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Exploitation of heterosis for yield and contributing traits in cucumber (*Cucumis sativus* L.)

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Abstract
Fourty five non reciprocal F_1 hybrids derived from ten diverse cucumber genotypes were evaluated in complete randomized block design (RBD) with three replications during summer 2006 to study heterosis over better parent and mid parent.
The results on earliness, vegetative characters and yield and its components, the hybrids Swarna ageti x Patna-3, PCUC-28 x Peelibheet local and CU-5 x Patna-3 were found to be the most promising. Heterosis to the tune of 23.0, 74.42 and 73.45 percent over their better parents and 30.68, 78.78 and 15.93 percent over their mid parents respectively. Therefore, these three hybrids were identified for evaluation at multi location and commercial exploitation.

Keywords: cucumber, F_1 hybrids, yield characters

Introduction
Wide range of genetic variability is available in cucumber (*Cucumis sativus* L.), providing good scope for improvement in yield and other characters of cucumber through selection. Cucumber being monoecious in nature is very well suited for hybrid seed production. Heterosis breeding is one of the most efficient tool to exploit the genetic diversity in cucumber.
Hayes and Jones (7) were the first to observe hybrid vigour in cucumber. Since then sporadic attempts have been done to observe the performance and heterotic effect in this crop. Moreover, there is a need to develop suitable hybrids. The hybrid varieties have advantage of being early, vigorous, high yielding, tolerant to disease and pests and more efficient in use of water and fertilizers. Which may be utilized on commercial scale. Therefore this study was conducted to generate information about nature and magnitude of heterosis and general and specific combining effects for different economic characters in a diallel cross system (excluding reciprocals) using ten parents of cucumber.

Materials and Methods
Ten genetically diverse parental lines of cucumber were used to develop 45 F_1s following a half diallel mating system, excluding reciprocals. The parental lines used were Swarna ageti, PCUC-28, CU-5, VRC-18-2, VRC-11-2, Patna-3, Swarna sheetal, Peelibheet local, Baramasi and BSC-2. The 45 F_1s along with their ten parents were evaluated during summer 2006 following completely randomized block design (RBD), which was replicated three times at Indian Institute of Vegetable Research Varanasi. All treatments were grown in 5.60 m long single row called plot, maintaining row to row and plant to plant distance of 2.0 m and 40 cm, respectively. Five plants were selected and tagged for recording the observations on different characters viz., vine length (m), number of branches per plant, days to appearance of first pistillate flower, nodal position of first female flower, number of fruits per plant, average fruit weight (g) and yield per plant (kg). All the cultural operations and plant protection measures were carried out as per schedule of crop. Heterosis was calculated as the percentage increase of F_1 performance over the better parent and mid parent.

Results and Discussion
The analysis of variance showed significant difference due to treatments for all the characters except parent Vs crosses (Table -1). Estimates of heterosis of the crosses were calculated over their respective better parent. In cucumber, flowering time, measured as the days to appearance of first pistillate flower and nodal position of first female flower, is a good index of earliness [Miller and Quisenberry (8)]. Earliness (indicated by negative estimates of heterosis) is a well recognized and prime objective of any hybrid breeding programme as it helps the

grower to earn a good early market price. It may be mentioned here that heterosis for early maturity is common in hybrid and may greatly increase the economic yield. When price differentials for early marketing are high (Riggs (12)). For days to appearance of first pistillate flower, the hybrids Swarna ageti x Patna-3 (-10.24%), CU-5 x Patna-3 (-7.87%) Swarna ageti x VRC-11-2 (-7.75%) and Swarna ageti x Swarna sheetal (-6.98%) were found to be heterosis over better parent. VRC-18-2 x VRC-11-2 (-57.14%), Swarna ageti x VRC-18-2 (-52.63%), Swarna ageti x Swarna sheetal (-52.63%) and VRC-18-2 x BSC-2 (-42.86%) were the hybrids with significant heterosis for nodal position of first female flower. All the above hybrids were significantly earlier.

