Exploiting Heterosis for Yield and Horticultural Traits in Cucumber (*Cucumis sativus* L.)

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(Received: 10 January 2011; Revised: 8 April 2011; Accepted: 25 April 2011)

Hybrids in cucumber have several well known advantages over the open-pollinated varieties. To find out more appropriate combinations for developing superior hybrids in cucumber, the crosses among eight parents (including two gynoecious lines) were attempted in half diallel fashion. Twenty-eight F_1s, eight parents and one check were grown in a Randomized Block Design with three replications at two different locations *viz*. Nauni (L1) and Chambaghat (L2). Sufficient genetic diversity among parents and F_1s for all the traits infers the scope of improvement through selection in the parental material. Among the parents, G_2 took minimum value for number of days to first female flower appearance, node number of first female flower and days to marketable maturity. Heterobeltiosis and standard heterosis for earliness were maximum in EC173934 x LC-40 and G_2 x Gyn1, respectively. The cross K-90 x G_2 exhibited maximum heterobeltiosis and standard heterosis for yield and number of fruits.

Key Words: Cucumber, Gynoecious line, Half diallel, Heterobeltiosis, Heterosis breeding

Introduction

Introduction of hybrids and their success in cucumber (*Cucumis sativus* L.), a member of family Cucurbitaceae has made it imperative for the breeders to find out more appropriate combinations to develop superior hybrids as these have several well known advantages over the open-pollinated varieties. Heterosis is of direct relevance for developing hybrids and effective tool in the hands of breeders for effective improvement in yield, earliness and quality. In cucumber too, success of F_1 hybrids has encouraged the breeders to develop hybrids which are early, vigorous, high yielding, tolerant to diseases and insect-pests and more efficient in the use of water and fertilizers. Moreover, use of gynoecious lines as a parent in producing cucumber hybrids ensures high yield level in the resultant hybrids

Currently, very few hybrids have been developed by public sector and the farmers are purchasing hybrid seeds from the private sector companies, who are charging exorbitantly. Stability of genotype is also important for its wider adaptation. To tide over the situation, there is a need to make concentrated efforts to develop F_1 hybrids and making their seed available to the farmers at a reasonable price. So, the present investigations were conducted to exploit hybrid vigour for developing the best suitable combination which can replace the conventional varieties as well as hybrids from private sector and also to make F_1 hybrids seed production cost effective with the use of gynoecious lines.

Materials and Methods

The present investigations were carried out at two locations *viz.* Experimental Farms, Nauni (L1) and Chambaghat (L2) of the Department of Vegetable Science, Dr. YS Parmar University of Horticulture and Forestry, Solan (Himachal Pradesh). Crosses among eight parents were attempted in a half diallel fashion. All the parents except two gynoecious lines were of monoecious type. The materials comprising twenty eight F_1s, eight parents and one check (Pusa Sanyog F_1) were grown in a Randomized Block Design with three replications at both the locations. Spacing was 1.25x 1.00 m. Data were recorded on five randomly selected plants/plot at each location for yield and quantitative

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characters. At each location, data were recorded on 555 plants for days to first female flower appearance, node to first female flower, days to marketable maturity, internodal length (cm), number of fruits/plant, yield/plant (Kg), fruits weight (g), fruit length (cm), fruit width (mm), TSS (^{o} B) and flesh to seed cavity ratio. Mean values were subjected to statistical analysis according to Fisher (1938) for analysis of variance. Heterotic effects of F_1s were worked out over better parents and over check and expressed as per cent increase or decrease over mean values.

Results and Discussion

Analysis of variance (Tables 1 and 2) indicated sufficient genetic diversity among parents and F_1s for all the traits at both the locations which infers scope of improvement through selection in the parental material.

Among the parents, G_2 took minimum value for number of days to first female flower appearance, node number of first female flower and days to marketable maturity followed by Gyn1 while EC173934 as well as LC-40 exhibited maximum values for these traits (Table 3). Very few crosses exhibited heterobeltiosis for days to first female flower appearance, node number of first female flower appeared and days to marketable maturity being maximum in EC173934xLC-40 at both locations (Tables 5 and 6). Heterosis over check variety was maximum in G2xGyn1 followed by K-90xG2 for these traits. Similar results on heterosis were reported by Pyzhenkov and Kosareva (1981) and Musamade and Kale (1986) for days to first female flower appearance; and by El-Shawaf (1980) for node number of first female flower and days to marketable maturity. In accordance with present findings, Doligibh and Sidorova (1983) and Singh *et al.* (1999) observed heterosis for earliness. Genotype or cross combination producing female flower earlier are desirable because ultimately the fruit is to develop from female flower. Similarly, appearance of female flowers on lower nodes is an indicative of earliness. Uniformity in results at different locations gives an indication of the authenticity of heterotic combinations.

