Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(1): 29-38
Received: 12-11-2018
Accepted: 14-12-2018

Sudhanshu Mishra
Department of Vegetable Science, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad, Uttar Pradesh, India

Satrughan Pandey
Department of Vegetable Science, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad, Uttar Pradesh, India

Navin Kumar
Department of Vegetable Science, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad, Uttar Pradesh, India

VP Pandey
Department of Vegetable Science, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad, Uttar Pradesh, India

T Singh
Department of Vegetable Science, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad, Uttar Pradesh, India

Correspondence
Satrughan Pandey
Department of Vegetable Science, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad, Uttar Pradesh, India

Studies on the extent of heterosis for the quantitative characters in kharif season bottle gourd [*Lagenaria siceraria* (Molina) standl.]

Sudhanshu Mishra, Satrughan Pandey, Navin Kumar, VP Pandey and T Singh

Abstract
Observations were recorded on parents and F1 for 12 traits viz. days to first male and female flower anthesis, node number to first male and female flower appearance, days to first fruit harvest, vine length (m), number of primary branches per plant, fruit length (cm), fruit circumference (cm), fruit weight (kg), number of fruits and fruit yield per plant (kg).
Heterosis for fruit yield per plant ranged from -42.02% to 47.92% over better parent and -44.85% to 54.74% over standard parent Pusa Naveen. Fruit yield, number of fruits per plant, vine length and primary branches per plant observed as top heterotic trait. P7 x P9 (54.74%), P1 x P7 (47.43%) and P3 x P7 (46.55%) were the top heterotic F1 for fruit yield and also possessed high estimates of significant heterosis for number of fruits per plant along with attractive fruit shape.

Keywords: Heterosis**;** Anthiensis; Bottleguard; Quantitative characters; F1 hybrid

Introduction
Bottle gourd [Lagenaria siceraria (Mol.) Standl.] having chromosome number 2n=22 also called white flowered gourd or calabash gourd is an important cultivated annual crop grown throughout the country. It is grown for its tender fruits which is basically used as vegetable and also used to prepare sweets, pickles, rayata and other delicious preparations. The dried shells of mature fruits are hard and used as containers, utensil, musical instrument or ornamental items. Lagenaria siceraria is used in Ayurvedic Pharmacopoeia in India. Its fruits are traditionally used as a nutritive agent having cardio protective, cardio tonic, general tonic, diuretic, aphrodisiac, antidote to certain poisons and scorpion stings, alternative purgative and cooling agents. It cures pain, ulcers and fever and is used for pectoral-cough, asthma and other bronchial disorders. The seeds are edible part in China where people boil it in salt and eat as an appetizer. It has been used routinely as a source of rootstock for watermelon and other cucurbit crops in both Korea and Japan as a mean to reduce the incidence of soil-borne diseases and to promote the vigour of the root system of the crop under conditions of low temperature.
This target can best be achieved through use of improved varieties and hybrid technology in combination with superior crop management skills. Substantial increase in productivity appears feasible even with diminishing land and water resources.
According to Cutler and Whitaker (1961) [3], this plant is probably indigenous to tropical Africa. Decandolle reported its occurrence in wild form in South Africa and India. Archaeological evidence showed that the presence of bottle gourd in Peru was 12000 year old. It can be cultivated in all kinds of soil, but thrives well in heavily manured loam soil. It requires a warm humid climate, but can also be grown during dry weather with plenty of watering. Generally two crops are raised in India.
The main criteria for crop improvement are yield, earliness, disease resistance or abiotic stress tolerance, uniformity and long fruiting period. A speedy crops and improvement can be brought about in bottle gourd by assessing the genetic variability and exploitation of heterosis. Due to its monoecious nature of the crop, large flower size, easy pollination, high proportion of fruits set on pollinated female flowers, large number of seeds per fruit and low seed rate required per unit area, bottle gourd is highly amenable for heterosis breeding programme (Singh, 2004).
Heterosis breeding depends mainly on choice of superior parents for hybridization and the knowledge of combining ability and gene actions. Among the various mating designs, diallel cross techniques has been most frequently use High level of heterosis in desirable direction coupled with high specific combining ability (sca) variance and non-additive type of gene

action have also been reported in several major economic traits of bottle gourd including yield by Rajendran, 1961; Chaudhary and Singh, 1971 [2]; Sharma et. al., 1993 [7] and Pitchaimuthu and Sirohi, 1994 indicating thereby ample scope of exploitation of hybrid vigour in bottle gourd.

