International Journal of Genetics
ISSN: 0975-2862 & E-ISSN: 0975-9158, Volume 11, Issue 9, 2019, pp.-640-643.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000226

Research Article

HETEROSIS STUDIES FOR YIELD AND QUANTITATIVE TRAITS IN CUCUMBER (*CUCUMIS SATIVUS* L.)

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Received: September 08, 2019; Revised: September 25, 2019; Accepted: September 26, 2019; Published: September 30, 2019

Abstract: Introduction of hybrids and their success in cucumber 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. Crosses among eight parents (including two gynoecious lines) were attempted in half diallel fashion to find out more appropriate combinations for developing superior hybrids in cucumber. Twenty-eight F_{1s}, eight parents and one check were grown in Randomized Block Design with three replications. Sufficient genetic diversity among parents and F_{1s} for all the traits infers the scope of improvement through selection in the parental material. G_2 was earliest in maturity. Heterobeltiosis and standard heterosis for earliness were maximum in EC 173934 x LC-40 and G_2 x Gyn_1, respectively. The cross combination K-90 x G_2 exhibited maximum heterobeltiosis and standard heterosis for yield and number of fruits per plant.

Keywords: *Heterosis, Heterobeltiosis, Cucumber, Yield*

Citation: Dogra B.S. and Kanwar M.S. (2019) Heterosis Studies for Yield and Quantitative Traits in Cucumber (*Cucumis sativus* L.). International Journal of Genetics, ISSN: 0975-2862 & E-ISSN: 0975-9158, Volume 11, Issue 9, pp.- 640-643.

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Academic Editor / Reviewer: Dr Rishee Kalaria

Introduction

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 (*Cucumis sativus* L.) too, success of F1 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. 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 research was carried out at Experimental Farm, Chambaghat of the Department of Vegetable Crops, Dr Y S Parmar University of Horticulture and Forestry, Solan, HP. 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) were grown in Randomized Block Design with three replications. Spacing was 1.25x1.00 m. Data were recorded on five randomly selected plants for yield and quantitative characters. Mean values were subjected to statistical analysis [1] 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 [Table-1] indicated sufficient genetic diversity among parents and F_{1s} for all the traits which infers scope of improvement through selection in the parental material. Very few crosses showed heterobeltiosis as well standard heterosis for days to first female flower appearance, node number of first female flower and days to marketable maturity. Heterobeltiosis was maximum in EC 173934 x LC-40 while heterosis over check variety was maximum in G_2 x Gyn_1 followed by K-90 x G_2 for these traits [Table-4]. Among the parents, G2 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 EC 173934 as well as LC-40 took maximum days to first female flower appearance, node number of first female flower and days to marketable maturity [Table-2]. The cross combination G_2 x Gyn_1 took minimum days to female flower appearance, lowest node for first female flower appearance and minimum days to maturity and recorded maximum heterosis over check followed by K-90 x G_2. Similar results on Heterosis were reported for days to first female flower appearance by various workers [2-6]; for node number of first female flower and days to marketable maturity [3, 7]. In accordance with present findings, earlier workers [8, 9] 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. Among the parents, Gyn_1 produced significantly longer fruits [Table-2]. Maximum heterbeltiosis was exhibited by G_2 x EC 173934 followed by Poinsette x LC-40 and maximum heterosis over check variety by EC 173934 x LC-40 followed by K-90 x LC-40 [Table 4]. Maximum fruit width was produced by K-90. Heterobeltiosis was maximum LC-11 x LC-40 while standard heterosis was maximum in G_2 x K-75 followed by K-75 x LC-11 and K-90 x K-75. Results are in accordance with earlier studies [6] for fruit length and width. TSS was maximum in parent EC 173934. Heterobeltiosis and standard heterosis were found low, being maximum in K-90 x Poinsette and LC-40 x Gyn_1, respectively. Flesh to seed cavity ratio was found maximum in Gyn_1 (among parents) and Poinsette x EC 173934 (among cross combinations) [Table-3]. The same cross combination recorded maximum heterobeltiosis as well as standard

Table-1 *Analysis of variance for different characters in cucumber*

Source of variation	Df	Character										
		Days to first female flower appearance	Node of first female flower	Days to marketable maturity	Fruit length	Fruit width	TSS	Flesh to seed cavity ratio	Fruit weight	No. of fruits per plant	Yield per plant	Internodal length
Genotype	35	396.22*	32.36*	436.21*	14.04*	12.40*	0.075*	0.003*	3579.39*	12.35*	0.91*	8.31*
Error	70	1.29	0.61	1.33	0.27	0.068	0.018	0.0001	147.70	0.45	0.03	1.07