G_2 recorded minimum internodal length. Among F_1s, LC-40xGyn1 observed minimum internodal length closely followed by K-90xG_2 at L1 and K-90xG2 closely followed by LC-40xGyn1 at L2. At L1, Heterobeltiosis and standard heterosis were maximum in LC-40xGyn1 while heterosis over better parent was maximum in PoinsettexLC-40 and over check variety in K-90xG2 at L2. Minimum internodal length means more number of nodes/vine for fruit bearing.

Table 1. Analysis of variance for plant traits in cucumber

Source of variation	Df	Days to first female flower appearance		Node to first female flower appearance		Days to marketable maturity		Internodal length		No. of fruits/plant		Yield/plant (Kg)	
		L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2
Genotype	35	508.72*	396.22*	24.12*	32.36*	531.33*	436.21*	10.95*	8.31*	8.72*	12.35*	0.90*	0.91*
Error	70	1.67	1.29	0.68	0.61	1.69	1.33	0.82	1.07	0.34	0.45	0.004	0.03

* Significant at 5% level of significance
L1-Nauni; L2-Chambaghat

Table 2. Analysis of variance for fruit traits in cucumber

Source of variation	Df	Fruit weight (g)		Fruit length (cm)		Fruit width (mm)		TSS (^{o}B)		Flesh to seed cavity ratio	
		L1	L2	L1	L2	L1	L2	L1	L2	L1	L2
Genotype	35	3936.12*	3579.39*	11.62*	14.04*	1.24*	12.40*	0.055*	0.075*	0.004*	0.003*
Error	70	187.07	147.70	0.012	0.27	0.007	0.068	0.004	0.018	0.0001	0.0001

* Significant at 5% level of significance
L1-Nauni; L2-Chambaghat

Table 3. Mean performance of parents and F_1s for plant traits in cucumber

Crosses/ Parents	Days to first female flower appearance		Node no. of first female flower		Days to marketable maturity		Internodal length (cm)		No. of fruits/ plant		Yield/plant (kg)	
	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2
K-90	71.33	63.00	9.00	10.00	78.33	70.33	13.33	13.90	7.67	8.33	2.70	3.07
G_2	40.33	35.33	1.00	1.00	46.67	42.67	7.67	9.00	11.67	12.67	2.61	2.83
Poinsette	60.33	53.33	6.00	6.67	68.00	61.33	15.83	15.03	6.34	7.00	1.81	1.96
EC173934	85.33	76.67	11.67	12.67	94.67	85.00	14.10	13.93	7.67	8.33	1.79	1.99
K-75	63.00	56.33	8.33	10.67	72.33	64.33	15.00	15.20	6.68	7.00	2.15	2.70
LC-11	80.33	70.67	8.00	11.33	88.67	79.00	13.00	13.67	5.67	6.33	1.50	1.68
LC-40	85.33	73.33	12.67	13.33	93.67	80.33	12.67	13.70	5.67	6.33	1.77	2.08
Gyn_1	42.00	38.00	1.33	1.33	49.00	45.00	12.43	12.37	10.67	12.33	2.32	2.64
Pusa Sanyog (check)	52.67	45.00	4.33	5.67	60.33	52.33	10.66	11.93	10.61	11.67	2.71	3.03
