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Jayanth S
Department of Vegetable Science, CCS HAU, Hisar, Haryana, India

Dr. Makhan Lal
Department of Vegetable Science, CCS HAU, Hisar, Haryana, India

Dr. DS Duhan
Department of Vegetable Science, CCS HAU, Hisar, Haryana, India

Sagar
Department of Genetics and Plant Breeding, CCS HAU, Hisar, Haryana, India

Corresponding Author:
Jayanth S
Department of Vegetable Science, CCS HAU, Hisar, Haryana, India

Exploitation of heterosis for yield and its contributing traits in bottle gourd [*Lagenaria siceraria* (Molina.) Standl.]

Jayanth S, Dr. Makhan Lal, Dr. DS Duhan and Sagar

Abstract
Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] also called white flower gourd or calabash gourd is an under exploited cucurbitaceous vegetable. Although, bottle gourd has a wide range of variability, very little attention has been given for its genetic improvement. The production of hybrids in bottle gourd having large number of seeds per fruit is commercially viable and hence, facilitates its hybrid seed production. Fifteen F_1 hybrids obtained through 6×6 half diallel system were evaluated to estimate heterosis. The ANOVA exhibited significant genotypic differences, showing considerable genetic variability among different genotypes. On the basis of mean performance, the parents Punjab Komal followed by Pusa Naveen and Punjab Long were the best for yield and its attributes. The extent of standard heterosis for fruit yield per vine ranged from 34.52% to 126.10% over the check HBGH-35 while, that over Pusa Hybrid-3 ranged from 39.73% to 157.96%. However, based on the mean performance andestimates of standard heterosis, the hybrids from the crosses Pusa Naveen×Punjab Komal followed by KBG-16×Pusa Samridhi and Pusa Samridhi×Punjab Komal were considered best in terms of number of fruits per vine, average weight of fruit (g), fruit yield per vine (kg) and fruit yield per hectare (q). These crosses were promising with respect to yield and its contributing traits and thus, could be exploited for further effective selection and heterosis breeding to augment the yield potential of bottle gourd.

Keywords: Bottle gourd, ANOVA, half diallel, heterosis

Introduction
Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is one of major cucurbitaceous vegetable crop though it has maximum ultility. The names "*lagenaria*" and "*siceraria*" are derived from Latin words "lagena" meaning bottle and "sicera" meaning drinking utensil (Bisognin, 2002) [1]. Archaeological evidence estimates a time depth of at least 12, 000 years for *Lagenaria* remains, both in new and old worlds (Hazra and Som, 2015) [5]. Among six species of the genus *Lagenaria* distributed over Africa, Madagascar, Indo-Malaysia and the Neo-tropics, only one annual and monoecious species, *Lagenaria siceraria*is cultivated as a major cucurbitaceous crop and has a chromosome number 2n=22. Bottle gourd bears white flowers and is highly cross pollinated in nature due to monoecious sex form and entomophilies. Bottle gourd like other members of the family Cucurbitaceae does not suffer much from inbreeding depression or do so only negligibly.

Most of the bottle gourd varieties available for cultivation in our country have lost their potentiality. Therefore, it is essential to increase its productivity through various new strategies. Development of hybrids with high yield and improved fruit quality is one of these ways to increase its productivity. Heterosis amounting superiority of F_1 hybrid in desirable direction over either or both its parents and standard check is manifested *via* increase in vigour, growth rate, size, yield, quality and other characteristics (Singh, 1993) [18]. The principle objective of heterosis breeding is to gain a quantum jump in yield and quality attributes of vegetable crops (Laxuman *et al*., 2012) [8]. It is commercially potential in bottle gourd having large number of seeds per fruit, which facilitates its hybrid seed production. Exploitation of hybrid vigour in bottle gourd could increase the yield. Commercialization of hybrids will be easy in bottle gourd due to its high seed content and easy seed extraction techniques (Janaranjani *et al.*, 2016) [6]. Although a number of commercial varieties are available, it is essential to study the genetic resources to incorporate valuable traits in the cultivated germplasm. The objective of the study was to investigate the magnitude of heterosis of bottle gourd F_1 hybrids in 6×6 half diallel system with desirable traits to improve yield.

Materials and Methods

The experiment was conducted at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during spring-summer and rainy season of 2017. The site islocated at latitude of 29º 10' North, longitude of 75º 46' East and at an altitude of 215.2 meters above mean sea level on South Western border of the Rajasthan state and at a distance of about 175 km in West of the national capital city, New Delhi. The soil of the experimental field was sandy loam in texture, non-saline, medium in organic carbon, low in available nitrogen, high in available phosphorus and rich in available potassium.