Table-2 *Mean performance of parents and F_{1s} for various characters in cucumber*

Crosses/Parents	Days to first female flower appearance	Node no. of first female flower	Days to marketable maturity	Fruit length (cm)	Fruit width (cm)	TSS (°B)
K-90	63.00	10.00	70.33	19.17	6.97	3.03
G_2	35.33	1.00	42.67	12.27	5.57	2.93
Poinsette	53.33	6.67	61.33	16.40	4.40	2.80
EC173934	76.67	12.67	85.00	14.07	6.17	3.47
K-75	56.33	10.67	64.33	16.90	6.10	3.03
LC-11	70.67	11.33	79.00	18.90	6.06	3.07
LC-40	73.33	13.33	80.33	14.90	6.43	3.13
Gyn_1	38.00	1.33	45.00	23.30	4.80	2.87
Pusa Sanyog (check)	45.00	5.67	52.33	16.83	5.20	3.33
K-90x G_2	41.33	4.33	48.00	14.20	5.23	2.93
K-90x Poinsette	54.33	8.67	62.00	17.80	5.40	3.30
K-90x EC173934	60.00	7.33	68.00	17.37	5.53	2.97
K-90x K-75	71.33	10.67	79.33	19.17	6.57	3.10
K-90x LC-11	73.33	9.33	81.00	18.43	6.13	2.97
K-90x LC-40	63.33	9.00	71.33	19.67	5.63	3.10
K-90x Gyn_1	43.67	4.33	50.67	18.23	5.50	2.97
G_2 xPoinsette	51.67	6.00	59.00	19.10	4.63	3.03
G_2 x EC173934	57.33	7.00	65.67	18.80	6.63	3.13
G_2x K-75	46.33	4.33	53.67	18.80	6.80	3.23
G_2 x LC-11	50.67	6.67	58.00	15.77	5.40	3.10
G_2 x LC-40	73.33	8.67	70.67	17.10	5.80	3.00
G_2 x Gyn_1	40.33	3.00	47.33	19.27	6.07	3.17
Poinsette x EC173934	68.33	7.67	76.67	17.93	5.63	3.27
Poinsettex K-75	57.33	8.00	65.67	15.80	5.50	3.23
Poinsettex LC-11	58.00	9.33	65.67	17.63	4.90	3.03
Poinsettex LC-40	63.00	8.33	71.00	20.13	6.27	2.93
Poinsettex Gyn_1	61.67	6.00	69.67	17.07	4.37	3.10
EC173934x K-75	68.00	13.33	76.00	17.20	6.03	2.87
EC173934x LC-11	74.00	8.33	82.00	18.90	6.17	3.04
EC173934x LC-40	66.33	7.33	74.33	18.27	5.77	3.00
EC173934x Gyn_1	61.67	6.67	69.67	18.60	5.40	3.03
K-75x LC-11	70.67	9.00	78.67	19.43	6.67	2.87
K-75x LC-40	72.67	7.33	80.33	18.67	5.20	3.30
K-75x Gyn_1	45.00	5.00	52.33	18.00	5.37	2.78
LC-11x LC-40	80.00	14.67	87.67	18.67	5.03	3.07
LC-11x Gyn_1	48.33	4.33	55.67	19.23	5.63	3.13
LC-40x Gyn_1	59.00	12.67	66.67	17.13	5.50	3.40
SE±	0.93	0.64	0.94	0.18	0.21	0.11
$CD_{0.05}$	1.85	1.28	1.87	0.36	0.42	0.22

heterosis [Table-5] in agreement [10] who reported significant heterosis for this trait. K-90 recorded maximum fruit weight among parents while K-90 x LC-11 produced significantly higher fruit weight [Table-3]. The same cross combination recorded maximum heterobeltiosis as well as standard heterosis [Table-5]. Similar trends were also reported [6, 11-13]. Cross combination K-90 x G_2 produced the maximum yield per plant and fruits [Table-3]. The same cross recorded maximum heterosis over better parent as well over check variety for yield [Table-5]. Poinsette x K-75 recorded highest heterobeltiosis for number of fruits followed by K-90 x G_2 while standard heterosis was maximum in K-90 x G_2. However, among parents, K-90 recorded the highest yield per plant. G_2 produced maximum number of fruits per plant and found to be at par with Gyn_1. Similar findings for number of fruits were reported earlier by [6, 9, 12, 14-15]. Positive and significant heterosis for yield was reported by many workers [10-14, 16-18]. Heterosis was also found for yield related traits [19]. G_2 recorded minimum internodal length. Among F_{1s}, K-90 x G_2 observed minimum internodal length closely followed by LC-40 x Gyn_1. Heterosis over better parent was maximum in Poinsette x LC-40 and over check variety in K-90 x G_2.