K-90x G_2	47.00	41.33	3.33	4.33	54.33	48.00	10.66	10.30	13.33	14.67	3.75	4.05
K-90xPoinsette	59.33	54.33	5.67	8.67	67.00	62.00	11.67	13.00	8.33	8.67	2.04	2.29
K-90xEC173934	67.68	60.00	7.33	7.33	74.67	68.00	11.40	12.13	6.32	7.00	2.02	2.18
K-90xK-75	77.66	71.33	9.68	10.67	84.67	79.33	14.70	15.23	7.33	8.33	1.90	2.20
K-90xLC-11	82.33	73.33	7.34	9.33	90.33	81.00	16.00	16.00	6.67	7.67	2.02	2.33
K-90xLC-40	71.33	63.33	7.33	9.00	78.67	71.33	14.60	12.67	6.33	7.33	1.74	2.06
K-90x Gyn_1	51.33	43.67	4.33	4.33	57.32	50.67	12.67	12.00	11.67	12.33	3.20	3.42
G_2 xPoinsette	54.00	51.67	4.33	6.00	63.68	59.00	13.00	12.00	8.67	9.67	2.08	2.38
G_2 x EC173934	66.00	57.33	5.68	7.00	74.00	65.67	12.30	13.13	7.33	7.67	1.70	1.87
G_2x K-75	55.33	46.33	3.67	4.33	63.66	53.67	13.50	11.57	10.33	11.00	2.97	3.08
G_2 x LC-11	57.67	50.67	5.34	6.67	64.65	58.00	11.83	11.47	8.33	8.67	2.63	2.75
G_2 x LC-40	73.67	73.33	6.68	8.67	81.33	70.67	11.13	11.63	6.33	7.67	1.41	1.81
G_2 x Gyn_1	43.34	40.33	2.67	3.00	52.00	47.33	11.83	11.60	10.67	11.33	2.58	2.88
Poinsette x EC173934	73.33	68.33	6.34	7.67	82.00	76.67	11.93	12.33	7.33	8.33	1.81	2.12
Poinsettex K-75	64.33	57.33	6.68	8.00	72.00	65.67	17.27	16.00	7.32	8.33	2.31	2.67
Poinsettex LC-11	65.68	58.00	5.33	9.33	73.34	65.67	16.20	15.90	7.34	8.00	1.48	1.72
Poinsettex LC-40	69.00	63.00	6.67	8.33	76.68	71.00	12.07	11.53	6.66	7.67	1.80	2.06
Poinsettex Gyn_1	68.33	61.67	4.68	6.00	76.67	69.67	14.83	14.07	8.67	9.67	2.62	2.98
EC173934x K-75	74.00	68.00	10.00	13.33	81.00	76.00	15.37	14.27	6.33	7.33	1.51	1.83
EC173934x LC-11	81.00	74.00	6.33	8.33	88.66	82.00	14.37	13.77	6.33	7.00	1.90	2.13
EC173934x LC-40	75.32	66.33	7.00	7.33	84.00	74.33	13.03	14.83	7.34	7.67	1.87	2.00
EC173934x Gyn_1	72.68	61.67	9.68	6.67	80.67	69.67	13.00	14.53	6.66	7.33	1.47	1.68
K-75x LC-11	77.68	70.67	8.33	9.00	85.67	78.67	12.73	13.63	7.33	7.67	1.82	2.03
K-75x LC-40	81.34	72.67	7.33	7.33	90.00	80.33	11.67	12.00	6.33	7.00	1.76	1.97
K-75x Gyn_1	50.00	45.00	4.33	5.00	57.68	52.33	13.76	13.57	10.66	11.33	2.98	3.05
LC-11x LC-40	87.00	80.00	13.33	14.67	95.00	87.67	14.40	13.33	5.33	6.33	1.73	1.94
LC-11x Gyn_1	53.00	48.33	3.68	4.33	60.00	55.67	12.67	11.67	8.67	8.67	2.84	3.13
LC-40x Gyn_1	69.00	59.00	6.33	12.67	75.67	66.67	10.00	10.93	6.67	7.66	1.68	2.02
SE±	**1.06**	**0.93**	**0.68**	**0.64**	**1.06**	**0.94**	**0.74**	**0.85**	**0.47**	**0.55**	**0.05**	**0.14**
$CD_{0.05}$	**2.10**	**1.85**	**1.35**	**1.28**	**2.11**	**1.87**	**1.47**	**1.69**	**0.94**	**1.09**	**0.10**	**0.28**