Methods and Materials

The experiment investigation aims at determining heterosis, combining ability and gene action in an experiment involving evaluation of 9 parental lines (Pusa Naveen, NDB-739, 707, 709-3, 718, 741, 744, 748 and 749-2) of bottle gourd and their 36 F1 conducted at MES, Vegetable Science, NDUAT, Kumarganj, Faizabad during Kharif, 2010. The experiment was laid out in RBD with three replications in single row of 3 x 3 m^2 plot size with row to row spacing of 3 m and plant to plant 50 cm. The selected parental lines i.e. Pusa Naveen (P_1), NDBG-739 (P_2), NDBG-707 (P_3), NDBG-509-3 (P_4), NDBG-718 (P_5), NDBG-741 (P_6), NDBG-744 (P_7) and NDBG-748 (-P_8) and NDBG-749-2 (P_9)were crossed in the all possible combinations in diallel technique, excluding reciprocals, during summer, 2009 to get 36 F1 hybrids for the study of heterosis for twelve characters. The experiment was carried out in a Randomized Complete Block Design with three replications to assess the performance of 36 F1 hybrids and their 9 parental lines. The crop was planted in rows spaced at 3.0 meters with plant to plant spacing of 0.5 meter. The experiment was sown on 10th August, 2010. All the recommended agronomic package of practices and plant protection measures were followed to raise a good crop.

The analysis of variance for design of experiment was done for partitioning the variance into treatments and replications according to procedures given by Panse and Sukhatme (1967).

The magnitude of heterosis was studied using information on various quantitative characters.

Heterosis expressed as per cent increase or decrease in the mean values of F1's (hybrid) over better-parent (heterobeltiosis) and standard variety as Pusa Naveen (standard heterosis) was calculated according to method suggested by Hayes *et al.* (1955) [6].

Results and Discussion

Bottle gourd has become a crop of commercial importance owing to the increased awareness about its nutritional and medicinal value, and consequent demand round the year among consumers. The major objective of bottle gourd breeding is to develop homogeneous high yielding varieties with earliness, desirable/ attractive fruit shape and size. Heterosis breeding offers the most efficient tool in form of hybrid to achieve this objective. With the use of inbreds in cross pollinated vegetable crops like bottle gourd hybrid with earliness, uniform fruits, fruit size, wide adaptability, resistance and high yield potential can be developed to enhance productivity and production.

Bottle gourd being predominantly monoecious, highly cross pollinated crop but does not suffer much from inbreeding depression (Allard, 1960) [1], and has the advantage of producing a large number of seed per fruit, facilitating heterosis breeding by economizing the cost of hybrid seed production.

However, despite the release of first two bottle gourd F_1 hybrids 'Pusa Meghdoot and Pusa Manjari' from public sector itself by Chaudhary and Singh (1971) [2] none of public sector hybrids could get commercial significance among the growers. Some of the private seed companies are marketing the seeds of bottle gourd developed by them but their popularity is limited only to the specific pockets. Maurya (1994) suggested the great scope of heterosis breeding in bottle gourd, and the possible use of hybrids in adverse environmental condition, in particular. Therefore, there is an urgent need to develop F_1 hybrid (s) with commercial heterosis, earliness, desirable fruit character as per market demand, wide adaptability and resistance.

(Samadia and Khandelwal, 2001; Singh and Kumar, 2002; Pandey *et al.,* 2003; Dubey and Maurya, 2004; Sharma *et al.,* 2004; Sirohi *et al.,* 2005; Dubey and Maurya, 2007; Sharma *et al.* 2010) [4, 9, 8] have also used this technique for estimating heterosis.

Keeping all these points in view, the present investigation was designed to investigate the extent of heterosis for twelve important quantitative traits, including fruit yield per plant, in a 9 x 9 diallel cross of bottle gourd. The important features of the findings of present investigation are discussed in the light of pertinent literature in the offing pages.