The experimental material comprised of 6 genetically diverse genotypes of bottle gourd and two standard check hybrids. Fifteen F_1crosses were generated from mating them into 6×6 half diallel system excluding reciprocals. These hybrids along with parents was grown in Randomized Block Design and evaluated against the standard check hybrids. The list of the germplasms involved in the study are presented in the Table 1.

Table 1: List of parents and standard checks included in the study

S. No.	Parents	Source
1.	KBG-16	CSAUAT, Kalyanpur, U.P.
2.	Pusa Naveen	IARI, New Delhi
3.	Punjab Long	PAU, Ludhiana, Punjab
4.	Pusa Samridhi	IARI, New Delhi
5.	GH-22	CCS HAU, Hisar, Haryana
6.	Punjab Komal	PAU, Ludhiana, Punjab
	Standard check	
1.	Pusa Hybrid-3 (National level released hybrid)	IARI, New Delhi
2.	HBGH-35 (Local hybrid)	CCS HAU, Hisar, Haryana

Bottle gourd being monoecious in nature, bear solitary male and female flowers on the same plant. Thus, healthy flower buds which were expected to open in the next day were selected for crossing. The selected female buds were pollinated using the pollens from well opened male flowers with dehisced anthers. The pollinated buds were covered with a thin layer of cotton to avoid contamination. The pedicel of each pollinated flowers was tied with label bearing information of female and male parents and date of crossing for identification. The mature healthy ripe fruits were harvested and the intact seeds were extracted manually in July-2017. Simultaneously, some flowers in each of these genotypes were selfed by covering the flowers with cotton. The selfed fruits were collected and seeds were extracted.

The seeds of six parental genotypes and fifteen F_1 hybrids which were obtained by crossing in the first season crop were sown along with two Standard check (1-Local hybrid + 1 National level released hybrid) during second week of July, 2017. Recommended cultural practices were followed before sowing the seeds in the field. The seeds were sown in a Randomized Block Design with twenty three entries in three replications and Plot size was 3.0 m×2.5 m. The standard cultural practices recommended in the package of practices for bottle gourd were followed to produce a healthy crop stand. Besides the application of farm yard manure @ 15 tonnes per hectare, chemical fertilizers were applied as per the recommendation of package of practices *i.e.*, 50:25:25 N:P:K kg per hectare. Half dose of nitrogen and full doses of phosphorous and potassium were applied at the time of field preparation. Remaining half dose of nitrogen was top dressed in equal amounts at thirty days after sowing and flowering stage.

Observations were recorded for days to first fruit harvest, number of primary branches per vine, fruit length (cm), fruit girth (cm), number of fruits per vine, average fruit weight (g), vine length at final harvest (m) and fruit yield per vine (kg). The analysis of variance was carried out as per Panse and Sukhatme (1985). Heterosis was calculated as the percentage increase or decrease of mean F1 performance (F1) over means of the standard checks (SC1 and SC2).The mean of all the replications for each parents, hybrids and check for all characters was computed and used in estimation of heterosis. The significance of the magnitude of heterosis was ascertained by following the formula of Wynne *et al*. 1970.

Results and discussion

The basic data including checks were analysed following Randomised Complete Block Design procedure. The analysis of variance for different quantitative characters studied during the experimentation indicated highly significant differences among the parents, crosses and commercial checks at 5% and 1% level of significance (Table 2) which indicates the validity of such genotypes employed in the experimental plot.

Evaluation of genotypes based on mean performance

In any crop breeding programme, it is essential to eliminate the undesirable types, which can be achieved by studying the mean performance of parents and hybrids. The results based on mean performance is presented in the Table 3. Early picking is desirable to fetch high remunerative market price and also provides ample scope for crop rotation in the field.