L1-Nauni; L2-Chambaghat

Table 4. Mean performance of parents and F_1s for fruit traits in cucumber

Crosses/Parents	Fruit weight (g)		Fruit length (cm)		Fruit width (mm)		TSS (°B)		Flesh to seed cavity ratio	
	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2
K-90	318.33	316.67	19.73	19.17	6.80	6.97	3.00	3.03	0.21	0.20
G_2	226.67	231.67	12.65	12.27	5.47	5.57	2.90	2.93	0.19	0.20
Poinsette	268.33	261.67	16.47	16.40	4.32	4.40	2.77	2.80	0.25	0.25
EC173934	243. 32	250.00	14.17	14.07	6.31	6.17	3.30	3.47	0.22	0.21
K-75	305.00	296.67	16.43	16.90	6.16	6.10	2.99	3.03	0.21	0.21
LC-11	280.00	283.33	18.30	18.90	6.17	6.06	2.98	3.07	0.24	0.23
LC-40	281.66	290.00	14.63	14.90	6.60	6.43	3.03	3.13	0.20	0.21
Gyn_1	241.67	238.33	20.30	23.30	4.61	4.80	2.88	2.87	0.27	0.27
Pusa Sanyog (check)	268.33	266.67	16.67	16.83	5.27	5.20	3.23	3.33	0.21	0.22
K-90x G_2	251.66	260.00	14.28	14.20	5.53	5.23	2.95	2.93	0.18	0.19
K-90x Poinsette	246.67	256.67	17.62	17.80	5.54	5.40	3.27	3.30	0.18	0.17
K-90x EC173934	323.33	330.00	17.33	17.37	5.60	5.53	2.99	2.97	0.18	0.18
K-90x K-75	265.00	273.33	19.50	19.17	6.75	6.57	3.03	3.10	0.21	0.23
K-90x LC-11	378.32	356.67	18.15	18.43	6.63	6.13	2.94	2.97	0.17	0.18
K-90x LC-40	280.00	285.00	19.27	19.67	5.18	5.63	3.06	3.10	0.21	0.19
K-90x Gyn_1	250.00	253.33	18.25	18.23	5.37	5.50	2.98	2.97	0.20	0.20
G_2 xPoinsette	240.00	223.33	18.63	19.10	4.65	4.63	3.02	3.03	0.18	0.17
G_2 x EC173934	233.33	228.33	17.83	18.80	6.25	6.63	3.05	3.13	0.19	0.18
G_2x K-75	275.00	280.00	18.47	18.80	6.20	6.80	3.15	3.23	0.20	0.18
G_2 x LC-11	301.66	303.33	15.65	15.77	5.35	5.40	3.07	3.10	0.19	0.18
G_2 x LC-40	210.00	230.00	16.82	17.10	5.33	5.80	3.23	3.00	0.21	0.21
G_2 x Gyn_1	213.33	221.67	19.25	19.27	5.90	6.07	3.14	3.17	0.19	0.19
Poinsette x EC173934	263.33	273.33	19.38	17.93	5.47	5.63	3.13	3.27	0.32	0.32
Poinsettex K-75	291.66	303.03	16.65	15.80	5.75	5.50	3.23	3.23	0.17	0.17
Poinsettex LC-11	308.33	306.67	17.77	17.63	4.70	4.90	2.97	3.03	0.18	0.21
Poinsettex LC-40	228.33	230.00	20.10	20.13	5.73	6.27	2.78	2.93	0.25	0.25
Poinsettex Gyn_1	266.67	255.33	17.13	17.07	4.78	4.37	3.13	3.10	0.27	0.25
EC173934x K-75	265.00	271.67	17.40	17.20	5.85	6.03	2.87	2.87	0.21	0.21
EC173934x LC-11	305.00	316.67	18.97	18.90	6.08	6.17	2.98	3.04	0.26	0.26
EC173934x LC-40	248.33	241.67	18.37	18.27	5.28	5.77	3.00	3.00	0.22	0.22
EC173934x Gyn_1	231.66	228.33	18.75	18.60	5.32	5.40	3.12	3.03	0.21	0.22
K-75x LC-11	276.66	270.00	19.38	19.43	6.51	6.67	3.04	2.87	0.17	0.18
K-75x LC-40	271.67	268.33	18.43	18.67	5.25	5.20	3.20	3.30	0.18	0.18
K-75x Gyn_1	276.66	271.67	18.07	18.00	5.13	5.37	2.83	2.78	0.18	0.19
LC-11x LC-40	316.66	320.00	18.47	18.67	5.15	5.03	3.04	3.07	0.20	0.19
LC-11x Gyn_1	311.67	311.67	19.17	19.23	5.16	5.63	3.15	3.13	0.18	0.19
LC-40x Gyn_1	228.33	235.00	17.30	17.13	5.35	5.50	3.28	3.40	0.20	0.19
SE±	**11.17**	**9.92**	**0.09**	**0.18**	**0.07**	**0.21**	**0.05**	**0.11**	**0.009**	**0.008**
$CD_{0.05}$	**22.27**	**19.79**	**0.18**	**0.36**	**0.14**	**0.42**	**0.10**	**0.22**	**0.018**	**0.017**

L1-Nauni; L2-Chambaghat

Table 5. Heterotic response of F_1s for plant traits in cucumber at Nauni (L1)