***Per se* performance of parental lines and F_1 hybrids**

Analysis of variance due to source of variations for different characters revealed highly significant differences among the genotypes, parents, hybrids and parents *vs* hybrids which suggested great variability in these source of variations for almost all the 12 characters studied.

Perusal of *Per se* performance of the parental lines and F_1 hybrids (Table-1) for all the traits studied revealed a wide range of mean values which indicated that the parental lines involved in this study were genetically diverse and had good breeding value, which confirmed the predictions of analysis of variance. Among the parental lines, P_1 was the earliest with respect to days to first male flower anthesis (43.83 days), days to first female flower anthesis (45.04) and days to first fruit harvest (52.81); parent P_5 had highest fruit length (57.56); parent P_6 had highest number of primary branches per plant (25.01) and longest vine length (7.26 cm). P_9 had thickest fruit circumference (38.75 cm) minimum nodes to first male flower appearance (10.1), parent P_7 had maximum number of fruits per plant (6.65) and P_8 had maximum fruit yield per plant (7.79 kg) and fruit weight (1.24 kg).

Out of 28 F_1 hybrids fifteen hybrids *viz*., P_1 x P_3, P_1 x P_5, P_1 x P_7, P_1 x P_9, P_2 x P_5, P_2 x P_7, P_3 x P_4, P_3 x P_6, P_3 x P_7, P_3 x P_8, P_4 x P_9, P_5 x P_6, P_5 x P_7, P_7 x P_8 and P_7 x P_9 produced significantly highest yield than the standard variety Pusa Naveen along with good fruit shape (Table 4.2). However, the best five hybrids (P_7 x P_9, P_1 x P_7, P_3 x P_7, P_1 x P_3 and P_3 x P_8 among the F_1 in respect to fruit yield per plant were also found superior for number of fruits per plant.. These top hybrids viz., P_7 x P_9, P_1 x P_7, P_3 x P_7, P_1 x P_3 and P_3 x P_8 were observed for small near cylindrical slight curve, medium long cylindrical slight curve, long thin curved, medium long near cylindrical and long thin slender bottled shaped fruits respectively and were found suitable for market demand. This indicated the superiority of F_1 hybrids against the standard variety.

Estimates of heterosis

Exploitation of heterosis in cultivated plants is one of the most important accomplishments of the science of genetics in agricultural practices. The exploitation of heterosis requires an intensive evaluation of germplasm to find out diverse donors with high nicking of genes and further identification of heterotic crosses.

The results obtained (Table 2) and range of mean values of parents, F_1 hybrids and range of heterosis indicating three best F_1 hybrids and the three most heterotic crosses with respect to each of the 12 economic traits (Table 3) have been discussed in ensuing paragraphs.

The nature and magnitude of heterosis differed for different traits in various hybrid combinations. A close examination of heterosis values of the five maturity traits *viz*., days to first male and female flower anthesis, node number to first male and female flower appearance and days to first fruit harvest (Table 2), revealed that only a few F_1 hybrids exhibited significant but very low level of heterosis in desirable direction for all these characters. For maturity traits, negative heterosis is usually desirable, because this will cause the hybrids to produce first fruits earlier as compared to parents, thereby increasing their productivity per day per unit area. The best performing F_1 hybrids regarding earliness based on performance over the standard variety (Pusa Naveen) was P_1 x P_8, for days to female flower anthesis, P_8 x P_9 for node number to first female flower appearance and P_1 x P_8 and P_6 x P_7 for days to first fruit harvest (Table 3). However significant heterobeltiosis was estimated for all the maturity traits in desirable direction and has also been reported by Singh *et al.* 1998; Singh and Kumar, 2002; Padama *et al.*, 2003; Singh *et al.*, 2005; Singh *et al.*, 2006 and Kumar, 2007). Our study further revealed that the either of the three early parents P_1 (Pusa Naveen), P_7 (NDBG-744) and P_8 (NDBG-748) or any two of them were invariably involved as one of the parents in the three top ranking F_1 hybrids over the standard variety for days to first fruit harvest which is the main early maturity trait. This is because the maturity traits approaches to that of earlier parents.

It may, therefore, safely be concluded that either of the parents P_1 or P_8 or both may be a better choice in any heterosis breeding programme intended to breed early hybrids. Present results are in conformity with the findings of Dubey and Maurya (2004) [4] and Singh (2008).

