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Exploitation of heterosis in cucumber for earliness, yield and yield components utilizing gynoecious lines

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ABSTRACT

Seven parental lines including two gynoecious lines were used to develop 21 F_1 hybrids of cucumber by half-diallel mating to determine the magnitude of heterosis for earliness yield and yield related traits during spring summer and rainy season. The mean sum of squares were highly significant for all the characters indicated a wide genetic variation for the characters studied and there is a possibility of genetic improvement using such genetic pools in future breeding programme. The gynoecious parental lines (PPC-2 and GPC-1) and monoecious parent Pusa Uday were observed to be the three top performing parents for yield per plant. Appreciable heterosis was observed over better parent and top parent for most of the characters studied. The F_1 hybrids those found to be superior in performance over top parents for various characters were GPC1 × PPC-2 for node number at first female flower, number of fruits per plant, PPC-2 × Pusa Uday for days to fruit set, days to first fruit harvest, yield per plant, Punjab Naveen × Pusa Uday for fruit length, fruit diameter, DC-1 × Pusa Uday for average fruit weight. The best three heterotic hybrids PPC-2 × Pusa Uday, GPC-1 × Pusa Uday and PPC-2 × Punjab Naveen showing 64.51, 55.61, and 54.57% heterosis, respectively, over standard check Pusa Uday for yield per plant, may be exploited for commercial cultivation.

Key words: Cucumber, heterosis, F_1 hybrids, gynoecious lines.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) belongs to family Cucurbitaceae is an important summer vegetable, grown for its immature fruits, used as salad, making pickles, *rayata* preparations and even brined on commercial scale in almost every part of the world. It is primarily a monoecious, cross-pollinated crop and produces large number of seeds per pollination, which provides ample scope for the utilization of heterosis breeding and has a great scope of improvement over its base population. Among many cucurbits grown across the world, cucumber is distinct with a unique sex mechanism and this feature can easily be manipulated for the production of F_1 hybrid seeds (*Arinia et al*., 1).

Several breeders have confirmed that hybrid vigour was manifested in cucumber in respect of earliness (Hutchins, 8) and increased yield due to large number of fruits per plant (Singh *et al.,* 17; Pandey *et al*., 15; Airina *et al.*, 1). Gynoecy, condition where all the flowering nodes produce only pistillate flowers, can be exploited for improving yield and economizing F_1 hybrid production. Using best combiners, heterosis breeding is one of the best methods to improve upon the existing varieties. India being considered the home of cucumber possesses a vast range of genetic diversity and variability for both growth and fruit characters, but this advantage has not been fully assessed and utilised. Heterosis breeding can be exploited as most efficient tools to exploit the genetic diversity in many cucurbitaceous crops including pumpkin (Mohanty and Mishra, 11). A large number of hybrids have been developed and in Western countries almost ninety per cent of the area grown for cucumbers is covered by hybrids. This was mainly possible due to the use of gynoecious lines for the development of hybrid varieties. There is a paramount need to develop suitable hybrids, which may be utilized on commercial scale especially in the north Indian plains. In India very few gynoecious based hybrids were developed and commercialised (More, 13; Sharma, 16; Airina *et al*., 1). Keeping in view the above facts, the present investigation was therefore, initiated with a view to obtain information for assessment of heterosis for earliness, yield and yield attributing traits utilizing gynoecious lines.

MATERIALS AND METHODS

The present experiments was undertaken during spring-summer and *kharif* seasons for two years (2011-12 and 2012-13) at Research Farm of Division of Vegetable Science, IARI, New Delhi. The seven genetically diverse lines (including two gynoecious lines), namely, GPC-1, PPC-2, DC-1, Kalyanpur Green, Swarna Poorna, Punjab Naveen and Pusa Uday were crossed in a half-diallel (excluding reciprocals) mating scheme (Hayman, 7) and 21

