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Evaluation of heterosis and inbreeding depression in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]

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Abstract
An investigation was conducted with ten diverse parents to develop forty-five F_1's and forty-five F_2's by using half-diallel mating design to estimate heterosis and inbreeding depression for fruit yield and its components in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. The analysis of variance revealed highly significant differences among parents, F_1's and F_2's almost all the characters studied. High heterosis for fruit yield per plant was reflected through high heterosis for number of fruits per plant, fruit length, and average fruit weight in most of crosses. High magnitude of mid parent heterosis for fruit yield per plant was recorded in the cross, Pusa Naveen × Kalyanpur long green followed by KBGL-14 × NDBG-1, KBGL-20 × KBGL-29, KBGL-22 × H-22 Kalyanpur long green × KBGL-22, Pusa Santhusti × Kalyanpur long green NDBG-1 × NDBG-121. The highest standard heterosis for fruit yield per plant was registered by the cross Pusa Naveen × Kalyanpur long green, followed by Kalyanpur long green × NDBG-1, KBGL-14 × NDBG-1, NDBG-1 × NDBG-121, Pusa Naveen × NDBG-1, Pusa Santhusti × Kalyanpur long green, Kalyanpur long green × KBGL-22. Two crosses *viz*., Pusa Naveen × Kalyanpur long green, KBGL-14 × NDBG-1and exhibited significant and lowest inbreeding depression for fruit yield per plant. The crosses with high heterotic values for fruit yield per plant and its important attributes also showed high inbreeding depression. The cross combinations, Pusa Naveen × Kalyanpur long green, Kalyanpur long green × NDBG-1 and Pusa Naveen × Kalyanpur long green, Kalyanpur long green × NDBG-1were the most promising cross combinations for fruit yield per plant, based on their high midparent and standard heterosis respectively in both F_1 and F_2 generations and thus, can be utilized effectively in the breeding programme.

Keywords: Heterosis, inbreeding depression, half-diallel mating design, bottle gourd

Introduction
Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is an important vegetable crop which belongs to the family cucurbitaceae. The family consists of about 118 genera and 825 species. The status of vegetable production is over 184.39 million tonnes from an area of 10.26 million hectares, in which bottle gourd contribute 2.683 million tonnes production with area of 0.157 million hectares (NHB, 2017-18) [9]. Bottle gourd is one of the most nutritive vegetable crops for human and tone up for energy and vigour, because it contains valuable source of carbohydrates, proteins, vitamins and minerals. The edible 100 g fresh fruits of bottle gourd contains fats (0.5%), proteins (0.20%), carbohydrates (2.9%), Vitamin C (11mg) and minerals (0.5%) such as calcium, iron, potassium and phosphorous (Thamburaj and Narendra Singh 2013) [10]. Heterosis breeding has been recognized as a practical tool in providing the breeder a means of increasing yield and other economic traits. Heterosis signifies increased or decreased vigour of the F_1 over the parents. The hybrid vigour or the superiority of F_1over its parents may be manifested in terms of high productivity, uniformity, improved quality, built in resistance, environmental adaptations, 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, for development of effective heterosis breeding programme in bottle gourd one need to elucidate the genetic nature and magnitude of quantitative inherited traits and estimated pre-potency of parents in hybrid combinations. Combining abilities studies like diallel analysis provide information in this direction. Besides heterosis studies, inbreeding depression is also important in deciding breeding methodology to be employed for crop improvement. The inbreeding depression results due to fixation of unfavourable recessive genes in F_2. Inbreeding depression studies also help to select which F_1 to be used as parents in mating design.

It also reveals deleterious recessive alleles, which can then be eliminated through assortative mating. Hence, the present investigation was undertaken to study the best heterotic combinations for the exploitation of heterosis and to study inbreeding depression in bottle gourd.

Materials and Methods

The experiments of the present research work were conducted with ten diverse parents *viz*. Pusa Naveen, Pusa Santusthi, Kalyanpur Long green, KBGL-20, KBGL-14, KBGL-22, KBGL-29, NDBG-1, NDBG-121 and H-22. All the 10 genotypes have crossed in diallel mating design to produce 45 F_1s hybrids (excluded reciprocal crosses) during *Zaid* 2020. Mature seeds of F_1s and parental selfed lines have to be harvested separately and procured for growing in the next crop season. Half seeds of all the F_1s will be grown and the plants so obtained will be selfed during Kharif 2020 to produce source seed of F_2s generation. Mature seeds will be harvested and procured for growing in final trial. During *Zaid* 2021 the final trial have been conducted taking total 100 treatments (10 parents + 45 F_1s and 45 F_2s) in Randomized Block Design with three replications at Vegetable Research Farm, Kalyanpur, C. S. Azad University of Agriculture and Technology, Kanpur. In the final trial the treatments were planted in rows spaced at 3.0 meters apart with a plant to plant spacing of 0.5 meter of Single row plot for Parents, F_1s while for F_2s two rows plot four meter long. The observations were recorded on the five plants for parents and F_1s as well as 10 competitive plants of F_2's were selected in each replication for fruit yield per plant and its components were summed up and divided by five to get mean value. *viz*., node number to first staminate flower appears, node number to first pistillate flower appears, ratio of pistillate: staminate flowers, internodal length (cm), vine length at last picking stage (m), number of primary branches per plant, days to first fruit harvest, average weight per fruit (kg), number of fruits per plant, fruit diameter (cm), fruit length (cm), duration of crop (days), total soluble solids (TSS) ^{0}Brix, specific gravity of fruits (g/cc) and fruit yield per plant (kg). The analysis of variance was performed to test the significance of difference among the genotypes for the characters studied as suggested by Hayes *et al.* (1955) [5]. The inbreeding depression was calculated from the deviation between F_1 and its corresponding F2 for each character separately (Allard 1960) [1].

Results and Discussion

The analysis of variance revealed (Table 1) highly significant differences among the genotypes for all the characters studied. This indicated that experimental material used in the present study had sufficient variability for different characters. Further partitioning of genotypic variance into parents, F_1's and F_2's also revealed that mean squares due to parents, F_1's and F_2's were also significant almost all the characters. Likewise, mean squares due to parents vs. F_1's and parents vs. F_2's were significant for the studied characters. This indicated that among parents as a group, F_1's as a group and F_2's as a group showed significant differences and average heterosis existed for the characters studied. Similar findings were reported by Ghuge *et al.* (2016), Malviya *et al.* (2017), Khot *et al.* (2018). Balat *et al.* (2020) [4, 8, 7, 2].