Standard heterosis over rest of the economic traits *viz*., vine length, number of primary branches per plant, fruit length, fruit weight, number of fruits per plant and fruit yield per plant were quite high, except for fruit circumference. High heterosis compared to early maturity traits for these characters have also been reported by Dubey and Maurya (2004) [4]; Pal *et al.* (2005) and Sirohi *et al.* (2005).

Considering the heterosis over standard variety (Pusa Naveen) the top ranking F_1 hybrids were P_7 x P_8 (50.55%) for vine length, P_6 x P_9 (62.41%) for number of primary branches per plant, P_3 x P_6 (35.05%) for fruit length, P_2 x P_9 (23.32%) for fruit circumference, P_3 x P_5 (14.89%) for fruit weight and P_3 x P_7 (60.41%) for number of fruit per plant and P_7 x P_9 (54.74%) for yield per plant (Table 3). The above observations revealed that for getting high standard heterosis in F_1 hybrids parent P_7, for long vine length, parent P_9 for high number of primary branches per plant and thick fruit circumference and parent P_7, P_3 and P_9 for number of fruit and fruit yield per plant may be considered preferable choice while, for thin fruit circumference Parent P_3 for low fruit weight parent P_6 and for smaller fruit length parent P_9 may be the better alternate.

Number of fruits per plant is one of the most important components of fruit yield in respect of which hybrids with positive heterosis are desirable. The findings of the present study revealed that the seven crosses P_1 x P_3, P_1 x P_5, P_1 x P_7, P_3 x P_7, P_4 x P_7, P_4 x P_9 and P_5 x P_6 expressed significant heterosis in desirable direction over better parent (Table 4.5). The highest heterosis for number of fruits per plant was recorded by the cross P_3 x P_7 followed by P_1 x P_3 and P_1 x P_7 over standard vareity Pusa Naveen (Table 3). In general, the hybrids with significant heterosis for number of fruit per plant. The work of Sharma *et al.* (1983) [10], Sirohi *et al.* (1987), Janakiram and Sirohi (1989), Sharma *et al.* (1993) [7]; Singh and Kumar (2002) and Pal *et al.* (2005) are also in close agreement with this finding.

Fruit yield per plant being a complex trait, is a multiplicative product of several basic component traits of yield. The improvement in heterosis for yield component may not necessarily be reflected in increased yield. Contrarily the increased fruit yield will definitely because of increase in one or more component traits. In the present study, the best performing F_1 hybrids for yield also showed significant heterosis either for fruit weight or number of fruit along with some other yield component traits. Likewise crosses showing heterosis for other yield component did not necessarily show heterosis for fruit yield. This showed that heterosis depends upon nicking for genes. Similar results have also been reported by Kumar (2000); Kumar (2007) and Singh (2008).

Parent P_7 having near cylindrical curve fruit shape was found as one of the parent among the top three ranked significant heterotic crosses for fruit yield per plant over standard parents (Table 2), showed negative heterosis for fruit circumference, number of fruit per plant, fruit weight and fruit length over better parent in all the half sib cross combinations, wherever, it had been involved, indicating their in ineffectiveness in transmitting increased fruit circumference, number of fruit per plant, fruit weight ad fruit length to the progenies. These findings revealed that round fruited genotypes may be used to get highly significant heterosis for fruit yield along with thin fruit circumference, low fruit weight and smaller fruited F_1 hybrid bearing long type fruit as per market demand.

The above findings indicated that some inbreds had strong heterotic capability compared to other ones during hybridization process. This may be due to diverse parent and favourable cross combination. As the performance of hybrids depended upon the heterotic capability of the parents involved, from economic point of view it will be useful to select and utilize the parentals and inbreds with strong heterotic capability for important traits associated with yield in order to achieve higher fruit yield in F_1 hybrids through exploitation of heterosis.