Table 2: Analysis of variance for 18 quantitative traits in a half diallel set of bottle gourd

		Mean sum of square		
S. No.	Source	Replications	Genotypes	Error
	Degrees of freedom (df)	**2**	**22**	**44**
1.	Days to first fruit harvest	1.08	7.80**	0.73
2.	Number of primary branches per vine	1.92	7.08**	0.60
3.	Vine length at final harvest (m)	0.01	2.13**	0.01
4.	Length of fruit (cm)	0.55	40.53**	1.84
5.	Girth of fruit (cm)	0.20	26.28**	0.78
6.	Number of fruits per vine	4.22	4.43**	1.46
7.	Average fruit weight (g)	3955.83	105317.67**	4899.71
8.	Weight of 100 seeds (g)	0.87	31.54**	1.33
9.	Fruit yield per vine (kg)	0.79	17.93**	0.93

* and ** indicates significance at 5% and 1% level, respectively

Therefore, with regards to days to fruit harvest the parent, Punjab Long (62.17 days) showed minimum days to first fruit harvest while, among the crosses Punjab Long×Punjab Komal (59.75 days) with minimum number of days to first fruit harvest was considered as early. However, only six crosses were earlier to Local check hybrid HBGH-35 (62.44 days) with regards to first fruit harvest but, all the crosses were found earlier to National check Pusa Hybrid-3 (65.89 days).Earliness for days to first fruit harvest was also reported by Podder *et al*. (2010) [15] in snake gourd and Jat *et al*. (2016) [7] in cucumber. The growth parameters like number of primary branches per vine and length of the vine contributes to vegetative growth and a desirable degree of vegetative growth is essential to realise good yield. The maximum number of primary branches was observed in the parent Pusa Naveen (15.58). Among the crosses, KBG-16×GH-22 (17.92) exhibited maximum number of primary branches per vine which was followed by KBG-16×Pusa Samridhi (16.68) and Pusa Samridhi×GH-22 (16.50).The highest vine length among the parents was recorded in KBG-16 (7.46 m) while, the hybrids from the crosses, KBG-16×GH-22 (8.14 m), KBG-16×Pusa Samridhi (7.63 m) and Pusa Samridhi×GH-22 (7.57 m) recorded the highest vine length at final harvest (m). Pal *et al*. (2005) [13] also reported the highest number of primary branches per vine in the cross VRBG-105×Pusa Naveen and the cross IC-92462×Pusa Naveen for highest vine length in bottle gourd.In contrary to the findings of current results, Dey *et al*. (2012) [3] reported shorter vine length to be best in case of bitter gourd (*c.v*. Pusa Vishesh).The maximum fruit length was observed in the parent Pusa Naveen (27.63 cm). Among the crosses, the maximum fruit length was recorded by the crosses Pusa Samridhi×Punjab Komal (40.22 cm) followed by Punjab Long×Pusa Samridhi (36.64 cm) and Punjab Long×GH-22 (33.51 cm). The maximum fruit girth (cm) was recorded in the parent KBG16 (32.54 cm) while, among the crosses the maximum fruit girth (cm) was recorded in Punjab Long×Pusa Samridhi (32.99 cm) which was closely followed by GH-22×Punjab Komal (32.26 cm). Thangamani *et al*. (2011) [20] also reported maximum fruit length and girth for improved fruit size in bitter gourd. Number of fruits per vine is positively associated with high yield. Thus, the genotypes with highest number of fruits are the best for realising high yield. The highest number of fruits per vine among the parents was recorded in Pusa Samridhi (9.48). The highest number of fruits per vine was found in the hybrids from the crosses Punjab Long×Punjab Komal (11.96) which was closely accompanied by Pusa Samridhi×Punjab Komal (11.72), Punjab Long×Pusa Samridhi (11.27) and KBG-16×GH-22 (11.26).The above results for number of fruits per vine are also in close conformity with Radharani *et al*. (2013) [16], Singh *et al*. (2013) [19] and Mahumad *et al*. (2016) in bitter gourd.

