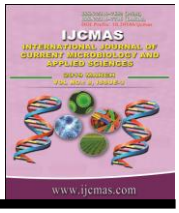
Int.J.Curr.Microbiol.App.Sci (2019) *8*(3): 916-924

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 8 Number 03 (2019)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2019.803.109

Heterosis Studies for Growth and Yield Traits in Cucumber (*Cucumis sativus* L.)

G.P. Preethi[1], M. Anjanappa[1], R.K. Ramachandra* and Vishnuvardhana[1]

[1]College of Horticulture, Bengaluru, Karnataka, India
**College of Horticulture, Mysore, Karnataka, India*

**Corresponding author*

Keywords

Cucumber, Heterosis, Growth parameter, Cucumber fruit, Hybrid vigour

Article Info

Accepted:
10 February 2019
Available Online:
10 March 2019

A B S T R A C T

An Indian origin cucumber (*Cucumis sativus* L.) is one of the most popular vegetables of the family Cucurbitaceae. It is the preferred in various ways, salad ingredient, pickles, deserts fruit and as a cooked vegetable, hence it has attained the crop improvement as compared to other cucurbit vegetables. Therefore the present investigation has been carried out to know the extent of heterosis for growth and yield parameters. The experimental materials consisted of 5 Lines and 5 Testers of cucumber collected from the germplasm maintained by the Department of Vegetable Science, College of Horticulture, UHS Campus, GKVK, and Bengaluru. Their 25 F_1's were developed by crossing them in Line X Tester mating design. The IIHR-285, IIHR-341, IIHR-304, Green Long, Pondicherry-1, were used as lines and the Poinsette, Phule Shubhangi, Punjab Naveen, Pusa Uday, Kerala-1 were used as testers based on their yield potentiality. Observation from five competitive plants was recorded on various characters viz., vine length (cm), number of branches per vine, number of nodes per vine, Node of female flower appearance, node of male flower appearance, days to first fruit harvest, sex ratio, days to female flower anthesis and on fruit yield per plant (kg). Analysis of variance was carried out separately for all the characters. The present experiment identified the important hybrids for commercial use viz Green long × Poinsette, Green long × Pusa Uday, Pondicherry 1 × Punjab Naveen as which have exhibited the maximum significant standard heterosis for fruit yield per vine , for fruit length, average fruit weight, number of fruits per vine over the check Chitra.

Introduction

Cucumber is a monoecious, trailing or climbing vine with angled, hirsute or rough stems. The staminate flowers have three stamens are in clusters with short, slender pedicels. The pistillate flowers contain upto five stigma and are epigynous and hermaphrodite flowers are perigynous. The main stem of monoecious cucumber is usually characterized by three phases of sex expressions. Only staminate flowers are produced in the first phase followed by a phase of irregularly alternating female, male or mixed nodes and finally a phase of only pistillate flowers. Fruits from perigynous

flowers are more rounded as opposed to elongated ones from epigynous ones. Cucumber exhibits a considerable heterozygosity in the population and does not suffer much due to the inbreeding depression resulting in natural variability in the population. The demand for the hybrids in cucumber is increasing because of earliness, uniformity and higher yield. Cucumber is a suitable crop for the development of hybrids of commercial importance due to monoecious sex form which eliminates emasculation and large number of seeds per cross, make it more economical. Heterosis breeding has been recognized as practical tool in providing breeder a means for increasing yield and other economic traits. The hybrid vigour or the superiority of the F_1 hybrids over parents may be manifested in terms of high productivity, uniformity in improved qualities, built in resistance, environmental adoptions, earliness etc. However it never happens that each hybridization is accompanied by manifestation of hybrid vigour. Only certain pair of parents gives heterotic progeny. Therefore exploitation of heterosis involving locally adapted cucumber genotypes to identify the good hybrids for both growth parameters and yield