Since earliness, desirable fruit shape are the important considerations for choice of elite high yielding F_1 hybrids, the decision for final selection of a hybrid for commercial cultivation should also take into account the earlier two factors *i.e.* earliness and fruit shape trait alongwith the latter *i.e.* high fruit yield. Out of the 36, 15 F_1 hybrids found highly significant heterotic over standard variety for fruit yield, the three best hybrids were P_7 x P_9, P_1 x P_7 and P_3 x P_7 which exhibited high standard heterosis of 54.74 per cent, 47.43 per cent and 46.55 per cent, respectively (Table 3). These top hybrids not only possessed very good fruit shape but were also found at par for days to first fruit harvest with standard parent and suitable for market demand. Finally the best F_1 hybrid (P_7 x P_9) for fruit yield per plant was also considered the best based on over all performance i.e. extent of standard heterosis for fruit yield, fruit number, small fruit length, at par fruit circumference and earliness along with very good fruit shape as per best choice from the consumers point of view.

The result of present study suggested preponderance of dominance genes in the expression of all the component traits studied. Therefore, heterosis breeding approach could be advantageous rather than selection to produce superior hybrids for high fruit yield in bottle gourd.

Table 1: Mean values for yield and yield attributing traits of parents and their F_1s in bottle gourd.

Genotypes	Days to first male flower anthesis	Days to first female flower anthesis	Node no. to first male flower appearance	Node no. to first female flower appearance	Days to first Fruit harvest	Vine length (m)
1	2	3	4	5	6	7
Parents						
Pusa Naveen (P_1)	43.8333	45.0433	10.8333	13.8333	52.8100	6.0267
NDBG-739 (P_2)	47.3000	49.3333	11.6500	14.6333	55.4667	7.2333
NDBG-707 (P_3)	51.2667	46.2500	10.6033	12.8033	55.5000	4.9500
NDBG-509-3 (P_4)	49.9333	50.1333	14.5800	16.4000	58.8667	7.1667
NDBG-718(P_5)	47.5667	47.1833	13.2667	14.4333	54.5333	7.0667
NDBG-741 (P_6)	49.0667	48.7000	14.5733	16.1333	58.5333	7.2667
NDBG-744 (P_7)	48.0000	47.3267	14.7667	16.0333	57.0000	6.8000
NDBG-748(P_8)	47.6667	47.4000	13.8000	15.6867	55.3100	7.2333
NDBG-749-2(P_9)	45.9167	47.5500	10.1767	13.2800	55.6467	6.8500
F1 hybrids						
P_1XP_2	42.0700	43.8733	10.4100	11.2833	52.5000	4.5800
P_1XP_3	47.5267	47.7667	11.0933	13.1767	55.4667	7.4833
P_1XP_4	44.6600	43.6333	10.8733	14.0033	52.5000	6.3300
P_1XP_5	44.2667	50.2733	12.2233	14.2200	53.6267	7.3467
P_1XP_6	46.2667	47.6633	13.5600	14.3867	55.0367	6.8567
P_1XP_7	44.7567	44.3867	13.6633	14.6700	52.2267	6.7500
P_1XP_8	43.6000	42.9000	11.3133	13.4500	51.5000	5.0433
P_1XP_9	45.2333	44.4367	12.2500	11.6433	53.6767	8.3633
P_2XP_3	43.1000	46.9300	12.7267	13.0467	54.1133	7.4467
P_2XP_4	48.1033	50.1333	13.4900	15.2067	56.4767	7.3733
P_2XP_5	47.6800	48.1767	12.7333	13.6700	54.4167	6.7567
P_2XP_6	46.6667	46.5133	12.2600	14.2233	54.0000	7.0067
P_2XP_7	48.0000	48.4833	12.8267	14.4200	56.4467	6.8167
P_2XP_8	46.7567	46.5100	12.8333	13.6800	53.2967	6.7133
P_2XP_9	45.7967	47.1300	9.9700	13.7200	52.8300	6.2133
P_3XP_4	48.1667	47.9000	12.8033	15.5333	55.8333	6.4900
P_3XP_5	46.6067	44.5400	12.6600	13.7133	54.3733	7.6433
P_3XP_6	47.1667	44.7833	13.1533	14.5867	54.6333	8.6500
P_3XP_7	45.1333	43.8600	14.6500	14.9700	53.1000	7.4600
P_3XP_8	45.8000	45.4667	13.3433	15.4367	53.1333	6.8633
P_3XP_9	45.1167	44.9300	11.5933	13.1567	52.5000	6.3000
P_4XP_5	48.2700	49.1000	12.4933	15.3400	55.1000	7.1133
P_4XP_6	50.1333	50.6200	15.0467	16.8200	58.4000	7.6667
P_4XP_7	51.7933	54.1567	13.7367	16.4200	63.0233	5.5800
P_4XP_8	46.4500	47.1733	12.7533	14.3433	54.6733	4.6600
P_4XP_9	50.2900	51.4633	12.1500	15.1800	59.5767	7.3833
P_5XP_6	47.7800	47.1967	13.6567	15.2267	56.1300	7.7700
P_5XP_7	50.5333	49.7867	12.6600	14.3833	55.9733	8.6833
P_5XP_8	48.4467	47.6933	13.8133	15.7967	54.6667	6.7633
P_5XP_9	45.3767	43.9733	11.6067	11.7767	52.5000	6.3400
P_6XP_7	45.5667	46.1733	12.1233	13.7567	51.5000	5.6400
P_6XP_8	47.3833	47.5633	13.4167	16.3033	56.6233	7.8900
P_6XP_9	50.7333	52.5633	13.7200	14.5767	64.1667	8.7300
P_7XP_8	48.9000	48.8067	13.1533	14.6333	56.4333	9.0733
P_7XP_9	47.4667	48.6667	12.7833	13.6633	54.4400	8.0800
P_8XP_9	50.9567	50.7933	10.5067	8.4833	59.3333	4.5200
Grand Mean	47.1801	47.4431	12.6289	14.2697	55.2865	6.9105
C.V.(%)	3.9803	3.8060	7.2030	7.2673	3.8119	11.2411
S.E.(+_)	1.0842	1.0425	0.5252	0.5987	1.2167	0.4485
C.D. 5%	3.0471	2.9299	1.4760	1.6827	3.4195	1.2605
C.D. 1%	4.0369	3.8817	1.9555	2.2293	4.5304	1.6699