Weight per fruit is an important yield contributing attribute which effects the yield decisively as studied by Yadav and Kumar (2011) [22]. The highest average fruit weight was observed in the parents Punjab Komal (622.33 g). Among the crosses, Pusa Naveen×Punjab Komal (1083.56 g) recorded the highest fruit weight followed by KBG-16×Pusa Samridhi (996.86 g) and KBG-16×Punjab Long (971.25 g).The results are in line with Pal *et al*. (2005) [13] who reported higher number of fruits and average fruit weight in the cross NDBG-140×Pusa Naveen in bottle gourd. The highest weight of 100 seeds among the parents was recorded in Pusa Naveen (22.44 g) while, among the crosses Pusa Samridhi×Punjab Komal (24.41 g) showed the highest weight of 100 seeds followed by KBG-16×Pusa Naveen (22.79 g) and PusaNaveen×Punjab Long (22.36 g). The current findings for weight of 100 seeds find the support of Nisha and Veeragavathatham (2014) in pumpkin. In contrary to the current findings, Janaranjani *et al*. (2016) [6] reported that the lowest weight of 100 seeds as a desirable attribute in bottle gourd. The fruit yield per vine are directly determined by a number of attributes like fruit weight, fruit size, number of fruits per vine, earliness traits *etc*. Fruit yield/plant is an important agronomic character and is the additive effect of yield component characters (Dey *et al*., 2005) [2]. For yield per vine (kg), the parent Punjab Komal (5.77 kg) recorded the highest yield. The hybrids from the crosses Pusa Naveen×Punjab Komal (11.35 kg) followed by Pusa Samridhi×Punjab Komal (11.04 kg) and KBG-16×Pusa Samridhi (10.44 kg) recorded the highest yield per vine (kg). All the crosses were found to be better yielding as against the standard checks HBGH-35 (5.02 kg) and Pusa Hybrid-3 (4.40 kg).The results are in close conformity with Pal *et al*. (2005) [13] who reported that the cross IC-92362×Pusa Naveen produced higher fruit yield in bottle gourd. Singh *et al*. (2013) [19] also reported that the highest mean values for yield per plant, yield per hectare, fruit weight, fruit length and fruit breadth was observed in bitter gourd.

Table 3: Mean performance of parents and crosses for different characters in 6×6 half diallel set of bottle gourd

S. No.	Genotypes	Days to first fruit harvest	Number of primary branches per vine	Vine length at final harvest (m)	Fruit length (cm)	Fruit girth (cm)	Number of fruits per vine	Average fruit weight (g)	Weight of 100 seeds (g)	Fruit yield per vine (kg)
1.	KBG-16	64.50	13.83	7.46	22.67	32.54	6.74	493.19	14.82	3.40
2.	Pusa Naveen	63.08	15.58	6.50	27.63	31.05	9.29	556.67	22.44	5.04
3.	Punjab Long	62.17	14.00	5.46	25.61	28.61	8.78	480.56	13.95	4.27
4.	PusaSamridhi	64.10	13.33	5.58	26.86	28.58	9.48	356.67	20.99	3.37
5.	GH-22	64.42	13.25	6.29	26.44	27.81	8.97	423.33	19.92	3.78
6.	Punjab Komal	63.17	12.75	6.08	27.58	26.60	9.27	622.33	20.83	5.77
7.	KBG-16 ×Pusa Naveen	62.54	15.00	6.45	30.95	27.51	10.95	632.50	22.79	6.94
8.	KBG-16×Punjab Long	64.04	12.92	5.85	30.40	28.67	8.85	971.25	20.08	8.66
9.	KBG-16×Pusa Samridhi	63.99	16.58	7.63	31.56	23.31	10.39	996.86	21.25	10.44
10.	KBG-16×GH-22	61.96	17.92	8.14	31.20	23.98	11.26	651.64	18.04	7.33
11.	KBG-16×Punjab Komal	59.79	11.75	5.73	32.78	25.95	10.27	660.42	11.60	6.75
12.	Pusa Naveen×Punjab Long	63.49	13.67	5.87	29.32	26.56	8.27	740.69	22.36	6.01
13.	Pusa Naveen×Pusa Samridhi	62.29	13.33	4.93	28.87	23.25	10.84	596.67	14.39	6.45
14.	Pusa Naveen×GH-22	63.63	14.17	5.57	31.36	30.38	9.10	556.25	20.96	5.06
15.	Pusa Naveen×Punjab Komal	59.88	12.92	6.29	32.17	30.85	10.40	1083.56	16.09	11.35

16.	Punjab Long×Pusa Samridhi	62.82	13.75	6.33	36.64	32.99	11.27	782.27	17.38	8.71
17.	Punjab Long×GH-22	62.60	14.25	6.54	33.51	31.48	9.05	622.50	18.75	5.66
18.	Punjab Long×Punjab Komal	59.75	13.83	7.02	29.44	31.14	11.96	763.89	19.21	9.10
19.	Pusa Samridhi×GH-22	63.46	16.50	7.57	32.95	27.19	9.26	693.33	21.78	6.45
20.	Pusa Samridhi×Punjab Komal	63.43	11.92	5.26	40.22	31.24	11.72	946.11	24.41	11.04
21.	GH-22×Punjab Komal	60.18	13.33	6.39	30.53	32.26	10.08	767.36	20.89	7.67
22.	HBGH-35 (SC1)	62.44	12.92	7.28	29.83	25.99	8.96	541.94	18.38	5.02
23.	Pusa Hybrid-3 (SC2)	65.89	12.08	5.65	28.84	26.26	8.32	563.61	21.25	4.40
	SE(d)	0.69	0.63	0.07	1.11	0.72	0.98	57.15	0.94	0.79
	C.D. at 5%	1.40	1.27	0.13	2.24	1.46	1.98	115.57	1.90	1.60