Materials and Methods

The experimental materials consisted of 5 Lines and 5 Testers of cucumber collected from the germplasm maintained by the Department of Vegetable Science, College of Horticulture, UHS Campus, GKVK, and Bengaluru. Their 25 F_1's were developed by crossing them in Line X Tester mating design. The IIHR-285, IIHR-341, IIHR-304, Green Long, Pondicherry-1, were used as lines and the Poinsette, Phule Shubhangi, Punjab Naveen, Pusa Uday, Kerala-1 were used as testers based on their yield potentiality. The study was undertaken in *Kharif* season of 2016-17 at Research Block of the Department of Vegetable Science, College of Horticulture, Bengaluru under open field condition by following Randomized Complete Block Design with 2 replications in the spacing of 1.5 m×1 m. Land preparation. Nursery raising, transplanting and intercultural operation was followed as per the recommendation of package of practices of UHS Bagalkot. Observation from five competitive plants were recorded on various growth and yield characters viz vine length (cm), number of branches per vine, number of nodes per vine, Node of female flower appearance, node of male flower appearance. days to first fruit harvest, sex ratio, days to female flower anthesis and fruit yield per plant (kg).

Results and Discussion

In the present study, most of the hybrids recorded heterosis in positive direction. The vine length was measured at time of harvest and the parent range of vine length was 148.60 cm to 205.60 cm. The vine length of the crosses ranged from 175.30 cm to 241.20 cm. The maximum vine length was exhibited by the hybrid Pondicherry -1 × Pusa Uday (241.20 cm), Green Long × Pusa Uday (19.91%) followed by Pondicherry 1 × Punjab Naveen (16.58 %) exhibited the significant positive standard heterosis over check Chitra. This results in line with the findings of Arya and Singh (2014) and Jat *et al.,* (2015).

Branches are the important growth parameters contributing to productivity. For realizing high fruit yield, desirable degree of vegetative growth is essential (Mule *et al.,* 2012). The parents had the range of 4.05 to 5.30 branches per vine. The maximum *per se* performance of parent was observed in Pondicherry 1 (5.30), while the hybrids had the range of 4.80 to 6.50 and maximum *per se* performance was observed in the cross Green long × Phule Shubhangi (6.50) followed by Pondicherry 1 × Punjab Naveen (6.35).. Green long × Phule

Shubhangi (25.00 %) followed by Pondicherry 1 × Punjab Naveen (22.12 %) exhibited the significant standard heterosis over check Chitra. Similar results with significant heterosis for number of branches were reported by Shaik *et al.,* (2011) and Sarkar *et al.,* (2015).

To increase the productivity, nodes play a very important role. The parents had the range of 15.75 to 20.55 nodes per vine. The maximum *per se* performance of parent was observed in Pondicherry- 1 and Poinsette (20.55), while the hybrids had the range of 17.70 to 29.30 and maximum *per se* performance was observed in the cross Pondicherry 1 × Phule Shubhangi (29.30) followed by Pondicherry 1 × Pusa Uday (29.00).. Pondicherry- 1 × Phule Shubhangi (46.50 %) followed by Pondicherry 1 × Pusa Uday (45.00 %) exhibited the significant standard heterosis over check Chitra. These results are in line with findings of Singh *et al.,* (2011). The prime objective is that the appearance of first female flower at the lower node for development of early hybrid. Among parents, the node at which the first female flower appeared is in the Green Long (4.35) and relatively higher in Pondicherry 1 (7.15). With respect to hybrids, Green Long × Poinsette (4.05) recorded the first female flower at lower node and it indicated the earliness. For the development of early fruiting, genotypes with negative heterosis are desirable for node number at which first female flower appears (Arya and Singh, 2014). The crosses IIHR 285 × Punjab Naveen (-27.87 %) and Pondicherry 1 × Punjab Naveen (-24.59%) exhibited the significant heterobeltiosis in negative direction. This is in accordance with the research findings of Singh *et al.,* (2015). The crosses exhibited the positive standard heterosis over superior Check and similar findings were reported by Dogra *et al.,* (2011) in cucumber. For earliness flowering at lower node is an indication. In cucurbits male flower appear at the lower node, usually 6-7 days before the female flower open. Hence, appearance male flower is related with earliness. Among the parents, IIHR 341 (2.10) showed flowering at lower nodes while Kerala -2 (3.45) showed first male flower at higher node. Heterosis in negative direction was desirable for this trait, the cross IIHR 304 × Pusa Uday (-49.28%) exhibited the significant negative heterosis over check. Similar standard heterosis was recorded by Singh and Ram (2009) in cucumber. Five crosses *viz.,* IIHR 304 × Phule Shubhangi (-45.59 %), IIHR 341 × Kerala-2 (-44.93 %), IIHR 285 × Kerala-2 (-43.48 %), IIHR 304 × Kerala -2 (-34.78 %) exhibited the significant negative heterobeltiosis. This result is in line with research findings of Singh *et al.,* (2010), Mule *et al.,* (2012) and Singh *et al.,* (2015) in cucumber.