Table 2: Estimates of heterosis (%) over better parent (BP) and standard variety (SV) for twelve characters in Bottle gourd.

Crosses	Days to first male flower anthesis		Days to first female flower anthesis	
	B.P.	S.V.	B.P.	S.V.
P_1XP_2	-11.06**	-4.02	-11.07**	-2.60
P_1XP_3	-7.30*	8.43*	3.28	6.05
P_1XP_4	-10.56**	1.89	-12.97**	-3.13
P_1XP_5	-6.94*	0.99	6.55*	11.61**
P_1XP_6	-5.71	5.55	-2.13	5.82
P_1XP_7	-6.76*	2.11	-6.21	-1.46
P_1XP_8	-8.53**	-0.53	-9.49**	-4.76
P_1XP_9	-1.49	3.19	-6.55*	-1.35
P_2XP_3	-15.93**	-1.67	-4.87	4.19
P_2XP_4	-3.66	9.74**	0.00	11.30**
P_2XP_5	0.24	8.78	-2.34	6.96*
P_2XP_6	-4.89	6.46	-5.72	3.26
P_2XP_7	0.00	9.51**	-1.72	7.64*
P_2XP_8	-1.91	6.67	-5.72	3.26
P_2XP_9	-3.18	4.48	-4.47	4.63
P_3XP_4	-6.05	9.89**	-4.45	6.34
P_3XP_5	-9.09**	6.33	-5.60	-1.12
P_3XP_6	-8.00**	7.60*	-8.04**	-0.58
P_3XP_7	-11.96**	2.97	-7.32*	-2.63
P_3XP_8	-10.66**	4.49	-4.08	0.94
P_3XP_9	-12.00**	2.93	-5.51	-0.25
P_4XP_5	-3.33	10.12**	-2.06	9.01**
P_4XP_6	0.40	14.37**	0.97	12.38**
P_4XP_7	3.72	18.16**	8.03**	20.23**
P_4XP_8	-6.98*	5.97	-5.90	4.73
P_4XP_9	0.71	14.73**	2.65	14.25**
P_5XP_6	-2.62	9.00*	-3.09	4.78
P_5XP_7	5.28	15.29**	5.20	10.53**
P_5XP_8	1.64	10.52**	0.62	5.88
P_5XP_9	-4.60	3.52	-7.52*	-2.38
P_6XP_7	-7.13*	3.95	-5.19	2.51
$P6XP_8$	-3.43	8.10*	-2.33	5.59
P_6XP_9	3.40	15.74**	7.93*	16.70**
P_7XP_8	1.88	11.56**	2.97	8.35*
P_7XP_9	-1.11	8.29*	2.35	8.04*
P_8XP_9	6.90*	16.25**	6.82*	12.77**

*-Significant at 5 per cent probability level

**- Significant at 1 per cent probability level

Table 2: (Contd.)