Crosses	Percentage increase or decrease for											
	Days to first female flower appearance		Node no. of first female flower		Days to marketable maturity		Internodal length (cm)		No. of fruits/ plant		Yield/plant (kg)	
	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check
K-90 x G_2	16.53	-10.76	233.33	-23.08	16.43	-9.94	39.13	0.00	14.40	25.18	38.77	38.25
K-90 x Poinsette	-1.66	12.66	-5.57	30.77	-1.47	11.05	-12.50	9.37	8.70	-21.88	-24.32	-24.60
K-90 x EC173934	-5.14	28.47	-18.52	69.23	-4.68	23.76	-14.50	6.87	-17.39	-40.63	-25.31	-25.58
K-90 x K-75	23.28	47.47	16.00	123.08	17.05	40.33	10.25	37.81	-4.35	-31.25	-29.51	-29.77
K-90 x LC-11	15.42	56.33	-8.33	69.23	15.32	49.72	23.08	50.00	-13.04	-37.50	-25.06	-25.34
K-90 x LC-40	-0.47	34.81	-18.52	69.23	0.43	30.39	15.26	36.87	-17.39	-40.63	-35.56	-35.79
K-90 x Gyn_1	22.22	-2.53	225.00	0.00	17.01	-4.97	1.88	18.75	9.38	9.38	-18.52	18.08
G_2 x Poinsette	33.88	2.53	333.33	0.00	36.43	5.52	69.57	21.87	-25.71	-18.75	-20.54	-23.37
G_2 x EC173934	63.64	25.32	466.67	30.77	58.57	22.65	60.44	15.31	-37.14	-31.25	-34.82	-37.15
G_2 x K-75	37.19	5.06	266.67	-15.39	36.43	5.52	76.09	26.56	-11.43	-3.13	13.52	9.47
G_2 x LC-11	42.98	9.49	433.33	23.08	38.57	7.18	54.35	10.93	-28.57	-21.87	0.51	-3.08
G_2 x LC-40	82.65	39.87	566.67	53.85	74.29	34.81	45.22	4.37	-45.71	-40.63	-46.05	-47.97
G_2 x Gyn_1	7.44	-17.72	166.67	-38.46	11.43	-13.81	54.35	10.93	-8.57	0.00	-1.40	-4.92
Poinsette x EC173934	21.55	39.24	5.56	46.15	20.59	35.91	-15.37	11.87	-4.35	-31.25	0.00	-33.21
Poinsettex K-75	6.63	22.15	11.11	53.85	5.88	19.34	15.11	61.87	10.00	-31.25	7.75	-14.51
Poinsettex LC-11	8.84	24.68	-11.11	23.08	7.84	21.55	24.62	51.87	15.79	-31.25	-18.23	-8.49
Poinsettex LC-40	14.37	31.01	11.11	53.85	12.75	27.07	-4.74	13.12	5.26	-37.50	-0.55	-33.58
Poinsettex Gyn_1	62.70	29.75	250.00	7.69	56.46	27.07	19.30	39.06	-18.75	-18.75	13.09	-3.32
EC173934 x K-75	17.46	40.51	20.00	130.77	11.98	34.25	8.98	44.06	-17.39	-40.63	-29.77	-44.28
EC173934 x LC-11	0.83	53.79	-20.83	46.15	0.00	46.96	10.51	34.68	-17.39	-40.63	6.15	-29.89
EC173934 x LC-40	-11.72	43.04	-40.00	61.54	-10.32	39.23	2.90	22.18	-4.35	-31.25	4.28	-31.12
EC173934 x Gyn_1	73.02	37.98	625.00	123.08	64.63	33.70	4.56	21.87	-37.50	-37.50	-36.69	-45.88
K-75 x LC-11	23.28	47.47	4.17	92.31	18.43	41.99	-2.05	19.37	10.00	-31.25	-15.19	-32.72
K-75 x LC-40	29.10	54.43	-12.00	69.23	24.42	49.17	-7.90	9.37	-5.00	-40.63	-17.98	-34.93
K-75 x Gyn_1	19.05	-5.06	225.00	0.00	17.69	-4.42	10.72	29.06	0.00	0.00	28.49	9.84
LC-11 x LC-40	8.30	65.19	66.67	207.69	7.14	57.46	13.68	35.00	-5.88	-50.00	-2.26	-36.29
LC-11 x Gyn_1	26.19	0.63	175.00	-15.38	22.45	-0.55	1.88	18.75	-18.75	-18.75	22.73	4.92
LC-40 x Gyn_1	64.29	31.01	375.00	46.15	54.42	25.14	-19.57	-6.25	-37.50	-37.50	-27.34	-37.88

Cross combination K-90 x G_2 produced the maximum yield/plant and number of fruits/plant. The same cross recorded maximum heterosis over better parent as well over check variety for yield at both the locations and for number of fruits/plant at L1 only. PoinsettexK-75 recorded highest heterobeltiosis for number of fruits followed by K-90xG_2 while standard heterosis was maximum in K-90xG_2. However, among parents, K-90 and G_2 recorded the highest yield/plant and number of fruits/ plant, respectively, at both locations. Similar findings for number of fruits were reported by Om *et al*. (1978), Solanki *et al.* (1982), Lower *et al.* (1982), Musamade and Kale (1986) and Singh *et al.* (1999).

Positive and significant heterosis for yield was reported by many workers (Belik and Koziner 1968; Ghaderi and Lower 1978; Om *et al*. 1978; Solanki *et al*. 1982; Hormuzdi and More, 1989). Bairagi *et al*. (2002) also found heterosis for yield related traits. As evident from the results, heterotic crosses combinations performed stably for yield and contributing traits at both the locations.