Conclusion

Extent of heterosis over better parents for yield and most of the quantitative traits was medium to high. Cross combination K-90 x G_2 was found best in terms of yield, number of fruits and maturity while G_2 x Gyn_1 and EC 173934 x LC-40 were specific to early maturity.

Application of research: It may be concluded that for developing high yielding and early maturing varieties, hybridization is the appropriate method.

Research Category: Heterosis

Acknowledgement / Funding: Authors are thankful to Department of Vegetable Crops, College of Horticulture & Forestry, Neri, 177001, Dr Y S P University of Horticulture and Forestry, Nauni, 173230, HP, India

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Research project name or number: Farm Research

Author Contributions: All authors equally contributed

Table-3 *Mean performance of parents and F_{1s} for various characters in cucumber*

Crosses / Parents	Flesh to seed cavity ratio	Fruit weight (g)	No. of fruits per plant	Yield per plant (kg)	Internodal length (cm)
K-90	0.20	316.67	8.33	3.07	13.90
G_2	0.20	231.67	12.67	2.83	9.00
Poinsette	0.25	261.67	7.00	1.96	15.03
EC173934	0.21	250.00	8.33	1.99	13.93
K-75	0.21	296.67	7.00	2.70	15.20
LC-11	0.23	283.33	6.33	1.68	13.67
LC-40	0.21	290.00	6.33	2.08	13.70
Gyn_1	0.27	238.33	12.33	2.64	12.37
Pusa Sanyog (check)	0.22	266.67	11.67	3.03	11.93
K-90x G_2	0.19	260.00	14.67	4.05	10.30
K-90x Poinsette	0.17	256.67	8.67	2.29	13.00
K-90x EC173934	0.18	330.00	7.00	2.18	12.13
K-90x K-75	0.23	273.33	8.33	2.20	15.23
K-90x LC-11	0.18	356.67	7.67	2.33	16.00
K-90x LC-40	0.19	285.00	7.33	2.06	12.67
K-90x Gyn_1	0.20	253.33	12.33	3.42	12.00
G_2 xPoinsette	0.17	223.33	9.67	2.38	12.00
G_2 x EC173934	0.18	228.33	7.67	1.87	13.13
G_2x K-75	0.18	280.00	11.00	3.08	11.57
G_2 x LC-11	0.18	303.33	8.67	2.75	11.47
G_2 x LC-40	0.21	230.00	7.67	1.81	11.63
G_2 x Gyn_1	0.19	221.67	11.33	2.88	11.60
Poinsette x EC173934	0.32	273.33	8.33	2.12	12.33
Poinsettex K-75	0.17	303.03	8.33	2.67	16.00
Poinsettex LC-11	0.21	306.67	8.00	1.72	15.90
Poinsettex LC-40	0.25	230.00	7.67	2.06	11.53
Poinsettex Gyn_1	0.25	255.33	9.67	2.98	14.07
EC173934x K-75	0.21	271.67	7.33	1.83	14.27
EC173934x LC-11	0.26	316.67	7.00	2.13	13.77
EC173934x LC-40	0.22	241.67	7.67	2.00	14.83
EC173934x Gyn_1	0.22	228.33	7.33	1.68	14.53
K-75x LC-11	0.18	270.00	7.67	2.03	13.63
K-75x LC-40	0.18	268.33	7.00	1.97	12.00
K-75x Gyn_1	0.19	271.67	11.33	3.05	13.57
LC-11x LC-40	0.19	320.00	6.33	1.94	13.33
LC-11x Gyn_1	0.19	311.67	8.67	3.13	11.67
LC-40x Gyn_1	0.19	235.00	7.66	2.02	10.93
SE±	0.008	9.92	0.55	0.14	0.85
$CD_{0.05}$	0.017	19.79	1.09	0.28	1.69