Out of positive significant crosses for yield per plant fifteen hybrids showed over mid parent KBGL-20 × KBGL-29 followed by KBGL-20 × KBGL-14, KBGL-22 × KBGL-29 while over standard variety was exhibited by Pusa Naveen × Kalyanpur long green for ratio of pistillate: staminate flowers, four hybrids showed over mid parent Pusa Naveen-20 × Pusa Santhusti followed by Pusa Naveen × KBGL-22 while over standard variety was exhibited by KBGL-14 × NDBG-1, followed by Kalyanpur long green × NDBG-1, Pusa Naveen-20 × Pusa Santhusti for number of primary branches per plant desirable and positive heterosis over mid parent which were Pusa Santhusti × Kalyanpur long green followed by KBGL-14 × KBGL-22, Kalyanpur long green × KBGL -20 while desirable and positive heterosis over standard variety was exhibited by NDBG-1 × H-22, for vine length at last picking stage three hybrids showed over mid parent which were Pusa Santhusti × KBGL-29 followed by Pusa Naveen × KBGL-29, KBGL-29 × H-22 while over standard variety was exhibited by KBGL-20 × KBGL-14, followed by KBGL-14 × NDBG-121, Kalyanpur long green × NDBG-121, for average weight per fruit (kg). Twelve hybrids showed (KBGL-14 × NDBG-1, followed by Pusa Santhusti × Kalyanpur long green, Pusa Naveen × Kalyanpur long green while over standard variety was exhibited by Pusa Naveen × Kalyanpur long green, followed by Pusa Santhusti × Kalyanpur long green, Kalyanpur long green × NDBG-121 for number of fruits per plant. Seven hybrids showed over mid parent which were Kalyanpur long green × KBGL-29 followed by Kalyanpur long green × H-22, KBGL-20 × NDBG-1 while over standard variety nine crosses were exhibited Pusa Santhusti × NDBG-121, followed by KBGL-22 × NDBG-121, (KBGL-20 × NDBG-121 for fruit diameter. sixteen hybrids showed over mid parent which were Pusa Santhusti × KBGL-29 followed by Pusa Santhusti × H-22, Pusa Santhusti × KBGL-14 while over standard variety was exhibited by KBGL-14 × KBGL-29, followed by KBGL-14 × KBGL-22, KBGL-20 × KBGL-22, KBGL-20 × NDBG-1 for fruit length, 27 hybrids showed over mid parent which were KBGL-20 × KBGL-14 followed by KBGL-14 × NDBG-121, KBGL-14 × H-22, KBGL-22 × NDBG-1 while 26 crosses over standard variety was exhibited which were KBGL-29 × H-22, followed by KBGL-29 × NDBG-121, KBGL-22 × NDBG-1, KBGL-22 × NDBG-121 for total soluble solids (TSS) ^{0}Brix. three hybrids showed over mid parent which were Pusa Naveen × Pusa Santhusti followed by Pusa Santhusti × KBGL-22, KBGL-20 × KBGL -22, while three crosses also over standard variety was exhibited which were KBGL-20 × KBGL -22, followed by KBGL-20 × KBGL-29, Kalyanpur long green × H-22 (2.19), for specific gravity of fruits (g/cc). Twelve hybrids showed over mid parent which were Pusa Naveen × Kalyanpur long green followed by KBGL-14 × NDBG-1, KBGL-20 × KBGL-29, KBGL-22 × H-22, Kalyanpur long green × KBGL-22, Pusa Santhusti × Kalyanpur long green, NDBG-1 × NDBG-121 while twelve crosses also over standard variety was exhibited which were Pusa Naveen × Kalyanpur long green, followed by Kalyanpur long green × NDBG-1, KBGL-14 × NDBG-1, NDBG-1 × NDBG-121, Pusa Naveen × NDBG-1, Pusa Santhusti × Kalyanpur long green, Kalyanpur long green × KBGL-22, for fruit yield per plant (kg). The crosses Pusa Naveen X Pusa Santhusti followed by Kalyanpur long green × KBGL-22, KBGL-20 × NDBG-121 exhibit significant inbreeding depression for yield per plant in F_2 generation which also exhibited significant inbreeding depression for other than the yield per plant *i.e.* internodal length (cm), number of fruits per plant, number of primary branches per plant, fruit diameter. Some of the characters which also exhibit significant inbreeding depression in F_2 which is mentioned in Table-1. similar finding observed by Yadav and Kumar (2012 b), Gayakawad *et al.* (2016), Jayanth *et al.* (2020) [11, 3, 6].

Table 1: Estimates of heterosis over mid and standard variety (per cent) and inbreeding depression (per cent) in a 10 parent's diallel cross for 15 characters in Bottle gourd.