For days to first harvest negative estimates of heterosis is a well-recognized and prime objective of any breeding programme as it helps the grower to earn a good early market price (Airina *et al.,* 2013). Among parent Pondicherry 1 (55.45) shows the early harvest while IIHR 285 (60.45) shows more days to first harvest. Heterosis in negative direction is desirable for days to first harvest. The cross Green long × Poinsette exhibited the significant negative heterobeltiosis (-20.65%) as well as standard heterosis (-23.74 %) over the check Chitra.

This is in line with the research findings with Kumar *et al.,* (2010) and Jat *et al.,* (2015) in cucumber. For sex ratio, out of 25 crosses, 10 crosses over better parent and 9 crosses over commercial check exhibited significant negative heterosis. The cross IIHR 341 × Punjab Naveen (-29.64 %)had showed maximum and significant heterosis over better parent which is low as compared to -80.14 per cent reported by Sundaram (2007) in bitter gourd (Table 1–3).

Table.1 Analysis of variance (mean sum of squares) of line × tester analysis for various characters in cucumber

Sl. No.	Character	Replications	Genotypes	Parents	Parents vs Crosses	Crosses	Lines	Testers	Line × Tester	Error
	Degree of freedom	1	34	9	1	24	4	4	16	34
1	Vine length (cm)b	12.85	1037.40**	538.52**	0.02**	553.01**	1580.53*	834.32*	225.81**	15.59
2	No. of branches per vine	0.25	0.71**	0.27*	10.90**	0.46**	1.83 **	0.33 NS	0.15 NS	0.09
3.	No. of nodes per vine	0.01	32.80**	5.14**	439.64**	26.22**	102.38**	8.46 NS	11.63**	0.23
4.	Node of female flower appearance	0.13	1.59**	1.34**	4.95**	1.55**	3.71*	1.60 NS	1.00**	0.05
5.	Node of male flower appearance	0.04	0.74**	0.48**	0.10 NS	0.87 **	1.69 NS	0.73 NS	0.70**	0.01
6.	Days to first fruit harvest	0.08	30.24**	4.93 NS	367.65**	25.68**	101.38**	5.32 NS	11.84*	5.06
7.	Sex ratio	0.01	1.34**	0.40**	25.31**	0.70**	2.54**	0.38 NS	0.32**	0.06
8.	Days to female flower anthesis	0.03	27.91**	10.05*	429.94**	17.86**	33.92 NS	17.58 NS	13.91**	3.86
9.	Number of fruits per plant	0.192	2.04**	0.92**	0.23 NS	2.54**	7.29*	0.16 NS	1.95**	0.07
10.	Fruit diameter (cm)	0.19	0.78**	0.32**	6.77**	0.71**	3.21**	0.04 NS	0.25*	0.09
11.	Fruit length (cm)	0.684	20.55**	4.38**	241.05**	17.42**	82.62**	5.05 NS	4.21**	0.23
12.	Average fruit weight (g)	92.20	48485.31**	28037.32**	141301.39**	52285.98**	231923.90 **	19514.9	15569.3**	62.78
13.	Fruit yield per plant (kg)	0.03	2.11**	0.42 NS	15.92 NS	2.17*	9.71**	1.92**	0.35 NS	0.89

*and ** indicate significance of values at p=0.05 and p=0.01, respectively, NS: Non significant

Table.2 Per se performance of parents and crosses for earliness, growth and yield parameters in cucumber