Evaluation of hybrids based on estimates of heterosis

Heterosis is an expression of the superiority of hybrids over the mean of parents, better parents, or the standard check (Hayes *et al.*, 1956) [4] with respect to agriculturally useful traits. The primary objective of heterosis breeding is to achieve a significant increase in crop yield and quality. For days to first fruit harvest, the crosses which were highly heterotic over standard checks HBGH-35 in desirable direction are Punjab Long×Punjab Komal (-4.31%) followed by KBG-16×Punjab Komal (-4.24%) and Pusa Naveen×Punjab Komal (-4.11%). All the crosses exhibited significant heterosis over the check Pusa Hybrid-3. The same former mentioned crosses showed heterosis in desired direction over Pusa Hybrid-3 with values -9.32%, -9.25% and -9.13% in the order of merit, respectively. The highest significant heterosis for early fruit harvest in bottle gourd was also reported by Ojha *et al*. (2009) [12]. The highest significant heterosis in desirable direction for number of primary branches per vine over the standard checks HBGH-35 and Pusa Hybrid-3 was found in the cross KBG-16×GH-22 (38.67%, 48.32%) followed by Pusa Samridhi×GH-22 (28.35%, 37.28%) and KBG-16×Pusa Samridhi (27.71%, 36.59%), respectively. The hybrids from the crosses KBG-16×GH-22 (11.72%) followed by KBG-16×Pusa Samridhi (4.85%) and Pusa Samridhi×GH-22 (3.94%) showed the highest significant positive heterosis for vine length over the check HBGH-35. The same three crosses showed significant positive heterosis for vine length over the check Pusa Hybrid-3 with the values 43.95%, 35.10% and 33.92%, respectively. For vine length at final harvest (m), the highest positive heterosis was reported in the cross Pusa Naveen×Punjab Komal by Janaranjani *et al*. (2016) [6] in bottle gourd. However, significant positive heterosis for both number of primary branches and vine length was reported by Ojha *et al*. (2009) [12] in bottle gourd. The hybrids from the crosses Pusa Samridhi×Punjab Komal followed by Punjab Long×Pusa Samridhi showed the highest significant positive heterosis for fruit length (cm) over the checks HBGH-35 (37.58, 24.44%) and Pusa Hybrid-3 (24.41%, 12.52%), respectively. The next highest significant heterosis for fruit length (cm) over the check HBGH-35 was Pusa Samridhi×GH-22 (9.89%). The highest significant positive heterosis for fruit girth (cm) was recorded in the hybrids from the crosses Punjab Long×Pusa Samridhi followed by GH-22×Punjab Komal and Punjab Long×GH-22 over the checks HBGH-35 (26.99%, 24.17%, 21.15%) and Pusa Hybrid-3 (25.63%, 22.84%, 19.86%) in the order of merit, respectively. Singh *et al*. (2013) [19] also reported highest significant heterosis for fruit length and fruit girth in bitter gourd.