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F_1 hybrids were obtained. These 21 F_1s along with the 7 parents were assessed in an experiment in randomized block design (RBD) with three replications during *kharif* season. The crop was grown in rows at 2.0 m apart with spacing of 0.60 m between the plants. All the recommended agronomic practices including weeding, hoeing, manures and fertilisers applications for irrigated conditions were followed to raise a healthy and successful crop. The gynoecious lines were maintained by spraying silver thiosulphate @ 200 ppm at 2-3 leaf stage. In each replication per treatment out of twenty plants, ten plants were randomly selected for observations on plant, fruit and yield characters on individual plant basis. The observations were recorded for ten important characters namely, node number of first female flower, days to first female flower anthesis, days to fruit set from opening of first female flower, days to first fruit harvest, number of fruits per plant, fruit length (cm), fruit diameter (cm), number of fruits per plant, vine length and total yield per plant (kg) (Table 1). Therefore, heterosis was calculated in favourable direction as percentage increase of F_1 performance over mid parent (MP), better parent (BP) and standard check (SC) (Hayes, 6; Turner, 19).

RESULTS AND DISCUSSION

There were highly significant differences among the parental lines in respect of different characters studied including total yield per plant. Among seven parents used in the study, it was evident that the gynoecious parent, GPC-1 had lowest node number for first female flower appearance, minimum days to first female flower anthesis, minimum days to first fruit harvest, maximum number of fruits per plant, and shortest vine length. The another gynoecious parent PPC-2 had lowest node number of first female flower, minimum days to first fruit set from opening of first female flower, and maximum yield per plant. The monoecious parent Pusa Uday showed the highest fruit length and diameter and maximum average fruit weight (Table 1). The range of mean performance of parents, range of heterosis percentage of F_1 hybrids, number of heterotic crosses and three superior crosses with their heterosis over better, mid and top parent in all characters are presented in Table 3.

Earliness, indicated by negative estimates of heterosis which helps the grower to fetch early market price, is a well recognised and one of the most important desirable parameter in any breeding programme particularly development of hybrids. This trait is associated with characters such as node number of first female flower, days to first female flower anthesis and days to first fruit harvest. In order of superiority, the best three F_1 hybrids, which gave best performance over top parent in relation to earliness were, GPC-1 × PPC-2 (-53.13%), GPC-1 × Pusa Uday (-37.96%) and GPC-1 × Punjab Naveen (-37.22%) for node number of first female flower; GPC-1 × Pusa Uday (-24.24%), PPC-2 × Pusa Uday (-23.84%) and GPC-1 × Punjab Naveen (-22.33%) for days to first female flower anthesis; PPC-2 × Pusa Uday (-26.68%), PPC-2 × Punjab Naveen (-26.44%) and GPC-1 × Pusa Uday (-26.36%) for days to fruit set from opening of first female flower; PPC-2 × Pusa Uday (-20.74%), PPC-2 × Punjab Naveen (-20.70%) and GPC-1 × Punjab Naveen (-20.35%) for days to first fruit harvest; GPC-1 × Pusa Uday (-27.93%), GPC-1 × Pant Parthenocarpic Cucumber-2 (-26.56%) and GPC-1 × Punjab Naveen (-26.49%) for vine length

Table 1. Mean performance of parents for important quantitative traits including yield per plant in cucumber.

Parent	NNFFF	DFFFA	DFSFFFF	DFFH	NF/P	FL (cm)	FD (cm)	AFW (g)	VL (cm)	Y/P (g)
P_1 (GPC-1)	3.44	40.22	3.50	46.07	13.98	9.07	3.25	103.16	91.90	1436.21
P_2 (PPC-2)	3.44	41.00	3.49	47.89	12.44	13.43	4.12	124.77	120.49	1547.84
P_3 (DC-1)	5.23	47.64	3.61	56.85	5.88	16.75	5.06	185.25	133.85	1083.53
P_4 (Kalyanpur Green)	4.98	45.49	3.81	55.70	5.59	15.83	4.68	178.22	141.88	986.21
P_5 (Swarna Poorna)	5.12	48.55	3.89	57.13	5.41	16.13	4.16	174.43	139.11	938.95
P_6 (Punjab Naveen)	5.38	49.61	4.22	60.19	6.22	16.43	5.19	196.16	141.32	1253.28
P_7 (Pusa Uday)	5.43	50.52	4.16	58.66	6.76	17.62	5.33	203.47	140.47	1369.30
Mean	4.72	46.15	3.81	54.64	8.04	15.04	4.54	166.49	129.86	1230.76
Range	3.44-5.43	40.22-50.52	3.49-4.22	46.07-60.19	5.41-13.98	9.07-17.62	3.25-5.33	103.16-203.47	91.90-141.88	938.95-1547.84
CD at 5%	0.67	4.60	0.68	4.88	2.04	2.48	0.78	22.21	13.46	189.91