SN	Crosses	Node number to first staminate flower appears			Node number to first pistillate flower appears			Ratio of pistillate: Staminate flowers		
		MP	SV	ID	MP	SV	ID	MP	SV	ID
1	PNXPS	-0.1	1.91	-7.32**	-0.42	0.19	-2.08**	8.43 **	2.27	13.33**
2	PNXKLG	-3.83	-15.04 **	-1.02**	-0.74	-11.50 **	-4.26**	17.70 **	8.33 *	24.48**
3	PNXKBGL20	-2.62	3.53	3.25**	-0.91	2.69	-3.25**	3.33	-29.55 **	-19.35**
4	PNXKBGL14	2.03	13.35 **	-0.64**	-8.34 **	7.60 **	-3.95**	42.86 **	2.27	20.00**
5	PNXKBGL22	-2.34	3.23	-8.15**	-0.69	11.41 **	-0.39	-7.04	-25.00 **	6.06**
6	PNXKBGL29	0.43	10.83 **	-6.05**	-1.36	6.23 *	-2.16**	1.49	-22.73 **	2.94**
7	PNXNDBG1	-6.44 *	-7.32 *	-3.51**	-0.44	-3.56	-2.81**	-13.18 **	-15.15 **	0.88**
8	PNXNDBG121	0.86	-3.42	-1.39**	6.23 *	-4.35	-3.14**	9.68 *	-22.73 **	0.97**
9	PNXH22	-0.58	-4.6	-3.79**	6.23 **	0.15	-3.99**	1.33	-13.64 **	2.63**
10	PSXKLG	-1.61	-11.11 **	-3.19**	-0.23	-10.44 **	-3.05**	-10.53 **	-22.73 **	14.71**
11	PSXKBGL20	2.54	11.08 **	-1.01**	-1.26	2.94	-3.40**	30.91 **	-18.18 **	33.33**
12	PSXKBGL14	-0.35	12.71 **	2.19**	-5.04 **	12.06 **	-0.19	-27.59 **	-52.27 **	-52.38**
13	PSXKBGL22	-3.63	3.79	-4.35**	-0.29	12.48 **	-0.56	-45.45 **	-59.09 **	-61.11**
14	PSXKBGL29	5.88 *	18.96 **	5.28**	-2.44	5.67 *	-4.47**	-45.16 **	-61.36 **	-82.35**
15	PSXNDBG1	-1.47	-0.42	-3.63**	-0.62	-3.12	-2.56**	-3.7	-11.36 **	43.59**
16	PSXNDBG121	-1.92	-4.12	-10.50**	5.70 *	-4.19	-9.57**	-50.88 **	-68.18 **	-64.29**
17	PSXH22	1.79	-0.28	0.82*	0.43	-4.71	2.78*	-20.00 **	-36.36 **	-14.29**
18	KLGXKBGL20	12.86 **	6.84 *	-3.94**	15.60 **	7.27 **	-1.94**	-1.89	-40.91 **	-11.54**
19	KLGXKBGL14	12.67 **	12.03 **	-1.80**	3.63	10.42 **	-2.03**	32.14 **	-15.91 **	10.81**
20	KLGXKBGL22	-1.3	-7.18 *	-6.89**	0.36	1.71	-2.21**	6.25	-22.73 **	26.47**
21	KLGXKBGL29	-1.95	-3.23	-4.06**	-0.65	-3.77	-1.73**	-16.67 **	-43.18 **	36.00**
22	KLGXNDBG1	-2.7	-14.95 **	-7.85**	-2.66	-16.27 **	-2.24**	-21.52 **	-29.55 **	39.77**
23	KLGNDBG121	17.08 **	-1.54	1.71**	23.88 **	-1.9	-0.64	5.45	-34.09 **	-10.34**
24	KLGXH22	-8.33 **	-22.72 **	1.63**	20.83 **	0.81	1.65**	-29.41 **	-45.45 **	-12.50**
25	KBGL20XKBGL14	7.26 **	25.95 **	0.67	-3.11	17.27 **	-0.89*	65.71 **	-34.09 **	-24.14**
26	KBGL20XKBGL22	-2.34	9.40 **	-2.77**	-1.09	14.56 **	-2.91**	44.19 **	-29.55 **	-6.45**
27	KBGL20XKBGL29	-32.44 **	-21.18 **	-4.98**	-23.11 **	-14.39 **	-1.46**	101.71 **	-10.61 **	13.55**
28	KBGL20XNDBG1	1.92	7.41 *	4.67**	-0.31	0.19	-4.57**	13.79 **	-25.00 **	-9.09**
29	KBGL20XNDBG121	-9.04 **	-7.15 *	-6.65**	-1.49	-7.73 **	-1.13**	41.18 **	-45.45 **	0.00
30	KBGL20XH22	8.02 **	10.49 **	-1.83**	14.03 **	11.64 **	-1.49**	-12.06 *	-53.03 **	-1.60**
31	KBGL14XKBGL22	-3.93	12.20 **	3.25**	-1.14	28.10 **	12.70**	47.83 **	-22.73 **	0.00
32	KBGL14XKBGL29	-1.86	19.19 **	-1.48**	-0.62	24.31 **	-1.04**	4.76	-50.00 **	18.18**
33	KBGL14XNDBG1	-21.57 **	-13.60 **	-1.30**	-19.79 **	-8.35 **	-3.18**	37.70 **	-4.55	26.19**
34	KBGL14XNDBG121	-9.37 **	-3.17	4.69**	0.65	8.12 **	8.30**	-8.11	-61.36 **	-41.18**
35	KBGL14XH22	4.57	11.95 **	4.53**	-0.76	10.81 **	4.70**	-44.00 **	-68.18 **	-71.43**
36	KBGL22XKBGL29	-3.55	11.92 **	-4.26**	-1.14	18.52 **	-2.64**	48.00 **	-15.91 **	24.32**
37	KBGL22XNDBG1	5.72 *	10.74 **	2.20**	3.83	13.23 **	7.58**	-15.94 **	-34.09 **	34.48**
38	KBGL22XNDBG121	15.86 **	17.53 **	-1.43**	11.26 **	13.73 **	3.85**	37.78 **	-29.55 **	29.03**
39	KBGL22XH22	-6.15 *	-4.6	-4.70**	0.41	6.89 **	-3.80**	17.24 **	-22.73 **	23.53**
40	KBGL29XNDBG1	-3.35	5.75	-1.83**	-1.18	3.33	-2.00**	-13.85 **	-36.36 **	39.29**
41	KBGL29XNDBG121	4.16	10.52 **	0.76*	12.53 **	9.98 **	-1.14*	-17.07 **	-61.36 **	-86.29**
42	KBGL29XH22	8.97 **	15.85 **	2.66**	6.02 **	8.10 **	2.31**	-33.33 **	-59.09 **	-44.44**
43	NDBG1XNDBG121	-9.47 **	-14.17 **	-2.61**	-0.05	-13.14 **	-2.16**	-6.67	-36.36 **	32.14**
44	NDBG1XH22	16.61 **	10.80 **	2.03**	16.33 **	6.02 *	3.54**	-20.55 **	-34.09 **	0.00**
45	NDBG121XH22	26.35 **	15.88 **	-3.12**	28.23 **	8.10 **	-2.12**	-2.04	-45.45 **	25.00**
46	No. of crosses with significant positive heterosis	11	21	14	12	23	7	15	1	26
47	No. of crosses with significant negative heterosis	8	9	30	4	7	33	17	41	17
48	No. of crosses with desirable positive / negative heterosis	18	9	0	23	5	5	6	2	2
49	SED	0.30	0.35	0.303	0.35	0.41	0.355	0.012	0.014	0.014
50	CD 5%	0.61	0.70	0.611	0.72	0.83	0.716	0.025	0.029	0.028
51	CD1%	0.92	0.92	0.79	0.93	1.08	0.931	0.029	0.038	0.036