With respect to number of fruits per vine, the hybrids from the crosses Punjab Long×Punjab Komal followed by Pusa Samridhi×Punjab Komal and Punjab Long×Pusa Samridhi showed the highest significant positive heterosis over the checks HBGH-35 (33.48%, 30.80%, 25.74%) and Pusa Hybrid-3 (43.75%, 40.87%, 35.42%) in the order of merit, respectively.The highest heterosis for average fruit weight (g) was recorded in the crosses Pusa Naveen×Punjab Komal (99.94%) followed by KBG-16×Pusa Samridhi (83.94%) and KBG-16×Punjab Long (79.22%) over the check HBGH-35. The same three crosses showed significant positive heterosis over the check Pusa Hybrid-3 with the values 92.25%, 76.87% and 72.33%, respectively.The highest significant heterosis for weight of 100 seeds (g) was observed in the crosses Pusa Samridhi×Punjab Komal (32.77%) followed by KBG-16× Pusa Naveen (23.97%) and Pusa Naveen×Punjab Long (21.65%) over the check HBGH-35. The crosses Pusa Samridhi×Punjab Komal (14.84%) followed by KBG-16× Pusa Naveen (7.23%) showed significant positive heterosis over the check Pusa Hybrid-3. The above results were in agreement with Radharani *et al*. (2013) [16], Samiyoddin and Evoor (2015) [17] in bitter gourd. For fruit yield per vine (kg) heterosis over the local check hybrid HBGH-35 ranged from 34.52 to 126.10% while, that for National check Pusa Hybrid-3 ranged from 39.73 to 157.96%. The hybrids from the crosses Pusa Naveen×Punjab Komal (126.10%) followed by Pusa Samridhi×Punjab Komal (120.02%) and KBG-16×Pusa Samridhi (107.90%) exhibited the highest significant positive heterosis for fruit yield over the check HBGH-35. The same former crosses were revealed to be significantly heterotic for yield per vine over Pusa Hybrid-3 with the values being 157.96%, 151.02% and 137.20% in the order of merit, respectively. Yadav and Kumar (2011) [22] reported highest heterosis for yield attributes *viz*., primary branches per plant, fruit length and fruit weight. Heterosis for fruit length, number of fruits per plant and fruit yield per plant was also reported by Maurya *et al*. (2009) [10] in bitter gourd.

From the foregoing discussion, it is suggested that yield is an important quantitative trait and is an ultimate product of the multiplicative interactions between various yield components. The breeding materials assessed in the present investigation possessed wide range of variation for various characters under study. The diallel analysis indicated high genotypic variation in the material investigated. Among the parents, Punjab Komal was observed as the best for yield and its attributing traits and can be used as parent in further breeding programme. Only one cross combination, Pusa Naveen×Punjab Komal, KBG-16×Pusa Samridhi and Pusa Samridhi×Punjab Komal expressed high mean performance and high standard heterosis for maximum number of traits. So this hybrid may be exploited for further effective selection and heterosis breeding to augment the production potential of bottle gourd.

Table 4: Standard Heterosis (%) for different characters in 6×6 half diallel set of bottle gourd

		DFFH		NPBV		VLFH (m)		FL (cm)		FG (cm)	
		Heterosis (%) over		Heterosis (%) over		Heterosis (%) over		Heterosis (%) over		Heterosis (%) over	
	Crosses	SC1	SC2	SC1	SC2	SC1	SC2	SC1	SC2	SC1	SC2
1.	KBG-16×Pusa Naveen	0.17	-5.08**	16.10**	24.17**	-11.40**	14.16**	4.33	-5.66*	5.88**	4.75*
2	KBG-16×Punjab Long	2.57**	-2.80**	-0.03	6.93**	-19.64**	3.54**	2.28	-7.51	10.34**	9.16**
3	KBG-16×Pusa Samridhi	2.48**	-2.89**	28.35**	37.28**	4.85**	35.10**	-8.50	-17.26**	-10.28**	-11.24**
4	KBG-16×GH-22	-0.77	-5.96**	38.67**	48.32**	11.72**	43.95**	6.47	-3.72*	-7.69**	-8.67**
5	KBG-16×Punjab Komal	-4.24**	-9.25**	-9.06**	-2.73	-21.36**	1.33	-8.28**	-17.06**	-0.12	-1.18
6	Pusa Naveen×Punjab Long	1.68*	-3.64**	5.78*	13.13**	-19.41**	3.83**	-13.76	-22.01	2.23	1.14
7	Pusa Naveen×Pusa Samridhi	-0.23	-5.46**	3.20	10.38**	-32.35**	-12.83**	-36.97	-43.00	-10.51**	-11.46**
8	Pusa Naveen×GH-22	1.90*	-3.43**	9.65*	17.27**	-23.53**	-1.47	5.03	-5.03**	16.92**	15.67**
9	Pusa Naveen×Punjab Komal	-4.11**	-9.13**	-0.03	6.93**	-13.58**	11.36**	-11.49*	-19.97**	18.75**	17.48**
10	Punjab Long×Pusa Samridhi	0.61	-4.65**	6.42**	13.82**	-13.12**	11.95**	24.44**	12.52**	26.99**	25.63**
11	Punjab Long×GH-22	0.26	-4.99**	10.29**	17.96**	-10.14**	15.78**	-4.55**	-13.69**	21.15**	19.86**
12	Punjab Long×Punjab Komal	-4.31**	-9.32**	7.07**	14.51**	-3.62**	24.19**	-12.64	-21.00	19.84**	18.56**
13	Pusa Samridhi×GH-22	1.64*	-3.69**	27.71**	36.59**	3.94**	33.92**	9.89**	-0.63**	4.66*	3.55
14	Pusa Samridhi×Punjab Komal	1.59*	-3.73**	-7.77**	-1.35	-27.77**	-6.93**	37.58**	24.41**	20.22**	18.94**
15	GH-22×Punjab Komal	-3.61**	-8.66**	3.20	10.38**	-12.20**	13.13**	-17.44	-25.34	24.17**	22.84**
	S. E. ±	0.40	0.40	0.40	0.40	0.22	0.22	1.16	1.16	0.75	0.75
	C.D. at 5%	0.81	0.81	0.80	0.80	0.44	0.44	2.35	2.35	1.52	1.52
	C.D. at 1%	1.08	1.08	1.07	1.07	0.58	0.58	3.14	3.14	2.04	2.04