GPC-1 = Gynoecious Pickling Cucumber-1, PPC-2 = Pant Parthenocarpic Cucumber-2, NNFFF = Node No. of first female flower, DFFFA = Days to first female flower anthesis, DFSFFFF = Days to fruit set from opening of first female flower, DFFH = Days to first fruit harvest, NF/P = No. of fruits per plant, FL = Fruit length, FD = Fruit diameter, AFW = Average fruit weight, VL = Vine Length, Y/P = Yield per plant

(Table 3). Significant heterosis for days to first harvest in crosses involving gynoecious lines of cucumber were also observed (Dogra *et al*., 2; Sharma, 16; Airina *et al*., 1). From the above findings it was found that gynoecious × gynoecious and gynoecious × monoecious hybrids manifested appreciable amount of heterosis in positive direction for earliness as compared to monoecious × monoecious hybrids.

Highest yield is the foremost and desirable character for any breeding programme. It is a complex trait resulting from the interaction of its component character of a crop. Moll and Stuber (12) pointed out that hetrosis estimates should indicate whether heterozygote's or homozygote's represent the more ideal genotype. In case of cucumber breeding, number of fruits per plant, fruit weight and fruit size are the direct yield components (Table 2). In order of merit the best three F_1 hybrids, which gave highest performance over top parent in relation to yield and its contributing characters were GPC-1 × PPC-2 (141.27%), PPC-2 × Pusa Uday(134.51%) and GPC-1 × Pusa Uday (134.47%) for number of fruits per plant; Punjab Naveen × Pusa Uday (15.42%), DC-1 × Pusa Uday (15.08%) and Swarna Poorna × Pusa Uday (10.95%) for fruit length; Punjab Naveen × Pusa Uday (15.56%), DC-1 × Pusa Uday (14.13%) and DC-1 × Punjab Naveen (8.00%) for fruit diameter; DC-1 × Pusa Uday (9.92%), Punjab Naveen × Pusa Uday (6.08%) and Swarna Poorna × Pusa Uday (5.13%) for average fruit weight; PPC-2 × Pusa Uday (64.51%), GPC-1 × Pusa Uday (55.61%) and PPC-2 × Punjab Naveen (54.57%) for yield per plant (Table 3). The range of mean values in F_1 hybrids were higher than that of parents for all the characters studied during experiment, except, node number of first female flower, days to first female flower anthesis, days to first fruit harvest and vine length (Table 3). Dogra *et al*. (2), Sharma (16), Airina *et al*. (1) also

Table 2. Mean performance of hybrids for important quantitative traits including yield per plant in cucumber.