Table 6. Heterotic response of F_1s for plant traits in cucumber at Chambaghat (L2)

Crosses	Percentage increase or decrease for											
	Days to first female flower appearance		Node no. of first female flower		Days to marketable maturity		Internodal length (cm)		No. of fruits/ plant		Yield/plant (kg)	
	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check
K-90 x G_2	16.98	-8.15	333.33	-23.53	12.50	-8.28	14.44	-13.69	15.78	25.71	32.07	33.52
K-90 x Poinsette	1.88	20.74	30.00	52.94	1.09	18.47	-6.47	8.94	4.00	-25.71	-25.22	-24.40
K-90 x EC173934	-4.76	33.33	-26.27	29.41	-3.32	29.94	12.71	1.68	-16.00	-40.00	-28.80	-28.02
K-90 x K-75	26.63	58.52	6.67	88.24	23.32	51.59	9.59	27.65	0.00	-28.57	-28.26	-27.47
K-90 x LC-11	16.40	62.96	-6.67	64.71	15.17	54.78	17.07	34.08	-8.00	-34.29	-24.02	-23.19
K-90 x LC-40	0.53	40.74	-10.00	58.82	1.42	36.31	-7.54	6.15	12.00	-37.14	-32.94	-32.20
K-90 x Gyn_1	14.91	-2.96	225.00	-23.53	12.59	-3.19	-2.97	0.56	0.00	5.71	11.41	12.64
G_2 x Poinsette	46.23	14.82	500.00	5.88	38.28	12.74	33.33	0.56	-23.68	-17.14	-15.88	-21.43
G_2 x EC173934	62.26	27.41	600.00	23.53	53.91	25.48	45.93	10.06	-39.47	-34.29	-33.88	-38.24
G_2 x K-75	31.13	2.96	333.33	-23.53	25.75	2.55	28.52	-3.07	-13.16	-5.71	8.82	1.65
G_2 x LC-11	43.40	12.59	566.67	17.65	35.94	10.83	27.41	-3.91	-31.58	-25.71	-2.94	-9.34
G_2 x LC-40	107.55	62.96	766.67	52.94	65.63	35.03	29.26	-2.51	-39.47	-34.29	-36.00	-40.22
G_2 x Gyn_1	14.15	-10.37	200.00	-47.06	10.94	-9.55	28.89	-2.79	-10.53	-2.86	1.77	-4.95
Poinsette x EC173934	28.13	51.85	15.00	35.29	25.00	46.50	-11.48	3.35	0.00	-28.57	6.01	-30.22
Poinsette x K-75	7.50	27.41	20.00	41.18	7.07	25.48	6.43	34.08	19.05	-28.57	-1.24	-12.09
Poinsette x LC-11	8.75	28.89	40.00	64.71	7.07	25.48	16.34	33.24	14.29	-31.43	-12.24	-10.33
Poinsette x LC-40	18.13	40.00	25.00	47.06	15.76	35.67	-15.81	-3.35	9.52	-34.29	-1.28	-32.20
Poinsette x Gyn_1	62.28	37.04	350.00	5.88	54.81	33.12	13.75	17.88	-21.62	-17.14	12.75	-1.87
EC173934 x K-75	20.71	51.11	25.00	135.29	18.14	45.22	2.39	19.55	-12.00	-37.14	-32.10	-39.56
EC173934 x LC-11	4.72	64.44	-26.47	47.06	3.80	56.69	0.73	15.36	-16.00	-40.00	6.85	-29.67
EC173934 x LC-40	-9.55	47.41	-42.00	29.41	-7.47	42.04	8.27	24.30	-8.00	-34.29	-4.00	-34.07
EC173934 x Gyn_1	62.28	37.04	400.00	17.65	54.82	33.12	17.52	21.79	-40.54	-37.14	-36.24	-44.51
K-75 x LC-11	23.44	57.04	-15.63	58.82	22.28	50.32	-0.24	14.25	9.52	-34.29	-24.82	-33.08
K-75 x LC-40	28.99	61.48	-31.25	29.41	24.87	53.50	-12.41	0.56	0.00	-40.00	-27.04	-35.06
K-75 x Gyn_1	18.42	0.00	275.00	-11.77	16.30	0.00	9.70	13.69	-8.11	-2.86	12.96	0.55
LC-11 x LC-40	13.20	77.78	29.41	158.82	10.97	67.52	2.44	11.73	0.00	-45.71	-6.72	-35.93
LC-11 x Gyn_1	27.19	7.41	225.00	-23.53	23.70	6.37	-5.66	-2.24	-29.73	-25.71	18.69	3.30
LC-40 x Gyn_1	55.26	31.11	850.00	123.53	48.15	27.39	-11.59	-8.38	-37.84	-34.29	-23.49	-33.41

K-90 recorded maximum fruit weight among parents while K-90xLC-11 produced significantly higher fruit weight (Tables 7 and 8). The same cross combination recorded maximum heterobeltiosis as well as standard heterosis. Ghaderi and Lower (1978), Solanki *et al.* (1982), Musamade and Kale (1986) and Hormuzdi and More (1989a) also observed heterosis for this trait.

Among the parents, Gyn1 produced significantly longer fruits at both the locations (Table 4). Maximum heterbeltiosis (Tables 7 and 8) was exhibited by G_2xEC 173934 followed by EC 173934xLC-40 (L1) and PoinsettexLC-40 (L2). However, maximum heterosis over check variety by PoinsettexLC-40 followed by K-90xK-75 at L1 and EC 173934xLC-40 followed by K-90 x LC-40 at L2. Maximum fruit width was produced by K-90. Heterobeltiosis was maximum in G_2xGyn1 at L1 and LC-11xLC-40 at L2 while standard heterosis was maximum in K-90xK-75 followed by K-90xLC-11 at L1 and G2xK-75 followed by K-75xLC-11 and K-90xK-75 at L2.