* and ** significant at 5% and 1% level, BP= better parent, MP = mid parent, SC1 = standard check 1, SC2 = standard check 2, DFFH=Days to fist fruit harvest, NPBV=Number of primary branches per vine, VLFH=Vine length at final harvest (m) FL=Fruit length (cm) FG= Fruit girth (cm)

		AFW (g)		NFPV		100 SW		FYPV (kg)	
	Crosses	Heterosis (%) over		Heterosis (%) over		Heterosis (%) over		Heterosis (%) over	
1.	KBG-16×Pusa Naveen	SC1	SC2	SC1	SC2	SC1	SC2	SC1	SC2
2	KBG-16×Punjab Long	16.71*	12.22	22.21**	31.61**	23.97**	7.23*	38.32**	57.81**
3	KBG-16×Pusa Samridhi	79.22**	72.33**	-1.26	6.33	9.26*	-5.49	72.57**	96.89**
4	KBG-16×GH-22	83.94**	76.87**	15.92	24.84*	15.61**	-0.01	107.90**	137.20**
5	KBG-16×Punjab Komal	20.24*	15.62*	25.67**	35.34**	-1.88	-15.13**	46.00**	66.58**
6	Pusa Naveen×Punjab Long	21.86**	17.18*	14.58	23.40*	-36.89**	-45.41**	34.57**	53.53**
7	Pusa Naveen×Pusa Samridhi	36.67**	31.42**	-7.66	-0.56	21.65**	5.22	19.67	36.53**
8	Pusa Naveen×GH-22	10.1	5.87	20.98*	30.29**	-21.71**	-32.28**	28.37*	46.46**
9	Pusa Naveen×Punjab Komal	2.64	-1.31	1.56	9.37	14.03**	-1.37	0.76	14.96
10	Punjab Long×Pusa Samridhi	99.94**	92.25**	16.07	25.00*	-12.45**	-24.27**	126.10**	157.96**
11	Punjab Long×GH-22	44.35**	38.80**	25.74**	35.42**	-5.44	-18.21**	73.73**	98.21**
12	Punjab Long×Punjab Komal	14.87	10.45	1.04	8.81	2.02	-11.76**	12.8	28.69*
13	Pusa Samridhi×GH-22	40.95**	35.54**	33.48**	43.75**	4.52	-9.60**	81.24**	106.78**
14	Pusa Samridhi×Punjab Komal	27.94**	23.02**	3.31	11.26	18.48**	2.48	28.69*	46.82**
15	GH-22×Punjab Komal	74.58**	67.87**	30.80**	40.87**	32.77**	14.84**	120.02**	151.02**
	S. E. ±	41.60**	36.15**	12.46	21.11*	13.65**	-1.7	52.97**	74.52**
	C.D. at 5%	83.88	83.88	0.92	0.92	0.95	0.95	1.27	1.27
	C.D. at 1%	169.52	169.52	1.87	1.87	1.91	1.91	2.57	2.57
		226.8	226.8	2.5	2.5	2.56	2.56	3.43	3.43

* and ** significant at 5% and 1% level, BP= better parent, MP = mid parent, SC1 = standard check 1, SC2 = standard check 2, AFW=Average fruit weight (g), NFPV=Number of fruits per vine, 100 SW = 100 seed weight, FYPV=Fruit yield per vine (kg)

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