Cross/Hybrid	NNFFF	DFFFA	DFSFFFF	DFFH	NF/P	FL (cm)	FD (cm)	AFW (g)	VL (cm)	Y/P (g)
P1 × P2	2.54	40.19	3.37	47.54	16.31	11.98	3.38	131.85	103.16	1598.22
P1 × P3	3.87	43.35	3.38	52.67	9.54	14.63	4.11	156.59	106.18	1568.23
P1 × P4	3.78	42.16	3.57	51.45	9.23	14.00	4.27	154.86	104.30	1497.89
P1 × P5	3.95	43.15	3.56	54.17	9.33	13.94	4.08	155.51	103.27	1483.80
P1 × P6	3.41	39.24	3.11	46.72	14.55	14.82	4.40	158.65	105.64	2015.39
P1 × P7	3.37	38.27	3.06	46.82	15.85	15.85	4.57	162.12	101.24	2130.74
P2 × P3	3.90	41.57	3.25	52.35	9.96	17.71	4.44	158.71	128.10	1612.86
P2 × P4	3.97	41.76	3.45	53.07	10.13	17.18	4.26	153.86	136.78	1528.33
P2 × P5	3.92	42.22	3.56	53.38	10.44	17.52	4.00	153.53	135.51	1503.23
P2 × P6	3.46	39.77	3.14	46.52	14.80	18.57	4.73	164.38	136.21	2116.55
P2 × P7	3.41	38.47	3.05	46.49	15.88	18.80	4.83	169.77	136.92	2252.68
P3 × P4	4.63	42.21	3.52	55.36	7.84	18.85	5.27	189.30	137.44	1315.07
P3 × P5	4.68	42.37	3.56	56.09	7.69	18.57	5.11	188.23	136.32	1309.30
P3 × P6	4.80	44.49	3.77	53.18	8.12	18.46	5.76	201.76	138.45	1626.86
P3 × P7	4.72	42.14	3.67	52.67	9.18	20.28	6.09	217.55	140.26	1815.11
P4 × P5	4.24	45.38	3.83	56.13	7.00	17.54	4.96	183.35	136.08	1286.07
P4 × P6	4.44	43.35	3.31	53.44	7.99	18.85	5.08	207.89	142.37	1480.61
P4 × P7	4.40	45.57	3.34	52.93	8.15	19.50	5.11	213.90	147.81	1590.89
P5 × P6	4.24	47.45	3.83	55.04	8.01	18.03	5.23	201.31	137.29	1417.39
P5 × P7	4.21	44.77	3.43	54.12	7.97	19.55	5.39	206.31	138.44	1476.58
P6 × P7	4.19	43.47	4.52	54.37	9.36	20.34	6.16	215.84	140.14	1602.33
Mean	4.01	42.45	3.49	52.12	10.35	17.38	4.82	178.35	128.19	1629.91
Range	2.54-4.80	38.27-47.45	3.05-4.52	46.49-56.13	7.00-16.31	11.98-20.34	3.38-6.16	131.85-217.55	101.24-147.81	1286.07-2252.68
CD at 5%	0.71	3.43	0.56	4.24	2.20	2.79	0.76	17.26	10.18	239.12

reported significant heterosis for number of fruits per plants and fruit length among crosses involving gynoecious cucumber combinations. Heterosis for fruit yield was also reported in gynoecious hybrids (More, 13; Dogra *et al.*, 2; Airina *et al*., 1). Similar results were also obtained in monoecious cultivars of cucumber by many workers (Hanchinamani and Patil, 4; Kumar *et al*., 9; Singh *et al.*, 18).

The result indicates that maximum yield per plant in the hybrids mentioned above was attributed by maximum number of fruits per plant. Therefore, gynoecious × gynoecious and gynoecious × monoecious hybrids were found to have maximum heterosis for earliness and total yield per plant and these hybrids can be used for exploitation of heterosis in cucumber under north Indian plains of India. Hayes and Jones (5) reported the first generation crosses in cucumber frequently exhibit high parent heterosis due to increase fruit size and fruit number per plant. Therefore, yield can more accurately be estimated by the number of fruits per plant, and it would be possible to achieve yield improvement in this crop by using gynoecious line as one of the parent in future breeding programme. Hence, breeder should concentrate mainly on fruit number rather than fruit size in their efforts to increase yield. The present experiment showed a fairly high degree of heterosis for fruit yield per plant in most of hybrids. Singh *et*

Table 3. Range of mean values of parents, F_1 hybrids and best performing parents and F_1 hybrids with their heterosis percent.