SN	Crosses	Internodal length (cm)			Vine length at last picking stage (m)			Number of primary branches per plant		
		MP	SV	ID	MP	SV	ID	MP	SV	ID
1	PNXPS	17.38 **	-8.82 *	-3.63**	-10.65 *	-18.82 **	-1.99**	12.53 **	6.67	6.25**
2	PNXKLG	0	9.09 *	2.27**	-11.30 **	-15.59 **	-2.80**	-6.21	-2.86	8.87**
3	PNXKBGL20	-1.67	-2.48	2.82**	-9.04 *	-16.13 **	3.85**	-7.22	-14.29 **	-6.67**
4	PNXKBGL14	-2.12	1.65	1.63**	-7.34	-11.83 **	4.88**	-8.35 *	-3.33	7.39**
5	PNXKBGL22	-3.75	-1.1	1.11**	-7.69	-16.13 **	3.78**	9.77 *	3.24	5.90**
6	PNXKBGL29	-3.28	1.65	2.74**	-7.82	-8.06	5.67**	-8.11	-10.95 *	-12.30**
7	PNXNDBG1	-2.38	7.44	5.38**	-12.78 **	-6.45	4.60**	-8.55 *	-0.95	10.19**
8	PNXNDBG121	-2.12	1.65	4.34**	-8.87 *	-13.28 **	3.35**	3.47	-7.62	4.64**
9	PNXH22	-1.21	0.83	2.46**	-7.43	-12.90 **	3.70**	6.49	-6.19	7.11**
10	PSXKLG	22.86 **	6.61	4.13**	2.5	-11.83 **	10.37**	-1.23	-2.86	7.35**
11	PSXKBGL20	25.45 **	-3.58	4.29**	0.26	-16.72 **	5.74**	2.16	-10.95 *	4.28**
12	PSXKBGL14	26.69 **	3.31	3.73**	-0.62	-14.52 **	1.89**	-1.69	-1.43	-2.90**
13	PSXKBGL22	18.49 **	-4.68	2.89**	0	-18.28 **	3.29**	0.24	-10.95 *	-10.16**
14	PSXKBGL29	25.79 **	4.13	10.32**	-2.67	-11.83 **	3.66**	-0.8	-9.05	-3.14**
15	PSXNDBG1	29.98 **	14.05 **	6.52**	-7.4	-9.14 *	4.73**	1.15	4.29	4.06**
16	PSXNDBG121	26.69 **	3.31	4.80**	-0.62	-14.52 **	3.15**	-5.52	-20.57 **	-7.91**
17	PSXH22	26.08 **	0.55	2.77**	-3.35	-17.90 **	2.03**	-6.06	-22.14 **	-7.65**
18	KLGXKBGL20	-3.05	4.96	3.94**	0.31	-12.37 **	3.07**	-4.22	-8.1	-6.01**
19	KLGXKBGL14	0.66	13.69 **	3.22**	-4.29	-13.55 **	3.92**	-0.31	8.71	4.20**
20	KLGXKBGL22	-2.98	8.51	-3.96**	-2.87	-16.45 **	-3.41**	2.1	-0.33	6.59**
21	KLGXKBGL29	-2.05	11.85 **	2.22**	-5.38	-10.22 *	2.99**	2.37	2.86	2.78**
22	KLGXNDBG1	0.35	19.56 **	0.92**	-14.96 **	-12.90 **	-4.94**	1.3	13.33 **	8.82**
23	KLGNDBG121	-0.76	12.09 **	3.66**	-1.79	-11.29 *	5.45**	-4.62	-11.43 *	-7.53**
24	KLGXH22	1.61	12.95 **	4.63**	0	-10.75 *	4.22**	-8.05	-15.71 **	-2.26**
25	KBGL20XKBGL14	-1.07	1.93	4.32**	-1.54	-13.98 **	1.25**	-33.33 **	-34.76 **	-6.57**
26	KBGL20XKBGL22	3.78	5.79	3.13**	-1.62	-18.28 **	3.95**	-4.13	-17.14 **	-1.15**
27	KBGL20XKBGL29	-4.1	0	-3.31**	-5.85	-13.44 **	-4.97**	1.33	-9.52	3.68**
28	KBGL20XNDBG1	2.14	11.57 **	5.31**	-1.08	-1.61	8.20**	-12.51 **	-11.90 *	-16.22**
29	KBGL20XNDBG121	-1.34	1.65	3.25**	-2.03	-14.41 **	3.90**	3.21	-15.71 **	10.73**
30	KBGL20XH22	-7.21	-6.06	-4.40**	-4.05	-17.20 **	-2.60**	3.55	-16.67 **	9.71**
31	KBGL14XKBGL22	-2.33	4.13	3.97**	1.25	-12.90 **	4.88**	-1.91	-2.38	-4.39**
32	KBGL14XKBGL29	-0.63	8.26	2.29**	-0.28	-5.38	5.11**	1.81	4.24	6.81**
33	KBGL14XNDBG1	0.12	14.05 **	3.86**	-3.41	-1.08	2.72**	1.69	15.71 **	2.47**
34	KBGL14XNDBG121	1.79	9.64 *	2.76**	-1.67	-11.18 *	2.54**	-4.52	-9.52	-5.26**
35	KBGL14XH22	-1.95	3.86	4.24**	-2.41	-12.90 **	3.70**	-6.87	-12.86 *	-3.82**
36	KBGL22XKBGL29	-2.68	4.96	3.15**	-2.67	-11.83 **	2.44**	1.05	-8.1	5.70**
37	KBGL22XNDBG1	-1.93	10.63 *	3.49**	-5.48	-7.26	5.27**	-2.58	-0.29	-4.39**
38	KBGL22XNDBG121	-1.55	4.96	4.72**	-1.25	-15.05 **	3.80**	2.29	-14.76 **	5.03**
39	KBGL22XH22	-6.49	-1.98	3.71**	-1.84	-16.61 **	-0.90**	0.81	-17.19 **	7.59**
40	KBGL29XNDBG1	-4.26	10.25 *	3.25**	-18.14 **	-12.42 **	3.01**	0.79	6.05	4.62**
41	KBGL29XNDBG121	-1.39	7.44	4.62**	-3.12	-8.06	5.26**	-4.42	-17.62 **	-6.94**
42	KBGL29XH22	-1.29	5.79	4.69**	-6.02	-11.83 **	3.66**	-0.28	-15.24 **	-5.06**
43	NDBG1XNDBG121	-5.93	7.16	-6.17**	-7.61	-5.38	-4.54**	4.42	1.9	4.67**
44	NDBG1XH22	0.49	12.67 **	3.67**	-1.33	0	1.61**	-4.67	-8.1	-6.22**
45	NDBG121XH22	0.13	6.06	3.12**	-2.41	-12.90 **	4.32**	4	-19.52 **	6.51**
46	No. of crosses with significant positive heterosis	9	13	40	0	0	37	2	2	24
47	No. of crosses with significant negative heterosis	0	1	5	7	36	8	4	20	20
48	No. of crosses with desirable positive / negative heterosis	26	6	0	6	1	0	19	7	0
49	SED	0.45	0.52	0.467	0.24	0.27	0.231	0.29	0.34	0.299
50	CD 5%	0.91	1.05	0.941	0.48	0.55	0.465	0.60	0.69	0.604
51	CD1%	1.18	1.36	1.22	0.62	0.72	0.606	0..78	0.90	0.786