Similar results have also been reported by Dogra *et al.* (3); Vijay Kumari *et al.* (17); and Pandey *et al.* (11). It is now a well construed fact that fruit yield per plant is positively associated with vegetative characters particularly number of branches per plant and vine length (Srivastava and Srivastava (16)); Fredrick and Staub (5); Although, there are some contrasting reports regarding the positive association of vine length with fruit yield as Singh *et al.* (13) and Dogra *et al.* (3) have reported that vine length did not contribute towards yield. But in this experiment, it was noted that as the crop duration progressed, the vine length kept on increasing bearing more of female flowers thus adding to the total yield per plant. Peelibheet local x Baramasi was the hybrid exhibiting the maximum heterosis over better parent for vine length (33.12%) and Swarna ageti x BSC-2 was the hybrid exhibiting the maximum heterosis over better parent for number of branches per plant (29.0%) followed by Peelibheet local x BSC-2 (25.47%) respectively for the two traits Patna-3 x Peelibheet local (44.64%) was another good hybrid for vine length whereas Swarna sheetal x BSC-2 (34.49%) for number of branches per plant over mid parent.

Delaney and Lower (2) and Solanki *et al.* (15) have also reported similar results. Yield heterosis has never been an individual and isolate effect, but it is expressed through component heterosis (Mohanty and Mishra (9). Hybrid vigour of even small magnitude of individual yield components may have additive or synergistic effect on the end product as Graffius (6) had mentioned that heterosis for yield is the result of interaction of simultaneous increase in the expression of heterosis for yield components. Among the various yield components, average fruit weight is one of the important one. PCUC-28 x Peelibheet local (30.09% and 31.06%) was adjudged as the best hybrid for average fruit weight followed by PCUC-28 x VRC-18-2 (26.38% and 28.47%) over better and mid parent respectively.

Yield improvement is the foremost breeding objective of any production breeding programme. Yield at marketable stage in cucumber is dependent primarily on number of fruit and fruit weight. The latter however is a function of time, which is under the control of grower. Hayes and Jones (7) and Singh and Amarchand (14) reported that the most important characters in cucurbits.

Which may be considered the best measure of increased vigour is the number of fruits per plant. Thus it would be possible to achieve yield improvement in this crop by manipulating this particular trait. The heterosis data pertaining to number of fruits per plant revealed that 45 crosses manifested positive significant heterosis over better and mid parent, all in desirable direction. The best heterotic hybrid was Patna-3 x Swarna sheetal (79.10% and 106.52%) followed by VRC-18-2 x Patna-3 (76.18 and 76.90%) over better and mid parent respectively. Which is ranged from 12.46% (Swarna ageti x PCUC-28) to 106.52% (Patna-3 x Swarna sheetal) over mid parent heterosis for number of fruits per plant. Similarly maximum negative heterosis for nodal position of first female flower was exhibited by VRC-18-2 x VRC-11-2 and Patna-3 x Swarna sheetal over better parent and mid parent respectively. Yield per plant is complex character. It is multiplicative product of several basic components character of yield (Graffius, 6).

Heterosis for yield per plant over better parent and mid parent exhibited a wide range, the value varied from 8.07 to 80.95 percent and 14.51 to 102.11 percent respectively. All crosses showed significant positive heterosis over better and mid parent in desired direction. The results are also in conformity with that obtained by Pandey *et al.* (11), Munshi *et al.* (10), Bairagi *et al.* (1) and Dubey and Maurya (4).

From the above results, one of the interesting facts to be learnt was that almost all the best performing hybrids produced significantly higher number of fruits per plant with higher average fruit weight accompanied with earliness to flowering, signifying the utility of hybrids from farmer's point of view. In the present investigation four hybrids namely VRC-18-2 x Patna-3, Baramasi x BSC-2, PCUC-28 x Peelibheet local and Baramasi x BSC-2 were found to be the potential heterotic combinations in terms of yield and most of the other yield contributing traits. Therefore, these four hybrids may worth exploiting for heterosis breeding and may also be recommended for commercial cultivation by the farmers after some additional multilocation traits.