Crosses	Node no. to first male flower appearance		Node no. to first female flower appearance	
	B.P.	S.V.	B.P.	S.V.
P_1XP_2	-10.64	-3.91	-22.89**	-18.43**
P_1XP_3	2.40	2.40	-4.75	-4.75
P_1XP_4	-25.42**	0.37	-14.61**	1.23
P_1XP_5	-7.86	12.83	-1.48	2.80
P_1XP_6	-6.95	25.17**	-10.83*	4.00
P_1XP_7	-7.47	26.12**	-8.50	6.05
P_1XP_8	-18.02**	4.43	-14.26**	-2.77
P_1XP_9	13.08	13.08	-15.83*	-15.83*
P_2XP_3	9.24	17.48*	-10.84	-5.69
P_2XP_4	-7.48	24.52**	-7.28	9.93
P_2XP_5	-4.02	17.54*	-6.58	-1.18
P_2XP_6	-15.87**	13.17	-11.84*	2.82
P_2XP_7	-13.14*	18.40**	-10.06	4.24
P_2XP_8	-7.00	18.46**	-12.79*	-1.11
P_2XP_9	-14.42*	-7.97	-6.24	-0.82
P_3XP_4	-12.19*	18.18**	-5.28	12.29
P_3XP_5	-4.57	16.86*	-4.99	-0.87
P_3XP_6	-9.74	21.42**	-9.59	5.45
P_3XP_7	-0.79	35.23**	-6.63	8.22
P_3XP_8	-3.31	23.17**	-1.59	11.59
P_3XP_9	9.34	7.02	-0.93	-4.89
P_4XP_5	-14.31**	15.32*	-6.46	10.89
P_4XP_6	3.20	38.89**	2.56	21.59**

P_4XP_7	-6.98	26.80**	0.12	18.70**
P_4XP_8	-12.53*	17.72*	-12.54*	3.69
P_4XP_9	-16.67**	12.15	-7.44	9.73
P_5XP_6	-6.29	26.06**	-5.62	10.07
P_5XP_7	-14.27**	16.86*	-10.29	3.98
P_5XP_8	0.10	27.51**	0.70	14.19*
P_5XP_9	-12.51*	7.14	-18.41**	-14.87*
P_6XP_7	-17.90**	11.91	-14.73**	-0.55
$P6XP_8$	-7.94	23.85**	1.05	17.86**
P_6XP_9	-5.86	26.65**	-9.65	5.37
P_7XP_8	-10.93*	21.42**	-8.73	5.78
P_7XP_9	-13.43**	18.00*	-14.78**	-1.23
P_8XP_9	-23.86**	-3.02	-45.92**	-38.67**

*-Significant at 5 per cent probability level
**- Significant at 1 per cent probability level

Table 2: (Contd)

