parent followed by Himangi x DC-2(-26.09%) and Shubhangi × DC-2(-16.16%). The heterosis over standared check ranged from (3.03 %) Puna khira x DC-2 and Puna khira × Fansu local to (-31.31%) Himangi × DC-2. Eight hybrids were found desirable in recording significant negative standard heterosis. The maximum negative significant standard heterosis (-31.31%) was recorded by Himangi × DC-2 followed by Himangi × AAUC-1 (-28.28 %) and Shubhangi × DC-2(-16.16%). Malav and Verma (2018) [9] reported similar findings in cucumber.

Days to first female flower appearance

For days to first female flower appearance heterobeltiosis ranged from (2.63%) Punakhira x DC-2 to (-13.68%) Himangi x AAUC-1. The 13 hybrids showed desirable negative significant heterobeltiosis. The hybrid Himangi x AAUC-1 (-13.68%) recorded maximum negative heterosis over better parent followed by Sheetal x Fansu local (-13.11%), Shubhangi × DC-2 and Shubhangi ×AAUC-1 (-12.71%). The heterosis over standared check ranged from (7.14%) Punakhira x Fansu local to (-9.82%) Himangi x AAUC-1. The heterosis over standared check 8 hybrids were found desirable in recording significant negative standard heterosis. The maximum negative standard heterosis recorded by Himangi x AAUC-1 (-9.82%) followed by Himangi × DC-2 and Himangi x AAUC-2 (-8.93%). Dogra and Kanwar (2011) [4] had reported negative significant heterobeltiosis and standared heterosis for this trait.

Nodal position of first female flower

Heterotic effects for nodal position of first female flower appearance, eighteen hybrids displayed desirable negative significant heterobeltiosis. The hybrids Sheetal x DARL-103 and Punakhira x DC-2(-66.67%) recorded maximum negative heterosis over better parent. The heterosis over standared check 4 hybrids were found desirable in recording significant negative standard heterosis. The hybrids Sheetal x DARL-103 and Puna khira x DC-2(-58.33%) recorded maximum negative significant standard heterosis. Thakur *et. al*. (2017) [18] desirable standard heterosis for the same trait.

Days to first picking

The results displayed in days to first picking that heterobeltiosis ranged from (0.71%) Punakhira x Fansu local to (-14.18%) Himangi x AAUC-1. The 12 hybrids showed desirable negative significant heterobeltiosis. The hybrids Himangi x AAUC-1 (-14.18%) recorded maximum negative heterosis over better parent followed by Sheetal x Fansu local (-11.35%) and Himangi x DC-2 (-10.87%). The standared heterosis ranged from 13.60% (Puna khira x Fansu local) to -3.20 % (Himangi x AAUC-1). None of the hybrids showed desirable significant negative standard heterosis. Malav and Verma (2018) [9] noted that most of the hybrids which flowered earlier than the better or check variety also showed earliness in maturity indicating the positive association between these characters.

Fruit length (cm)

In fruit length heterobeltiosis ranged from (37.02 %) Sheetal x AAUC-2 to (-4.09%) Puna khira x DARL-103. The 19 hybrids showed desirable positive significant heterobeltiosis. The hybrids Sheetal x AAUC-2 recorded maximum (37.02%) positive heterosis over better parent followed by Puna khira x AAUC-2 (33.08%) and Himangi x AAUC-1(33.01%). The standared heterosis ranged from (15.06%) Puna khira x DARL-103 to (41.82%) Sheetal x DARL-103. All 24 hybrids showed desirable significant standard heterosis. The maximum positive standard heterosis recorded by Sheetal x DARL-103 (41.82%) followed by Sheetal x AAUC-2(33.13%) and Himangi x AAUC-1(31.41%).Similar results were reported for heterobeltiosis by earlier workers, Singh *et. al.* (2010), Kushwaha *et. al.* (2011)and Mule *et al.* (2012) [17, 8, 10]. For standard heterosis similar results given by Thakur *et. al*. (2017) [18].

Fruit diameter (cm)

Fruit diameter directly played important role in the enhancement of the yield. The heterobeltiosis ranged from (6.34%) Sheetal x Fansu local to (31.82%) Himangi x DARL-103. The 8 hybrids showed desirable positive significant heterobeltiosis. The hybrids Himangi x DARL-103 recorded maximum positive heterosis (31.82 %) over better parent followed by Puna khira x VRC-19 (23.85%) and Puna khira x AAUC-1 (22.02%). The standared heterosis ranged from (-1.89) Sheetal x AAUC-2 to (36.79%) Himangi x DARL-103. The 8 hybrids showed desirable significant standard heterosis. The maximum positive standard heterosis was recorded by 36.79% (Himangi x DARL-103) followed by Puna khira x Fansu local (28.30%) and Puna khira x VRC-19 (27.36%).This result also coincided with the findings of Sudhakar *et al.* (2005) while for standard heterosis Kaur and Dhall (2017) and Thakur *et. al*. (2017) [7, 18] recorded similar findings.