Table 1: Analysis of variance of diallel progenies for seven characters in cucumber

Source of Variation	d.f.	Vine length (m)	Number of branches per plant	Days to appearance of first pistillate flower	Nodal position of first female flower	Number of fruit per plant	Average fruit weight (g)	Yield per plant (kg)
Replications	2	0.0032	0.0038	0.0242	0.2969	0.1276	177.212	0.0265
Treatments	54	0.2494**	0.1341**	28.373**	7.306**	2.906**	1109.385**	0.2969**
Parents	9	0.4345**	0.0795**	34.444**	13.851**	1.292**	447.193**	0.1027**
Crosses	44	0.2151**	0.1475**	27.078**	4.982**	1.243**	798.332**	0.1383**
Parent Vs. Crosses	1	0.0890**	0.0316	30.708**	50.688**	90.631**	20757.472**	9.020**
Error	108	0.0022	0.0129	1.005	1.025	0.1263	83.418	0.0082

Table 2. Mean performance of parents for different characters in cucumber

Parent	Vine length (m)	Number of branches per plant	Days to appearance of first pistillate flower	Nodal position of first female flower	Number of fruits per plant	Average fruit weight (g)	Yield per plant (kg)
Swarna ageti	2.30	1.33	43.00	6.33	4.65	234.61	1.21
PCUC-28	1.86	1.36	41.33	3.33	5.19	239.10	1.36
CU-5	1.64	1.34	46.02	2.67	4.57	223.78	1.13
VRC-18-2	1.36	1.05	36.01	7.00	4.10	247.16	1.19

VRC-11-2	1.11	1.43	43.00	7.00	4.32	217.07	1.01
Patna-3	0.99	1.18	42.33	4.00	4.07	245.02	1.13
Swarna sheetal	1.62	1.06	44.00	7.33	2.99	216.43	0.77
Peelibheet local	1.25	1.17	40.33	2.31	5.34	242.71	1.43
Baramasi	1.58	1.56	38.00	5.00	4.17	237.56	1.10
BSC-2	1.46	1.24	36.00	8.33	4.21	217.62	1.05

Table 3: Top four hybrids selected separately on the basis of cross mean and heterosis over better parent and mid parent in cucumber

Characters	Cross mean	Crosses	Heterosis (%)	
			Over better parent (BP)	Over mid parent (MP)
Vine length (m)	2.10	Peelibheet local x BaramasiVRC-11-2 x	33.12**	48.65**
	1.48	Patna-3	32.63**	40.41**
	1.62	Patna-3 x Peelibheet local	29.60**	44.64**
	1.61	VRC-11-2 x Peelibheet local	29.07**	36.53**
Number of branches per plant	1.72	Swarna ageti x BSC-2	29.00**	33.51**
	1.56	Peelibheet local x BSC-2	25.47**	29.46**
	1.55	Swarna sheetal x BSC-2	24.40**	34.49**
	1.64	Swarna ageti x Patna-3	23.00**	30.68**
Days to appearance of first pistillate flower (days)	38.00	Swarna ageti x Patna-3	-10.24**	-10.94**
	39.00	CU-5 x Patna-3	-7.87**	-11.70**
	39.67	Swarna ageti x VRC-11-2	-7.75**	-7.75**
	40.00	Swarna ageti x Swarna sheetal	-6.98**	-8.05**
Nodal position of first female flower	3.01	VRC-18-2 x VRC-11-2	-57.14**	-57.14**
	3.00	Swarna ageti x VRC-18-2	-52.63**	-55.00**
	3.02	Swarna ageti x Swarna sheetal	-52.63**	-56.10**
	4.00	VRC-18-2 x BSC-2	-42.86**	-47.83**
Number of fruits per plant	7.28	Patna-3 x Swarna sheetal	79.10**	106.52**
	7.22	VRC-18-2 x Patna-3	76.18**	76.90**
	7.01	Baramasi x BSC-2	66.43**	67.16**
	6.90	VRC-11-2 x Patna-3	59.68**	64.56**
Average fruit weight (g)	315.73	PCUC-28 x Peelibheet local	30.09**	31.06**
	312.36	PCUC-28 x VRC-18-2	26.38**	28.47**
	266.16	VRC-11-2 x BSC-2	22.30**	22.46**
	258.72	Swarna sheetal x BSC-2	18.88**	19.21**
Yield per plant (kg)	2.15	VRC-18-2 x Patna-3	80.95**	85.90**
	1.94	Baramasi x BSC-2	76.06**	79.88**
	2.50	PCUC-28 x Peelibheet local	74.42**	78.78**
	1.96	CU-5 x Patna-3	73.45**	73.71**

**, Significant and 1 percent level of probability, BP=Better parent, MP = mid parent

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