Sl. No.	Genotypes	Vine length (cm)	No. of branches per vine	No. of nodes per vine	Node of female flower appearance	Node of male flower appearance	Days to first fruit harvest	Avg. fruit weight (g)	Fruit yield per plant (kg)
1.	IIHR 285 × Poinsette	194.30	5.10	26.10	5.10	2.30	49.75	256.35	1.35
2.	IIHR 285 × Phule Shubhangi	180.35	5.30	19.30	5.80	3.65	50.80	260.60	1.40
3.	IIHR 285 × Punjab Naveen	214.15	5.30	24.50	4.40	2.30	53.10	386.05	1.59
4.	IIHR 285 × Pusa Uday	223.13	5.10	25.30	4.95	2.45	52.55	415.15	2.80
5.	IIHR 285 × Kerala-2	211.10	5.10	22.10	4.85	1.95	51.60	520.65	3.10
6.	IIHR 341× Poinsette	175.30	5.70	20.68	5.20	2.15	49.40	292.75	3.10
7.	IIHR 341 × Phule Shubhangi	212.10	6.00	26.80	4.80	3.25	58.30	278.80	2.75
8.	IIHR 341 × Punjab Naveen	217.10	5.50	26.30	4.75	3.40	51.65	403.05	3.45
9.	IIHR 341 × Pusa Uday	219.00	5.50	27.30	4.50	1.95	48.75	522.30	3.15
10.	IIHR 341 × Kerala-2	214.40	5.50	22.25	4.40	1.90	53.15	358.15	3.65
11.	IIHR 304 × Poinsette	206.15	5.00	18.45	5.35	3.25	50.80	293.65	2.00
12.	IIHR 304 × Phule Shubhangi	184.15	5.15	17.70	5.25	1.85	52.25	327.05	1.75
13.	IIHR 304 × Punjab Naveen	211.65	4.80	21.40	5.75	1.80	49.40	250.80	1.55
14.	IIHR 304 × Pusa Uday	219.35	5.30	18.70	6.80	1.75	53.65	369.30	2.75
15.	IIHR 304 × Kerala -2	211.25	5.50	19.30	5.55	2.25	54.55	515.70	2.35
16.	Green Long × Poinsette	221.30	5.40	24.60	4.05	2.55	46.10	557.05	4.65
17.	Green Long × Phule Shubhangi	226.10	6.50	24.30	4.60	3.45	54.75	670.70	2.70
18.	Green Long × Punjab Naveen	233.00	6.30	22.60	4.70	3.25	55.15	601.75	3.35
19.	Green Long × Pusa Uday	241.20	6.20	26.70	4.50	2.40	46.25	698.65	4.63
20.	Green Long × Kerala -2	223.25	5.60	28.40	4.40	2.50	54.00	599.20	4.05
21.	Pondicherry- 1 × Poinsette	228.50	5.75	27.70	5.35	3.50	57.60	717.65	2.25

22.	Pondicherry- 1 × Phule Shubhangi	231.00	6.30	29.30	4.20	2.55	58.55	747.75	3.95
23.	Pondicherry- 1 × Punjab Naveen	234.50	6.35	28.60	4.60	3.65	46.35	699.25	4.50
24.	Pondicherry- 1 × Pusa Uday	226.00	6.20	29.00	7.30	3.30	56.35	683.85	3.75
25.	Pondicherry- 1 × Kerala 2	223.15	5.60	24.50	7.25	3.40	55.75	547.65	4.40
	Lines								
26.	IIHR 285	182.60	4.50	17.70	6.10	2.20	60.45	202.75	2.05
27.	IIHR 341	186.00	4.05	18.55	4.75	2.10	58.35	206.10	2.10
28.	IIHR 304	148.60	4.38	16.50	6.15	2.70	59.35	344.80	2.25
29.	Green Long	180.80	4.85	18.33	4.35	2.35	56.85	480.75	2.55
30.	Pondicherry- 1	205.20	5.30	20.55	7.15	3.15	55.45	515.70	2.68
	Testers								
31.	Poinsette	163.25	4.82	20.55	5.35	2.45	56.15	330.70	1.25
32.	Phule Shubhangi	169.93	4.50	18.25	5.50	3.40	56.15	377.90	1.75
33.	Punjab Naveen	186.10	4.90	15.75	6.15	2.45	57.45	376.75	1.60
34.	Pusa Uday	186.10	5.05	19.20	5.40	2.45	56.65	405.70	1.58
35.	Kerala-2	197.50	4.95	19.90	6.35	3.45	58.10	402.85	1.63
	Check								
36.	Chitra	201.50	5.20	20.00	5.70	3.45	60.45	510.35	3.00
	S.Em+_	3.94	0.30	0.48	0.24	0.12	2.24	7.92	0.94
	CD at 5%	8.15	0.62	1.00	0.50	0.26	4.64	16.35	1.95
	CD at 1%	11.04	0.84	1.36	0.68	0.35	6.29	22.16	2.65