Average fruit weight (g)

Average fruit weight recorded heterobeltiosis ranged from (-20.23%) Himangi x DARL-103 to (23.41%) Shubhangi x Fansu local. The 4 hybrids showed desirable positive significant heterobeltiosis. The hybrids Shubhangi x Fansu local recorded (23.41%) maximum positive heterosis over better parent followed by Himangi x Fansu local (20.44%) and Himangi x AAUC-2 (19.48%). The standared heterosis ranged from (-6.02%) Himangi x DARL-103 to (20.89%) Himangi x DC-2. The 16 hybrids showed desirable significant standard heterosis. The maximum (20.89%) positive standard heterosis recorded by (Himangi x DC-2) followed by Sheetal x VRC-19 (19.19%) and Himangi x AAUC-2 (18.82%). Significant heterosis for this trait have also been reported earlier by Singh *et al.* (2016) [15] and Singh and Tiwari (2018) [19].

Number of marketable fruits per vine

Yield in cucumber is dependent primarily on number of fruits (Bairagi *et al*. 2002) [2]. The latter, however is a function of time, which is under the control of grower. Therefore, improvement in a complex trait like yield is possible and easier if progress is made through components like number of fruits vine^{-1}. The heterobeltiosis ranged from (-27.27 %) Shubhangi x VRC-19 to (64.55%) Sheetal x Fansu local. The 6 hybrids showed desirable positive significant heterobeltiosis. The hybrid Sheetal x Fansu local recorded (64.55%) maximum positive heterosis over better parent followed by Punak hira x Fansu local (62.37%) and Sheetal x VRC-19 (59.79%). The standared heterosis ranged from (-18.18%) Shubhangi x VRC-19 to (76.70%) Sheetal x Fansu local. The 8 hybrids showed desirable significant standard heterosis. The maximum positive standard heterosis recorded by Sheetal x Fansu local (76.70 %) followed by Sheetal x VRC-19 and Punakhira x Fansu local (71.59%). The present findings related to heterobeltiosis for number of fruits plant^{-1} are in close agreement with Dogra Kanwar (2011) [4] and Simi *et al.* (2017) [14]. Similar findings are recorded for standard heterosis by Tiwari and Singh (2016) and Thakur *et al*. (2017) [19, 18].

Marketable yield per vine (kg)

The high consistent performance of these hybrids for marketable yield may be attributed to their hybrid vigour for increased fruit size, weight and number recorded in the present study. The heterobeltiosis ranged from (-17.85%) Himangi x Fansu local to (65.09 %) Sheetal x Fansu local. The 7 hybrids showed desirable positive significant heterobeltiosis. The hybrid Sheetal x Fansu local recorded (65.09%) maximum positive heterosis over better parent followed by Sheetal x VRC-19 (56.52%) and Punakhira x VRC-19 (51.99%). The standared heterosis ranged from (-11.13%) Himangi x AAUC-2 to (93.88 %) Sheetal x Fansu local. While 7 hybrids showed desirable significant standard heterosis. The maximum (93.88 %) positive significant standard heterosis was recorded by Sheetal x Fansu local followed by Sheetal x VRC-19 (60.30%) and Puna khira x VRC-19 (56.22%). Airina *et. al*. (2013), and Sharma *et al.* (2016) [1, 13] reported significant positive heterobeltiosis and positive significant standared heterosis by Brar *et al.* (2011) [3].

Harvest duration

Duration in positive direction is desirable because more the duration more is the yield. None of the hybrid showed desirable positive significant heterobeltiosis hence, duration is in negative direction while in standard heterosis the 4 hybrids showed desirable results in these Sheetal x Fansu local recorded maximum (25.76%) positive significant standard heterosis.

Number of primary branches per plant

The magnitude of the heterobeltiosis ranged from (-40.00%) Himangi x Fansu local to (37.04%) Puna khira x AAUC-2. The 5 hybrids showed desirable positive significant heterobeltiosis. The hybrid Puna khira x AAUC-2 recorded (37.04%) maximum positive heterosis over better parent followed by Punakhira x AAUC-1 (19.35%) and Shubhangi x AAUC-2 (14.81%). The standared heterosis ranged from (-17.65%) Himangi x Fansu local to (49.02 %) Sheetal x DC-2. The 13 hybrids showed desirable significant standard heterosis. The maximum (49.02%) positive standard heterosis recorded by Sheetal x DC-2 followed by Sheetal x AAUC-2, Puna khira x AAUC-2, Puna khira x DC-2, Puna khira x AAUC-1 and Punakhira x Fansu local (45.10%).Significant heterosis for this traits have also been reported earlier by Yadav *et al.* (2008) and Singh and Tiwari (2018) [22, 16].

Vine length (m)

The heterobeltiosis for vine length ranged from (-46.16 %) Sheetal x AAUC-1 to (-9.75%) Himangi x AAUC-2. None of the hybrids showed desirable positive significant heterobeltiosis. The standared heterosis ranged from (-23.71%) Puna khira x AAUC-2 to (-7.54%) Puna khira x AAUC-1. None of the hybrids showed desirable positive significant standard heterosis. Iranna *et al.* (2011) [6] recorded positive significant heterosis over check.

Total soluble solids (^{0}Brix)

The heterobeltiosis ranged from (-34.78 %) Himangi x VRC-19 to (10.45 %) Puna khira x Fansu local. Only one hybrid Punakhira x Fansu local showed desirable (10.45%) positive significant heterobeltiosis. The standered heterosis ranged from (-34.85%) Shubhangi x AAUC-1 to (7.58%) Sheetal x AAUC-1. None of the hybrid showed desirable significant standard heterosis. Malav and Verma (2018) [9] reported highest heterosis for total soluble solids which improve the quality of cucumber fruits.

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