Table-4 *Heterotic response of F_{1s} for various characters in cucumber*

Crosses	Percentage increase or decrease for											
	Days to first female flower appearance		Node no. of first female flower		Days to marketable maturity		Fruit length		Fruit width		TSS	
	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	OverBP	OverCheck	OverBP	OverCheck	Over P	Over check
K-90x G_2	16.98	-8.15	333.33	-23.53	12.50	-8.28	-25.91	-15.64	-24.88	0.64	-3.29	-12.00
K-90x Poinsette	1.88	20.74	30.00	52.94	1.09	18.47	-7.13	5.74	-22.49	3.85	8.79	-1.00
K-90x EC173934	-4.76	33.33	-26.27	29.41	-3.32	29.94	-9.39	3.17	-20.57	6.41	-14.42	-11.00
K-90x K-75	26.63	58.52	6.67	88.24	23.32	51.59	0.00	13.86	-5.74	26.28	2.19	-7.00
K-90x LC-11	16.40	62.96	-6.67	64.71	15.17	54.78	-3.83	9.51	-11.96	17.95	-3.26	-11.00
K-90x LC-40	0.53	40.74	-10.00	58.82	1.42	36.31	2.61	16.83	-19.14	8.33	-2.13	-8.00
K-90x Gyn_1	14.91	-2.96	225.00	-23.53	12.59	-3.19	-27.93	8.32	-21.05	5.76	-2.19	-11.00
G_2 xPoinsette	46.23	14.82	500.00	5.88	38.28	12.74	16.46	13.47	-16.77	-10.90	3.41	-9.00
G_2 x EC173934	62.26	27.41	600.00	23.53	53.91	25.48	33.65	11.68	2.70	21.80	-9.62	-6.00
G_2x K-75	31.13	2.96	333.33	-23.53	25.75	2.55	11.24	11.68	11.47	30.77	6.59	-3.00
G_2 x LC-11	43.40	12.59	566.67	17.65	35.94	10.83	-16.58	-6.34	10.99	3.85	0.00	-8.00
G_2 x LC-40	107.55	62.96	766.67	52.94	65.63	35.03	14.77	1.58	-9.85	11.54	-4.26	-10.00
G_2 x Gyn_1	14.15	-10.37	200.00	-47.06	10.94	-9.55	-23.85	14.46	8.98	16.67	7.96	-5.00
Poinsette x EC173934	28.13	51.85	15.00	35.29	25.00	46.50	9.35	6.54	-8.65	8.33	-5.77	-2.00
Poinsettex K-75	7.50	27.41	20.00	41.18	7.07	25.48	-6.51	-6.14	-9.84	5.77	6.59	-3.00
Poinsettex LC-11	8.75	28.89	40.00	64.71	7.07	25.48	-6.70	4.75	-19.23	-5.77	-1.09	-9.00
Poinsettex LC-40	18.13	40.00	25.00	47.06	15.76	35.67	22.76	19.60	-2.59	20.51	-6.38	-12.00
Poinsettex Gyn_1	62.28	37.04	350.00	5.88	54.81	33.12	-32.54	1.39	-9.03	-16.03	8.14	-7.00
EC173934x K-75	20.71	51.11	25.00	135.29	18.14	45.22	1.78	2.18	-2.16	16.03	-17.13	-14.00
EC173934x LC-11	4.72	64.44	-26.47	47.06	3.80	56.69	0.00	12.28	0.00	18.59	-12.50	-9.00
EC173934x LC-40	-9.55	47.41	-42.00	29.41	-7.47	42.04	22.59	8.52	-10.36	10.90	-13.46	-10.00
EC173934x Gyn_1	62.28	37.04	400.00	17.65	54.82	33.12	-26.48	10.50	-12.43	3.85	-12.50	-9.00
K-75x LC-11	23.44	57.04	-15.63	58.82	22.28	50.32	2.82	15.45	9.29	28.21	-6.52	-14.00
K-75x LC-40	28.99	61.48	-31.25	29.41	24.87	53.50	10.45	10.89	19.17	0.00	5.32	-1.00
K-75x Gyn_1	18.42	0.00	275.00	-11.77	16.30	0.00	-28.85	6.93	12.02	3.21	-8.24	-16.50
LC-11x LC-40	13.20	77.78	29.41	158.82	10.97	67.52	-0.18	12.08	21.76	-3.21	-2.13	-8.00
LC-11x Gyn_1	27.19	7.41	225.00	-23.53	23.70	6.37	-23.98	14.26	-7.14	8.33	2.17	-6.00
LC-40x Gyn_1	55.26	31.11	850.00	123.53	48.15	27.39	-32.62	1.78	-14.51	5.77	8.51	2.00