Table.3 Heterosis (%) over better parent, the best parent and the commercial check for Vine length, No. of branches /vine, and Fruit yield per plant (kg)

Sl. No.	Cross	Vine length (cm)			No. of branches per vine			Fruit yield per plant (kg)		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1.	IIHR 285 × Poinsette	6.41**	7.47**	-3.41	5.92	5.15	-1.92	-34.15	-47.06**	-55.16**
2.	IIHR 285 × Phule Shubhangi	-1.23	-0.25	-10.34**	17.78*	9.28	1.92	-31.95	-45.29**	-53.26**
3.	IIHR 285 × Punjab Naveen	15.07**	18.45**	6.46	8.27	9.28	1.92	-22.68	-37.84**	-47.26**
4.	IIHR 285 × Pusa Uday	19.90**	23.41**	10.92**	0.99	5.15	-1.92	36.59**	9.80	-6.60
5.	IIHR 285 × Kerala-2	6.89**	16.76**	4.95	3.03	5.15	-1.92	51.22**	21.57	3.53
6.	IIHR 341× Poinsette	-5.75**	-3.04	-12.85**	18.38**	17.53**	9.62	47.62**	21.57	3.53
7.	IIHR 341 × Phule Shubhangi	14.03**	17.31**	5.44	33.33**	23.71**	15.38*	30.95	7.84	-8.30
8.	IIHR 341 × Punjab Naveen	16.66**	20.08**	7.93	12.36	13.40*	5.77	64.29**	35.29**	13.30*
9.	IIHR 341 × Pusa Uday	17.68**	21.13**	8.87*	8.91	13.40*	5.77	50.00**	23.53**	5.30
10.	IIHR 341 × Kerala-2	8.56**	18.58**	6.59	11.11	13.40*	5.77	63.81**	43.14**	21.60**
11.	IIHR 304 × Poinsette	26.28**	14.02**	2.49	3.84	3.09	-3.85	-11.11	-21.57	-33.33**
12.	IIHR 304 × Phule Shubhangi	8.37**	1.85	-8.45*	14.44*	6.19	-0.96	-22.22	-31.37**	-41.60**
13.	IIHR 304 × Punjab Naveen	13.73**	17.06**	5.22	-1.94	-1.03	-7.69	-31.11	-39.22**	-48.30**
14.	IIHR 304 × Pusa Uday	17.87**	21.32**	9.05*	4.95	9.28	1.92	22.22	7.84	-8.30
15.	IIHR 304 × Kerala -2	6.96**	16.84**	5.02	11.11	13.40*	5.77	4.44	-7.84	-21.60**
16.	Green Long × Poinsette	22.40**	22.40**	10.02*	11.34	11.34	3.85	68.22**	61.57**	55.79**
17.	Green Long × Phule Shubhangi	25.06**	25.06**	12.40**	34.02**	34.02**	25.00**	5.88	5.88	-10.00
18.	Green Long × Punjab Naveen	25.20**	28.87	15.83**	28.70**	29.90**	21.15**	31.37**	31.37**	11.60
19.	Green Long × Pusa Uday	17.54**	33.41**	19.91**	22.77**	27.84**	19.23**	66.47**	66.47**	54.30**
20.	Green Long × Kerala -2	13.04**	23.48**	10.99*	13.13*	15.46*	7.69	58.82**	58.82**	35.53**
21.	Pondicherry- 1 × Poinsette	11.35**	26.38**	13.60**	8.49	18.56**	10.58	-11.76	-11.76	-25.26**
22.	Pondicherry- 1 × Phule Shubhangi	12.57**	27.77**	14.84**	18.87**	29.90**	21.15**	47.66**	54.90**	31.32**
23.	Pondicherry- 1 × Punjab Naveen	14.28**	29.70**	16.58**	19.81**	30.93**	22.12**	55.79**	62.35**	50.47**
24.	Pondicherry- 1 × Pusa Uday	21.44**	25.00**	12.35**	16.98**	27.84**	19.23**	47.06**	47.06**	35.89**
25.	Pondicherry- 1 × Kerala 2	8.75**	23.42**	10.94*	5.66	15.46*	7.69	4.47	9.80	-6.60
	S.Em+_	3.94	3.94	3.94	0.30	0.30	0.30	0.94	0.94	0.94
	CD at 5%	8.15	8.15	8.15	0.62	0.62	0.62	1.95	1.95	1.95
	CD at 1%	11.04	11.04	11.04	0.84	0.84	0.84	2.65	2.65	2.65