SN	Crosses	Days to first fruit harvest			Average weight / fruit (kg)			Number of fruits per plant		
		MP	SV	ID	MP	SV	ID	MP	SV	ID
1	PNXPS	-5.32	-6.81	-2.74	6.98	9.52	-1.73**	9.14 *	1.46	18.66**
2	PNXKLG	0.97	6.24	-2.14	-3.7	23.81 *	-3.07**	38.33 **	20.87 **	5.62**
3	PNXKBGL20	-3.12	-0.51	-2.17	7.14	42.86 **	-5.00**	-19.08 **	-40.29 **	-20.32**
4	PNXKBGL14	1.36	3.8	-0.77	-13.75	19.52	-1.59**	5.2	-17.52 **	1.71**

5	PNXKBGL22	-3.02	-0.68	-3.43	-4.17	9.52	-6.95**	25.58 **	4.85	27.32**
6	PNXKBGL29	-0.7	3.13	-2.08	16	38.10 **	4.83**	-18.54 **	-34.95 **	-4.48**
7	PNXNDBG1	1.42	3.63	-1.53	12.5	28.57 *	-2.22**	6.67	0.97	13.46**
8	PNXNDBG121	-1.42	0.11	-1.76	-10.33	28.10 *	-4.46**	2.23	-19.85 **	5.51**
9	PNXH22	0.2	0.85	-1.29	8.16	26.19 *	-4.15**	-9.37 *	-22.33 **	5.63**
10	PSXKLG	-0.51	3.12	-3.58	-12.73	14.29	-22.50**	39.58 **	12.14 **	18.18**
11	PSXKBGL20	-2.85	-1.76	-2.54	-6.32	27.14 *	-6.74**	-2.55	-34.95 **	3.73**
12	PSXKBGL14	0.35	1.19	-1.46	-0.68	40.00 **	4.08**	-5.58	-32.62 **	-3.03**
13	PSXKBGL22	-5.22	-4.43	-4.57	1.63	18.57	-2.01**	0.38	-23.25 **	5.76**
14	PSXKBGL29	0.71	3.01	-2.15	17.65 *	42.86 **	7.67**	-16.67 **	-39.32 **	-17.60**
15	PSXNDBG1	3.85	4.48	-2.28	6.12	23.81 *	-6.15**	9.70 *	-3.88	11.11**
16	PSXNDBG121	-2.26	-2.27	-4.18	-3.61	40.00 **	-4.77**	2.04	-27.18 **	8.00**
17	PSXH22	-5.7	-6.57	-5.54**	5.2	25.24 *	4.56**	-4.1	-24.56 **	-5.79**
18	KLGXKBGL20	-0.92	6.92	-1.65	-2.94	57.14 **	1.21**	-1.59	-39.81 **	0.00**
19	KLGXKBGL14	0.1	7.74	-2.43	-22.22 **	30.00 *	3.66**	33.51 **	-12.18 **	1.88**
20	KLGXKBGL22	-2.37	5.08	-1.87	9	55.71 **	-6.42**	15.00 **	-18.50 **	20.85**
21	KLGXKBGL29	-1.51	7.43	0.37	7.1	58.10 **	5.12**	6.14	-28.64 **	4.08**
22	KLGXNDBG1	-1.4	5.9	-2.68	-10.67	27.62 *	-9.71**	36.69 **	12.14 **	16.88**
23	KLGNDBG121	1.89	8.80 *	1.72	5.83	81.43 **	6.83**	-2.58	-35.92 **	-2.27**
24	KLGXH22	0.51	6.41	-3.57	3.93	50.95 **	7.26**	1.63	-25.73 **	0.00**
25	KBGL20XKBGL14	-3.94	0.96	-0.62	13.02 *	94.29 **	0.00	-12.09	-54.13 **	-4.76
26	KBGL20XKBGL22	-6.05	-1.25	-2.93	-4.19	41.43 **	9.09**	2.54	-41.26 **	-3.31**
27	KBGL20XKBGL29	-3.65	2.67	-4.09	3.75	58.10 **	-7.53**	23.08 **	-33.98 **	8.09**
28	KBGL20XNDBG1	-3.14	1.59	-3.63	1.61	50.00 **	9.84**	-7.09	-36.41 **	-5.34**
29	KBGL20XNDBG121	-3.76	0.34	-3.05	-3.51	70.00 **	0.00	17.21 *	-38.83 **	11.90**
30	KBGL20XH22	-2.42	0.85	-4.16	-6.35	40.48 **	-2.38**	9.34	-34.95 **	2.24**
31	KBGL14XKBGL22	-3.57	1.08	-3.82	5.92	61.90 **	1.17**	-1.96	-39.32 **	-5.60**
32	KBGL14XKBGL29	-0.67	5.56	0.21	-3.63	51.90 **	3.13**	-5.83	-45.15 **	1.77**
33	KBGL14XNDBG1	-0.33	4.26	-2.56	-14.64 *	30.48 *	-5.11**	48.17 **	8.25	13.00**
34	KBGL14XNDBG121	0.15	4.13	-3.44	4.46	89.52 **	8.04**	-1.62	-44.13 **	-11.21**
35	KBGL14XH22	1.21	4.31	-2.72	9.51	70.00 **	2.52**	-8.52	-41.36 **	-0.99**
36	KBGL22XKBGL29	-4.83	1.14	-3.14	8.93	45.24 **	-0.32**	-8.81	-42.23 **	0.84**
37	KBGL22XNDBG1	-3.21	1.24	-4.55	8.89	40.00 **	-4.08**	-24.35 **	-40.87 **	-6.90**
38	KBGL22XNDBG121	-3.11	0.74	-4.16	5.76	66.19 **	1.14**	-4.31	-40.78 **	1.39**
39	KBGL22XH22	-2.67	0.31	2.22	9.82	43.81 **	-12.25**	16.94 **	-19.08 **	14.58**
40	KBGL29XNDBG1	-1.86	4.07	-2.91	6.07	41.43 **	5.05**	1.95	-24.03 **	1.09**
41	KBGL29XNDBG121	-2.77	2.5	-3.32	5.88	71.43 **	1.11**	4.17	-39.32 **	-0.80**
42	KBGL29XH22	-2.58	1.82	-1.73	15.79 *	57.14 **	0.91**	-8.85	-40.24 **	-9.67**
43	NDBG1XNDBG121	0.49	4.26	-4.19	-10.91	40.00 **	-16.33**	34.22 **	-1.94	21.78**
44	NDBG1XH22	0	2.84	-4.03	3.64	35.71 **	-2.81**	-2.14	-21.36 **	-1.85**
45	NDBG121XH22	-1.05	1.14	-1.85	8.06	72.38 **	-5.52**	-11.55 *	-43.30 **	8.39**
46	No. of crosses with significant positive heterosis	0	1	0	3	40	19	13	3	29
47	No. of crosses with significant negative heterosis	0	0	1	2	0	25	6	36	15
48	No. of crosses with desirable positive / negative heterosis	31	8	40	25	5	2	11	4	0
49	SED	1.96	2.27	2.144	0.07	0.08	0.064	0.24	0.28	0.097
50	CD 5%	3.96	4.57	4.322	0.14	0.16	0.130	0.49	0.57	0.195
51	CD1%	5.15	5.95	5.623	0.18	0.21	0.169	0.64	0.74	0.254