Range of mean values	Node No. of first female flower	Days to first female flower anthesis	Days to fruit set from opening of first female flower	Days to first fruit harvest	No. of fruits per plant
Parent	3.44-5.43	40.22-50.52	3.49-4.22	46.07-60.19	5.41-13.98
F_1	2.54-4.80	38.27-47.45	3.05-4.52	46.49-56.13	7.00-16.31
Range of heterosis % over					
BP	-10.64-to-37.96	-12.37 to 7.80	-13.04 to 4.24	-7.36 to 17.58	38.51 to -33.95
MP	-5.10 to -26.10	-1.03 to -15.92	-20.30 to 7.84	-13.93 to 4.98	65.39 to -3.75
TP	-11.55 to -53.13	-6.08 to -24.24	-26.68 to 8.57	-4.32 to -20.74	141 to 3.55
No. of heterotic crosses over					
BP	21	12	20	11	21
MP	21	18	21	12	21
TP	21	21	21	21	21
Three top parents with their mean values	P_1 &P_2 (3.44)	P_1 (40.22)	P_2 (3.49)	P_1(46.07)	P_5 (13.98)
	P_4 (4.98)	P_2 (41.00)	P_1 (3.50)	P_2 (47.89)	P_6(12.44)
	P_5 (5.12)	P_4 (45.49)	P_3(3.61)	P_4(55.70)	P_4 (6.76)
Three top F_1 hybrids with heterosis %[1] over BP	$P_1 \times P_7$ (-37.96)	$P_6 \times P_7$ (-12.37)	$P_4 \times P_6$ (-13.04)	$P_3 \times P_7$ (-7.36)	$P_6 \times P_7$ (38.51)
	$P_2 \times P_7$ (-37.10)	$P_3 \times P_7$ (-11.54)	$P_2 \times P_7$ (-12.69)	$P_6 \times P_7$ (-7.31)	$P_3 \times P_7$ (35.85)
	$P_1 \times P_6$ (-36.64)	$P_3 \times P_5$ (-11.07)	$P_1 \times P_7$ (-12.48)	$P_3 \times P_6$ (-6.45)	$P_3 \times P_4$ (33.33)
Three top F_1 hybrids with heterosis %[1] over MP	$P_1 \times P_2$ (-26.10)	$P_2 \times P_7$ (-15.92)	$P_2 \times P_7$ (-20.30)	$P_2 \times P_6$ (-13.93)	$P_2 \times P_7$ (65.39)
	$P_1 \times P_7$ (-24.06)	$P_1 \times P_7$ (-15.64)	$P_1 \times P_7$ (-20.02)	$P_2 \times P_7$ (-12.73)	$P_2 \times P_6$ (58.61)
	$P_2 \times P_7$ (-23.04)	$P_3 \times P_7$ (-14.13)	$P_1 \times P_6$ (-19.40)	$P_1 \times P_6$ (12.07)	$P_1 \times P_7$ (52.84)
Three top F_1 hybrids with heterosis %[1] over TP	$P_1 \times P_2$ (-53.13)	$P_1 \times P_7$ (-24.24)	$P_2 \times P_7$ (-26.68)	$P_2 \times P_7$ (-20.74)	$P_1 \times P_2$ (141.27)
	$P_1 \times P_7$ (-37.96)	$P_2 \times P_7$ (-23.84)	$P_2 \times P_6$ (-26.44)	$P_2 \times P_6$ (-20.70)	$P_2 \times P_7$ (134.51)
	$P_1 \times P_6$ (-37.22)	$P_1 \times P_6$ (-22.33)	$P_1 \times P_7$ (-26.36)	$P_1 \times P_6$ (-20.35)	$P_1 \times P_7$ (134.47)

Table 3 contd...

Table 3 contd...