Table 7. Heterotic response of F_1s for fruit traits in cucumber at Nauni (L1)

Crosses	Percentage increase or decrease for									
	Fruit weight (g)		Fruit length (cm)		Fruit width (mm)		TSS (°B)		Flesh to seed cavity ratio	
	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check
K-90x G_2	-20.94	-6.21	-27.62	-14.30	-18.68	4.80	-1.67	-8.87	-10.00	-14.28
K-90x Poinsette	-22.51	-8.08	-10.69	5.74	-18.59	4.93	9.12	1.13	-28.00	-15.63
K-90x EC173934	1.57	20.50	-12.76	4.00	-17.65	6.13	-9.39	-7.53	-15.39	-14.04
K-90x K-75	-16.75	-1.24	-1.18	17.00	-0.69	27.99	1.22	-6.19	-1.59	-3.13
K-90x LC-11	18.75	40.99	-8.02	8.90	-2.45	25.71	-1.78	-8.97	-27.78	-18.75
K-90x LC-40	-12.04	4.35	-2.37	15.60	-23.82	-1.83	1.10	-5.36	3.23	0.00
K-90x Gyn_1	-21.47	-6.83	-21.67	9.50	-21.09	1.71	-0.67	-7.94	-24.39	-3.13
G_2 xPoinsette	-10.56	-10.56	13.16	11.80	-14.93	-11.81	4.02	-6.70	-29.33	-17.19
G_2 x EC173934	-4.11	-1304	25.88	7.00	-0.95	18.45	-7.58	-5.67	-12.31	-10.94
G_2x K-75	-9.84	2.48	12.37	10.80	0.76	17.56	5.35	-2.47	-4.76	-6.25
G_2 x LC-11	7.74	12.42	-14.48	-6.10	-13.30	1.33	2.79	-5.16	-22.22	-12.50
G_2 x LC-40	-25.44	-21.74	14.92	0.90	-19.28	1.01	6.83	0.00	3.33	-3.13
G_2 x Gyn_1	-11.73	-20.50	-17.38	15.50	7.86	1.81	8.28	-2.89	-29.27	-9.38
Poinsette x EC173934	-1.86	-1.86	17.71	16.30	-13.31	3.66	-5.05	-3.09	26.67	48.44
Poinsettex K-75	-4.37	8.69	-4.96	-6.10	-6.61	8.97	7.91	-0.10	-32.00	-20.31
Poinsettex LC-11	10.12	14.91	-2.91	6.60	-23.84	-10.99	-0.56	-8.25	-26.67	-14.06
Poinsettex LC-40	-18.94	-14.91	22.07	20.60	-13.18	8.65	-8.04	-13.92	1.33	18.75
Poinsettex Gyn_1	-0.62	-0.62	-26.47	2.80	3.61	-9.41	8.67	-3.09	-2.44	25.00
EC173934x K-75	-13.12	-1.24	5.88	4.40	-7.24	10.93	-13.03	-11.24	-4.62	-3.13
EC173934x LC-11	8.93	13.67	3.64	13.80	-3.59	15.29	-9.60	-7.73	8.33	21.88
EC173934x LC-40	-11.83	-7.45	25.51	10.20	-20.09	0.00	-9.09	-7.22	0.00	1.56
EC173934x Gyn_1	-4.79	-13.67	-19.53	12.50	-15.74	0.76	-5.56	-3.61	-21.95	0.00
K-75x LC-11	-9.29	-3.11	5.92	16.30	5.57	23.37	1.45	-6.08	-27.78	-18.75
K-75x LC-40	-10.93	1.24	12.17	10.60	-20.44	-0.44	5.73	-1.03	-15.87	-17.19
K-75x Gyn_1	-9.29	3.11	-22.46	8.40	-16.73	-2.84	-5.57	-12.58	-32.93	-14.06
LC-11x LC-40	12.43	18.01	0.91	10.80	-21.96	-2.34	0.55	-5.88	-18.06	-7.81
LC-11x Gyn_1	11.31	16.15	-17.74	15.00	-16.27	-2.14	5.59	-2.58	-32.93	-14.06
LC-40x Gyn_1	-18.94	-14.91	-25.75	3.80	-18.98	1.39	4.48	1.55	-28.05	-7.81

TSS has direct relevance to sweetness in cucumber and was maximum in parent EC 173934 at both locations (Table 4). Heterobeltiosis and standard heterosis were found low at each location, being maximum in K-90 x Poinsette and LC-40xGyn1, respectively (Tables 7 and 8). Flesh to cavity ratio was found maximum in Gyn1 (among parents) and Poinsette x EC 173934 (among cross combination) at each location. Maximum flesh to seed cavity is desired. The same cross combination recorded maximum heterobeltiosis as well as standard heterosis (Tables 5 and 6).