SN	Crosses	Fruit diameter (cm)			Fruit length (cm)			Duration of crop (days)		
		MP	SV	ID	MP	SV	ID	MP	SV	ID
1	PNXPS	-37.34 **	0	-38.63**	18.52 **	-5.2	20.79**	-3.97	-4.88	-4.32
2	PNXKLG	-2.79	-4.57 *	1.10**	-0.83	-2.99	-2.36	-1.8	1.26	-3.19
3	PNXKBGL20	1.65	-1.83	2.79**	-6.99 *	6.35	-5.43**	-4.12	-6.34	-2.84
4	PNXKBGL14	-2.48	-1.37	-2.32**	-3.75	11.28 **	-10.53**	-1.36	-0.79	-1.62
5	PNXKBGL22	-0.45	0	0.68**	-4.91	5.42	-7.98**	-1.61	-2.8	-2.78
6	PNXKBGL29	1.68	-3.2	4.48**	9.08 **	19.27 **	1.07	-2.69	-7.18 *	-4.76
7	PNXNDBG1	1.88	-0.91	4.75**	-2.01	-6.3	-4.90**	-4.17	-1.82	-4.39
8	PNXNDBG121	-0.9	5.89 **	-0.04**	-0.36	-3.24	-5.36**	-0.99	-2.44	-0.43
9	PNXH22	5.85 **	2.47	2.81**	-6.48 *	-1.12	-9.88**	-1.47	-0.88	-4.63
10	PSXKLG	-37.22 **	-0.96	-14.34**	17.79 **	-8.34 *	-0.93	-3.87	-1.78	-4.33
11	PSXKBGL20	-39.04 **	-4.79 *	-42.06**	26.52 **	19.35 **	25.27**	-4.03	-7.16 *	-4.06