Table-5 *Heterotic response of F_{1s} for various characters in cucumber*

Crosses	Percentage increase or decrease for									
	Flesh to seed cavity ratio		Fruit weight		No. of fruits per plant		Yield per plant		Internodal length	
	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check	Over BP	Over Check
K-90x G_2	-6.67	-13.05	-17.90	-2.50	15.78	25.71	32.07	33.52	14.44	-13.69
K-90x Poinsette	-29.73	-20.00	-18.95	-3.75	4.00	-25.71	-25.22	-24.40	-6.47	8.94
K-90x EC173934	-14.29	-16.92	4.21	23.75	-16.00	-40.00	-28.80	-28.02	12.71	1.68
K-90x K-75	6.25	4.62	-13.68	2.50	0.00	-28.57	-28.26	-27.47	9.59	27.65
K-90x LC-11	-22.86	-16.92	12.63	33.75	-8.00	-34.29	-24.02	-23.19	17.07	34.08
K-90x LC-40	-7.94	-10.77	-10.00	6.88	12.00	-37.14	-32.94	-32.20	-7.54	6.15
K-90x Gyn_1	-28.05	-9.23	-20.00	-5.00	0.00	5.71	11.41	12.64	-2.97	0.56
G_2 xPoinsette	-29.73	-20.00	-14.65	-16.25	-23.68	-17.14	-15.88	-21.43	33.33	0.56
G_2 x EC173934	-12.70	-15.39	-8.67	-14.38	-39.47	-34.29	-33.88	-38.24	45.93	10.06
G_2x K-75	-15.63	-16.92	-5.62	5.00	-13.16	-5.71	8.82	1.65	28.52	-3.07
G_2 x LC-11	-21.43	-15.39	7.06	13.75	-31.58	-25.71	-2.94	-9.34	27.41	-3.91
G_2 x LC-40	1.59	-1.54	-20.69	-13.75	-39.47	-34.29	-36.00	-40.22	29.26	-2.51
G_2 x Gyn_1	-31.71	-13.85	-6.99	-16.88	-10.53	-2.86	1.77	-4.95	28.89	-2.79
Poinsette x EC173934	28.38	46.15	4.46	2.50	0.00	-28.57	6.01	-30.22	-11.48	3.35
Poinsettex K-75	-29.73	-20.00	2.25	13.75	19.05	-28.57	-1.24	-12.09	6.43	34.08
Poinsettex LC-11	-13.51	-1.54	8.24	15.00	14.29	-31.43	-12.24	-10.33	16.34	33.24
Poinsettex LC-40	2.70	16.92	-20.67	-13.75	9.52	-34.29	-1.28	-32.20	-15.81	-3.35
Poinsettex Gyn_1	-8.54	15.39	-2.42	-4.25	-21.62	-17.14	12.75	-1.87	13.75	17.88
EC173934x K-75	0.00	-1.54	-8.43	1.88	-12.00	-37.14	-32.10	-39.56	2.39	19.55
EC173934x LC-11	12.86	21.54	11.77	18.75	-16.00	-40.00	6.85	-29.67	0.73	15.36
EC173934x LC-40	3.18	0.00	-16.67	-9.38	-8.00	-34.29	-4.00	-34.07	8.27	24.30
EC173934x Gyn_1	-20.73	0.00	-8.67	-14.48	-40.54	-37.14	-36.24	-44.51	17.52	21.79
K-75x LC-11	-21.43	-15.39	-8.99	1.25	9.52	-34.29	-24.82	-33.08	-0.24	14.25
K-75x LC-40	-15.63	-16.92	-9.55	0.63	0.00	-40.00	-27.04	-35.06	-12.41	0.56
K-75x Gyn_1	-31.71	-13.85	-8.43	1.88	-8.11	-2.86	12.96	0.55	9.70	13.69
LC-11x LC-40	-17.14	-10.77	10.35	20.00	0.00	-45.71	-6.72	-35.93	2.44	11.73
LC-11x Gyn_1	-31.71	-13.85	10.00	16.88	-29.73	-25.71	18.69	3.30	-5.66	-2.24
LC-40x Gyn_1	-29.27	-10.77	-18.96	-11.88	-37.84	-34.29	-23.49	-33.41	-11.59	-8.38

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Experimental Farm, Chambaghat

Cultivar / Variety name: Cucumber (*Cucumis sativus* L.)

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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