Extent of heterosis over better parents for yield and most of the horticultural characters was medium to high. It may be concluded that for developing high yielding and early maturing varieties, hybridization is the appropriate method. Cross combination K-90xG_2 was found best in terms of yield and number of fruits while G_2xGyn1 and EC 173934xLC-40 were earliest in maturity at both locations.

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Table 8. Heterotic response of F_1s for fruit traits in cucumber at Chambaghat (L2)

Crosses	Percentage increase or decrease for									
	Fruit weight (g)		Fruit length (cm)		Fruit width (mm)		TSS (°B)		Flesh to seed cavity ratio	
	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check
K-90x G_2	-17.90	-2.50	-25.91	-15.64	-24.88	0.64	-3.29	-12.00	-6.67	-13.05
K-90x Poinsette	-18.95	-3.75	-7.13	5.74	-22.49	3.85	8.79	-1.00	-29.73	-20.00
K-90x EC173934	4.21	23.75	-9.39	3.17	-20.57	6.41	-14.42	-11.00	-14.29	-16.92
K-90x K-75	-13.68	2.50	0.00	13.86	-5.74	26.28	2.19	-7.00	6.25	4.62
K-90x LC-11	12.63	33.75	-3.83	9.51	-11.96	17.95	-3.26	-11.00	-22.86	-16.92
K-90x LC-40	-10.00	6.88	2.61	16.83	-19.14	8.33	-2.13	-8.00	-7.94	-10.77
K-90x Gyn_1	-20.00	-5.00	-27.93	8.32	-21.05	5.76	-2.19	-11.00	-28.05	-9.23
G_2 xPoinsette	-14.65	-16.25	16.46	13.47	-16.77	-10.90	3.41	-9.00	-29.73	-20.00
G_2 x EC173934	-8.67	-14.38	33.65	11.68	2.70	21.80	-9.62	-6.00	-12.70	-15.39
G_2x K-75	-5.62	5.00	11.24	11.68	11.47	30.77	6.59	-3.00	-15.63	-16.92
G_2 x LC-11	7.06	13.75	-16.58	-6.34	10.99	3.85	0.00	-8.00	-21.43	-15.39
G_2 x LC-40	-20.69	-13.75	14.77	1.58	-9.85	11.54	-4.26	-10.00	1.59	-1.54
G_2 x Gyn_1	-6.99	-16.88	-23.85	14.46	8.98	16.67	7.96	-5.00	-31.71	-13.85
Poinsette x EC173934	4.46	2.50	9.35	6.54	-8.65	8.33	-5.77	-2.00	28.38	46.15
Poinsettex K-75	2.25	13.75	-6.51	-6.14	-9.84	5.77	6.59	-3.00	-29.73	-20.00
Poinsettex LC-11	8.24	15.00	-6.70	4.75	-19.23	-5.77	-1.09	-9.00	-13.51	-1.54
Poinsettex LC-40	-20.67	-13.75	22.76	19.60	-2.59	20.51	-6.38	-12.00	2.70	16.92
Poinsettex Gyn_1	-2.42	-4.25	-32.54	1.39	-9.03	-16.03	8.14	-7.00	-8.54	15.39
EC173934x K-75	-8.43	1.88	1.78	2.18	-2.16	16.03	-17.13	-14.00	0.00	-1.54
EC173934x LC-11	11.77	18.75	0.00	12.28	0.00	18.59	-12.50	-9.00	12.86	21.54
EC173934x LC-40	-16.67	-9.38	22.59	8.52	-10.36	10.90	-13.46	-10.00	3.18	0.00
EC173934x Gyn_1	-8.67	-14.48	-26.48	10.50	-12.43	3.85	-12.50	-9.00	-20.73	0.00
K-75x LC-11	-8.99	1.25	2.82	15.45	9.29	28.21	-6.52	-14.00	-21.43	-15.39
K-75x LC-40	-9.55	0.63	10.45	10.89	19.17	0.00	5.32	-1.00	-15.63	-16.92
K-75x Gyn_1	-8.43	1.88	-28.85	6.93	12.02	3.21	-8.24	-16.50	-31.71	-13.85
LC-11x LC-40	10.35	20.00	-0.18	12.08	21.76	-3.21	-2.13	-8.00	-17.14	-10.77
LC-11x Gyn_1	10.00	16.88	-23.98	14.26	-7.14	8.33	2.17	-6.00	-31.71	-13.85
LC-40x Gyn_1	-18.96	-11.88	-32.62	1.78	-14.51	5.77	8.51	2.00	-29.27	-10.77

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