12	PSXKBGL14	-36.93 **	1.37	-13.51**	28.83 **	23.17 **	3.86**	-2.86	-3.22	-3.89
13	PSXKBGL22	-34.66 **	4.57 *	-105.68**	13.04 **	2.7	38.38**	-1.49	-3.61	-5.14
14	PSXKBGL29	-35.40 **	0	-18.49**	38.28 **	23.51 **	3.92**	-1.63	-7.10 *	-4.98
15	PSXNDBG1	-35.95 **	0.46	-87.23**	30.11 **	-1.63	34.80**	-3.98	-2.54	-4.49
16	PSXNDBG121	-30.86 **	15.07 **	-75.56**	17.69 **	-9.28 *	33.15**	-1.16	-3.55	-4.43
17	PSXH22	-39.56 **	-5.48 *	-21.30**	33.34 **	14.29 **	3.30*	-2.18	-2.52	-4.15
18	KLGXKBGL20	1.69	-3.65	0.47**	-6.10 *	5.33	42.90**	-2.95	-2.17	-4.22
19	KLGXKBGL14	2.07	1.37	3.15**	9.49 **	24.21 **	4.66**	-1.7	1.92	-3.14
20	KLGXKBGL22	-3.24	-4.57 *	0.96**	2.56	11.47 **	-7.33**	-3.66	-1.82	-4.61
21	KLGXKBGL29	10.02 **	2.74	2.22**	15.74 **	24.02 **	5.48**	0.54	-0.97	-3.71
22	KLGXNDBG1	4.31 *	-0.46	2.48**	1.55	-5.11	-5.28**	-4.26	1.07	-3.42
23	KLGNDBG121	1.65	6.76 **	0.34*	6.13	0.75	2.53**	-1.52	0.1	-4.76
24	KLGXH22	8.13 **	2.69	3.29**	7.71 *	11.54 **	4.80**	-1.72	1.93	-4.23
25	KBGL20XKBGL14	0.93	-1.37	0.51	-6.67 **	21.30 **	6.72**	-2.79	-4.48	-4.62
26	KBGL20XKBGL22	0.71	-2.28	1.87**	1.36	26.91 **	4.28**	-2.79	-6.22	-4.66
27	KBGL20XKBGL29	4.03	-4.52 *	1.00**	-4.81	17.74 **	-7.07**	-2.29	-9.06 **	-5.14
28	KBGL20XNDBG1	7.88 **	1.23	1.67**	15.10 **	26.57 **	4.83**	-4.52	-4.39	-4.81
29	KBGL20XNDBG121	4.06 *	7.63 **	15.74**	9.22 **	21.73 **	4.95**	-2.37	-6.07	-3.39
30	KBGL20XH22	2.4	-4.38	3.58**	-9.30 **	8.90 *	2.89	-3.54	-5.2	-3.81
31	KBGL14XKBGL22	-0.22	1.37	0.45**	1.75	28.70 **	2.57	-1.15	-1.77	-4.39
32	KBGL14XKBGL29	-6.16 **	-9.59 **	-14.24**	5.1	31.33 **	2.78	-3.12	-7.03 *	-5.57
33	KBGL14XNDBG1	3.71	2.05	5.59**	-9.74 **	0.41	-8.04**	-2.82	0.12	-3.51
34	KBGL14XNDBG121	1.48	9.59 **	3.37**	-1.66	10.86 **	1.69	0.38	-0.52	-4.95
35	KBGL14XH22	1.63	-0.46	2.75**	2.21	24.02 **	2.88*	-1.04	0.12	-4.92
36	KBGL22XKBGL29	0.72	-3.65	-2.84**	0.07	20.29 **	-6.00**	-1.52	-7.25 *	-4.35
37	KBGL22XNDBG1	-3.27	-5.48 *	-3.09**	6.07	12.95 **	-5.02**	-3.09	-1.89	-4.69
38	KBGL22XNDBG121	2.98	10.50 **	3.76**	16.68 **	25.98 **	3.57**	0.02	-2.66	-3.65
39	KBGL22XH22	4.23 *	1.37	2.25**	-3.9	12.05 **	-7.55**	-1.79	-2.39	-4.47
40	KBGL29XNDBG1	3.21	-4.57 *	3.35**	4.09	9.24 *	5.87**	-2.95	-5.05	-4.54
41	KBGL29XNDBG121	1.88	3.97	3.03**	3.43	10.09 **	0.46	-1.03	-7.05 *	-3.94
42	KBGL29XH22	-0.99	-8.90 **	-4.21**	-3.21	11.37 **	4.20**	-2.15	-6.09	-1.81
43	NDBG1XNDBG121	1.58	5.75 *	2.20**	-7.74 *	-14.46 **	-10.82**	-2.84	-1.89	-4.74
44	NDBG1XH22	0.63	-5.34 *	0.48**	1.09	2.45	-6.88**	-3.71	-0.78	-4.31
45	NDBG121XH22	2.16	5.89 **	-0.69**	-2.52	0.24	-6.02**	-1.94	-2.8	-4.79
46	No. of crosses with significant positive heterosis	7	9	28	16	27	21	0	0	0
47	No. of crosses with significant negative heterosis	10	10	16	7	2	17	0	7	0
48	No. of crosses with desirable positive / negative heterosis	20	14	1	12	8	6	3	7	0
49	SED	0.13	0.16	0.123	1.26	1.45	1.247	3.23	3.73	3.532
50	CD 5%	0.28	0.32	0.249	2.54	2.93	2.514	6.51	7.52	7.118
51	CD1%	0.36	0.42	0.324	3.30	3.81	3.271	8.47	9.78	9.261

SN	Crosses	Total soluble solids (TSS) o°Brix			Specific gravity of fruits (g/cc)			Fruit yield per plant (kg)		
		MP	SV	ID	MP	SV	ID	MP	SV	ID
1	PNXPS	3.16	1.63	-19.56**	1.84 **	1.09	1.80**	14.44 *	10.19	16.93**
2	PNXKLG	2.22	0.92	-17.37**	0.18	0.73	0.36**	35.70 **	46.95 **	0.90**
3	PNXKBGL20	19.55 **	14.37 **	15.51**	-3.15 **	1.09	0.71**	-2.29	-12.69	-23.03**
4	PNXKBGL14	2.05	-3.47	-16.26**	0.36	0.36	0.37**	0.21	0.49	2.69**
5	PNXKBGL22	0.98	9.89 **	-14.47**	0	0	0.36**	-0.15	-7.14	3.66**
6	PNXKBGL29	5.50 **	18.35 **	5.68**	-3.86 **	0	0.00	-1.3	-10.61	-0.08
7	PNXNDBG1	7.06 **	2.04	-18.38**	0	0.36	0.00	23.81 **	31.28 **	9.67**
8	PNXNDBG121	-1.5	-2.75	-15.20**	-0.18	-0.36	0.36**	-0.23	3.47	1.47**
9	PNXH22	1.25	-0.71	-9.96**	0.18	0.73	0.73**	1.3	-0.21	3.41**
10	PSXKLG	5.35 **	2.45	-9.95**	-0.55	-0.73	0.37**	25.33 **	31.07 **	2.22**
11	PSXKBGL20	0.32	-5.50 *	-12.62**	-3.52 **	0	0.72**	-3.48	-17.34 *	-2.35**
12	PSXKBGL14	11.00 **	3.36	7.99**	-0.37	-1.09	0.00	-2.33	-5.69	0.73*
13	PSXKBGL22	3.13	10.70 **	-7.73**	1.47 *	0.73	1.82**	1.75	-9.15	2.98**
14	PSXKBGL29	10.77 **	22.63 **	8.73**	-2.12 **	1.09	1.08**	0.52	-12.69	-8.82**
15	PSXNDBG1	2.99	-3.36	-23.21**	0.37	0	0.72**	17.32 **	20.04 **	6.41**
16	PSXNDBG121	2.2	-0.61	-16.31**	0.55	-0.36	0.36**	2.01	2.01	4.15**
17	PSXH22	16.83 **	12.84 **	9.03**	0.18	0	0.72**	0	-5.2	-1.17**
18	KLGXKBGL20	0.22	-5.40 *	-1.51**	-4.70 **	0	0.00	-1.92	-4.23	2.24**