Character	Fruit length (cm)	Fruit dia. (cm)	Av. fruit wt. (g)	Vine length (cm)	Yield per plant (g)
Parent	9.07-17.62	3.25-5.33	103.16-203.47	91.90-141.88	938.95-1547.84
F_1	11.98-20.34	3.38-6.16	131.85-217.55	101.24-147.81	1286.07-2252.68
Range of heterosis % over					
BP	15.42 to -13.56	15.56 to -18.66	6.92 to -20.32	4.18 to -27.93	-1.26 to 45.54
MP	24.33 to 6.43	17.16 to -8.28	1.56 to 15.69	4.94 to -12.87	7.12 to 54.44
TP	15.42 to -32.03	15.56 to -36.63	-35.20 to 6.92	5.22 to -27.93	-4.38 to 64.51
No. of heterotic crosses over					
BP	21	20	02	06	12
MP	21	21	01	03	08
TP	17	21	09	06	06
Three top parents with their mean values	P_7 (17.62)	P_7 (5.33)	P_7 (203.47	P_1 (91.90)	P_2 (1547.84)
	P_3 (16.75)	P_6 (5.19)	P_6 (196.16)	P_2 (120.49)	P_1 (1436.21)
	P_6 (16.43)	P_3 (5.06)	P_3 (185.25)	P_3 (133.85)	P_7 (1369.30)
Three top F_1 hybrids with heterosis % over BP	$P_3 \times P_5$ (15.42)	$P_6 \times P_7$ (15.56)	$P_3 \times P_7$ (6.92)	$P_1 \times P_7$ (-27.93)	$P_1 \times P_7$ (48.36)
	$P_3 \times P_7$ (15.08)	$P_3 \times P_7$ (14.13)	$P_6 \times P_7$ (6.08)	$P_1 \times P_4$ (-26.49)	$P_2 \times P_7$ (45.54)
	$P_4 \times P_6$ (14.71)	$P_3 \times P_6$ (10.91)	$P_1 \times P_2$ (5.98)	$P_1 \times P_5$ (-25.77)	$P_1 \times P_6$ (40.33)
Three top F_1 hybrids with heterosis % over MP	$P_2 \times P_6$ (24.33)	$P_3 \times P_7$ (17.16)	$P_1 \times P_2$ (15.69)	$P_1 \times P_7$ (-12.87)	$P_2 \times P_7$ (54.44)
	$P_2 \times P_7$ (21.04)	$P_6 \times P_7$ (17.10)	$P_4 \times P_7$ (12.08)	$P_1 \times P_4$ (-10.77)	$P_1 \times P_7$ (51.90)
	$P_1 \times P_7$ (18.76)	$P_5 \times P_7$ (13.44)	$P_1 \times P_5$ (12.05)	$P_1 \times P_5$ (-10.60)	$P_2 \times P_6$ (51.12)
Three top F_1 hybrids with heterosis % over TP	$P_6 \times P_7$ (15.42)	$P_6 \times P_7$ (15.56)	$P_3 \times P_7$ (6.92)	$P_1 \times P_7$ (-27.93)	$P_2 \times P_7$ (64.51)
	$P_3 \times P_7$ (15.08)	$P_3 \times P_7$ (14.13)	$P_6 \times P_7$ (6.08)	$P_1 \times P_2$ (-26.56)	$P_1 \times P_7$ (55.61)
	$P_5 \times P_7$ (10.95)	$P_3 \times P_6$ (8.00)	$P_5 \times P_7$ (5.13)	$P_1 \times P_5$ (-26.49)	$P_2 \times P_6$ (54.57)

TP = Top parent, BP = Better parent, MP = Mid parent

al. (18) observed positive heterosis desirable for length of fruit, weight per fruit, number of fruits per plant and fruit yield per plant was common in most of the crosses. Kushwaha *et al.* (10) observed that hybrids manifested significant heterobeltiosis for nodal position of first female flower, fruit length, fruit diameter, fruit weight and for number of fruits per vine and fruit yield per vine. Musmade (14) also reported similar results in cucumber hybrids. Appreciable heterosis in desirable direction was found over better parent and mid parent for all the characters studied (Pandey *et al.*, 15). In accordance to the present findings, Grafius (3) was of the opinion that hybrid vigour of even small magnitude of individual yield components may have additive or synergistic effect on the end product, as had mentioned that heterosis for yield is the result of interaction of simultaneous increase in the expression of heterosis for yield components. Based on the performance of 21 F_1 hybrids three best performing hybrids PPC-2 × Pusa Uday, GPC-1 × Pusa Uday and PPC-2 × Punjab Naveen showing 64.51, 55.61, and 54.57% heterosis, respectively over standard check Pusa Uday for yield per plant may be tested under multi-locational trials.

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