*and ** indicate significance of values at p=0.05 and 0.01, respectively.

BP- Heterosis over better parent BTP- Heterosis over the best parent (Green Long) CC- Heterosis over the commercial check (Chitra)

The cross IIHR 341× Poinsette (-21.73 %) exhibited the maximum and negative heterosis over the commercial check and is comparable with earlier report -29.90 per cent by Thangamani *et al.,* (2011) in bitter gourd. The parent Poinsette (47.55) showed significant negative heterosis. The crosses Green Long × Poinsette (39.60) and Pondicherry 1 × Punjab Naveen (41.00) exhibited the significant negative heterosis. The reason for significant negative heterosis may be due to the presence of dominant loci in different directions leading to cancellation of effects (Pandey *et al.*, 2005). Most of the crosses shown significant negative heterosis over commercial check and few crosses exhibited the significant negative heterosis over better parent. The crosses showing no heterosis indicated that the parent involved in the cross do not differ in the gene frequency with respect character under study (Pandey *et al.,* 2005). Increase in the fruit yield per vine is an important criteria to increase the productivity. Pondicherry- 1 (2.68) and Pondicherry- 1 × Punjab Naveen (4.65 kg) exhibited the maximum yield potential among parents and hybrids respectively. Hanchinamani and Patil (2009) reported that the maximum yield attributed to increase in average fruit weight and total number of fruits per plant. For yield and yield attributing characters heterosis in positive direction is desirable. Only 16 crosses exhibited the significant standard heterosis over the check Chitra. Among 25 crosses, 13 crosses exhibited the significant positive heterobeltiosis and maximum was observed in Green Long × Pusa Uday (68.22 %). Similar results were reported by Airina *et al.,* (2013) and Singh *et al.,* (2015). The cross Pondicherry- 1 × Punjab Naveen (55.79 %) exhibited the significant positive heterosis over the check. It is in line with the research findings of Arya and Singh (2014) and Jat *et al.,* (2015) in cucumber.

In conclusion, the magnitude of heterosis over the standard check (Chitra) has been identified for important traits viz earliness, growth and yield parameters. The range of various traits was also high for the yield contributing traits viz for vine length the range observed was from -12.85 to 19.91, for node at first female flower appearance -12.85 to 19.91, for node of male flower appearance -49.28 to 5.8, for days to first fruit harvest -3.14 to -23.74, for sex ratio -20.27 to 34.17, for days to female flower anthesis -9.67 to -28.46, for number of fruits per plant -17.68 to 44.44, for fruit length -10.05 to 41.94, for average fruit weight -45.37 to 46.52 and fruit yield per plant -53.16 to 55.79. The hybrids viz Green long × Poinsette, Green long × Pusa Uday, Pondicherry 1 × Punjab Naveen exhibited the maximum significant standard heterosis for yield per vine, for fruit length, average fruit weight, number of fruits per vine over the check (Chitra) and which were considered as promising hybrids.

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How to cite this article:

Preethi, G.P., M. Anjanappa, R.K. Ramachandra and Vishnuvardhana. 2019. Heterosis Studies for Growth and Yield Traits in Cucumber (*Cucumis sativus* L.) *Int.J.Curr.Microbiol.App.Sci.* 8(03): 916-924. doi: https://doi.org/10.20546/ijcmas.2019.803.109