19	KLGXKBGL14	-11.09 **	-17.02 **	-27.52**	0.54	1.09	0.71**	5.21	14.22 *	5.10**
20	KLGXKBGL22	8.63 **	16.82 **	-13.61**	-0.18	0.36	0.37**	26.26 **	27.88 **	16.22**
21	KLGXKBGL29	4.41 *	15.80 **	-5.46**	-3.32 **	1.09	0.00**	14.98 *	13.66 *	8.48**
22	KLGXNDBG1	3.52	-2.65	-12.36**	-0.54	0.36	0.00**	24.96 **	42.86 **	8.25**
23	KLGNDBG121	13.28 **	10.40 **	1.02**	0	0.36	0.37**	4.02	16.50 *	5.36**
24	KLGXH22	20.38 **	16.51 **	1.14**	1.08	2.19 **	-2.14**	4.55	11.65	6.83**
25	KBGL20XKBGL14	30.10 **	17.43 **	9.38**	-3.85 **	0.36	0.00	-0.19	-10.54	-3.88**
26	KBGL20XKBGL22	11.51 **	16.51 **	8.84**	1.40 *	5.84 **	5.17**	0.21	-17.48 **	5.04**
27	KBGL20XKBGL29	4.06 *	12.23 **	-3.45**	-4.04 **	4.01 **	2.11**	31.19 **	4.85	0.79**
28	KBGL20XNDBG1	15.63 **	5.20 *	9.30**	-4.53 **	0	0.72**	0.33	-4.3	2.90**
29	KBGL20XNDBG121	8.21 **	2.14	-15.97**	-4.03 **	0	1.09**	11.03	3.33	10.67**
30	KBGL20XH22	9.30 **	2.45	-7.07**	-4.35 **	0.36	0.37**	4.18	-8.46	3.03**
31	KBGL14XKBGL22	17.40 **	21.41 **	7.98**	-0.73	-0.73	0.00	4.76	-2.29	-4.33**
32	KBGL14XKBGL29	10.84 **	18.35 **	-3.10**	-3.51 **	0.36	0.00	-8.85	-17.20 *	4.52**
33	KBGL14XNDBG1	12.24 **	0.92	-17.27**	0.36	0.73	0.73**	32.42 **	40.78 **	8.37**
34	KBGL14XNDBG121	23.21 **	14.98 **	7.71**	-0.55	-0.73	0.37**	1.97	6.03	-2.03**
35	KBGL14XH22	20.79 **	11.93 **	12.30**	0.54	1.09	2.17**	1.79	0.55	2.07**
36	KBGL22XKBGL29	0.59	21.71 **	-0.33**	-3.51 **	0.36	0.37**	1.24	-15.40 *	2.46**
37	KBGL22XNDBG1	20.70 **	25.69 **	3.33**	-0.36	0	0.00	-16.46 **	-17.27 *	-11.32**
38	KBGL22XNDBG121	15.17 **	23.85 **	1.73**	-0.55	-0.73	0.74**	1.04	-2.29	2.06**
39	KBGL22XH22	8.06 **	15.49 **	-6.18**	-0.54	0	0.72**	28.53 **	17.61 **	5.31**
40	KBGL29XNDBG1	3.56	11.31 **	-9.43**	-3.85 **	0.36	-0.36**	11.27	7.49	5.10**
41	KBGL29XNDBG121	14.71 **	27.22 **	10.18**	-3.69 **	0	0.36**	10.33	4.02	0.00
42	KBGL29XH22	17.89 **	29.97 **	3.29**	-3.32 **	1.09	2.17**	5.88	-5.69	-8.82**
43	NDBG1XNDBG121	1.14	-4.89 *	-17.68**	0.55	0.73	0.73**	25.12 **	37.31 **	9.09**
44	NDBG1XH22	15.28 **	7.65 **	1.42**	-0.9	0	-0.73**	1.43	6.03	-5.95**
45	NDBG121XH22	2.79	-0.51	-13.12**	0	0.36	-2.54**	-4.88	-2.77	1.57**
46	No. of crosses with significant positive heterosis	27	26	17	3	3	33	12	12	33
47	No. of crosses with significant negative heterosis	1	2	28	17	0	4	1	6	10
48	No. of crosses with desirable positive / negative heterosis	15	8	0	15	35	8	22	12	0
49	SED	0.06	0.07	0.067	0.005	0.006	0.005	0.27	0.31	0.249
50	CD 5%	0.12	0.14	0.136	0.011	0.013	0.010	0.55	0.64	0.501
51	CD1%	0.16	0.18	0.177	0.014	0.017	0.013	0.72	0.83	0.652

Significance Levels* =05, ** = <.01 PN=Pusa Naveen, PS=Pusa Santhusti, KLG=Kalyanpur long green

Conclusion

The highest mid parent heterosis for fruit yield per plant was recorded in the cross, Pusa Naveen × Kalyanpur long green (35.70) KBGL-14 × NDBG-1 (32.42), KBGL-20 × KBGL-29 (31.19) and Pusa Naveen × Kalyanpur long green (46.95), Kalyanpur long green × NDBG-1 (42.86), KBGL-14 × NDBG-1 (40.78 highest standard heterosis for fruit yield per plant. Pusa Naveen × Kalyanpur long green, Kalyanpur Long Green × NDBG-1, KBGL-14 × NDBG-1and exhibited significant and lowest inbreeding depression for fruit yield per plant. Such crosses could be exploited in future breeding programmes for development of varieties with increased fruit yield per plant by taking specific trials in bottle gourd.

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