Crosses	Days to first fruit harvest		Vine length (m)	
	B.P.	**S.V.**	**B.P.**	**S.V.**
P_1XP_2	-5.35	-0.59	-36.68**	-24.00*
P_1XP_3	-0.06	5.03	24.17*	24.17*
P_1XP_4	-10.82**	-0.59	-11.67	5.03
P_1XP_5	-1.66	1.55	3.96	21.90*
P_1XP_6	-5.97*	4.22	-5.64	13.77
P_1XP_7	-8.37**	-1.10	-0.74	12.00
P_1XP_8	-6.89*	-2.48	-30.28**	-16.32
P_1XP_9	-3.54	1.64	22.09*	38.77**
P_2XP_3	-2.50	2.47	2.95	23.56*
P_2XP_4	-4.06	6.94*	1.94	22.35*
P_2XP_5	-1.89	3.04	-6.59	12.11
P_2XP_6	-7.74**	2.25	-3.58	16.26
P_2XP_7	-0.97	6.89*	-5.76	13.11
P_2XP_8	-3.91	0.92	-7.19	11.39
P_2XP_9	-5.06	0.04	-14.10	3.10
P_3XP_4	-5.15	5.72	-9.44	7.69
P_3XP_5	-2.03	2.96	8.16	26.83*
P_3XP_6	-6.66*	3.45	19.04*	43.53**
P_3XP_7	-6.84*	0.55	9.71	23.78*
P_3XP_8	-4.26	0.61	-5.12	13.88
P_3XP_9	-5.65	-0.59	-8.03	4.54
P_4XP_5	-6.40*	4.34	-0.74	18.03
P_4XP_6	-0.79	10.59**	5.50	27.21*
P_4XP_7	7.06*	19.34**	-22.14*	-7.41
P_4XP_8	-7.12*	3.53	-35.58**	-22.68*
P_4XP_9	1.21	12.81**	3.02	22.51*
P_5XP_6	-4.11	6.29	6.93	28.93**
P_5XP_7	-1.80	5.99	22.88*	44.08**
P_5XP_8	-1.16	3.52	-6.50	12.22
P_5XP_9	-5.65	-0.59	-10.28	5.20
P_6XP_7	-12.02**	-2.48	-22.39*	-6.42
P_6XP_8	-3.26	7.22*	8.58	30.92**
P_6XP_9	9.62**	21.50**	20.14*	44.86**
P_7XP_8	-0.99	6.86*	25.44**	50.55**
P_7XP_9	-4.49	3.09	17.96	34.07**
P_8XP_9	6.63*	12.35**	-37.51**	-25.00*

*-Significant at 5 per cent probability level
**- Significant at 1 per cent probability level

Table 2: (Contd.)

Crosses	No. of primary branches per plant		Fruit length (cm)	
	B.P.	**S.V.**	**B.P.**	**S.V.**
P_1XP_2	-47.06**	-40.31**	-15.75**	-4.50
P_1XP_3	12.86	12.86	0.42	6.53
P_1XP_4	-11.39	-9.69	7.28	7.28
P_1XP_5	-16.79*	-16.79*	-24.32**	-1.95
P_1XP_6	-37.42**	-18.03**	-21.13**	0.20
P_1XP_7	12.86	12.86	-16.46**	-6.56
P_1XP_8	-13.10*	-10.37	-2.55	-0.68

P_1XP_9	31.34**	31.34**	-29.28**	-29.28**
P_2XP_3	-6.53	5.38	2.05	15.68**
P_2XP_4	26.13**	42.20**	-4.55	8.20*
P_2XP_5	-28.50**	-19.39**	-7.81**	19.44**
P_2XP_6	-19.92**	4.89	-23.56**	-2.89
P_2XP_7	-8.73	2.90	-3.04	9.90**
P_2XP_8	-6.78	5.10	11.71**	26.62**
P_2XP_9	-10.33	1.10	-23.49**	-13.28**
P_3XP_4	6.85	8.90	-0.49	5.56
P_3XP_5	80.17**	32.06**	-0.95	28.33**
P_3XP_6	4.52	36.89**	6.30*	35.05**
P_3XP_7	56.98**	31.50**	16.53**	30.35**
P_3XP_8	7.61	10.99	20.51**	27.83**
P_3XP_9	41.21**	38.62**	-15.51**	-10.38**
P_4XP_5	23.99**	26.37**	2.84	33.23**
P_4XP_6	-5.68	23.54**	-6.94*	18.23**
P_4XP_7	-13.80*	-12.15	5.70	18.23**
P_4XP_8	-6.58	-3.65	-0.15	1.76
P_4XP_9	10.10	12.22	-15.03**	-15.83**
P_5XP_6	-22.27**	1.82	-1.72	27.33**
P_5XP_7	52.54**	27.78**	-7.52**	19.81**
P_5XP_8	0.25	3.40	-5.96*	21.83**
P_5XP_9	12.50	10.44	-30.14**	-9.49*
P_6XP_7	-16.82**	8.95	-12.13**	11.63**
P6XP_8	-1.80	28.62**	-6.70*	18.53**
P_6XP_9	24.00**	62.41**	-29.85**	-10.88**
P_7XP_8	50.08**	54.80**	-15.49**	-5.48
P_7XP_9	39.64**	37.09**	-21.23**	-11.89**
P_8XP_9	-27.36**	-25.08**	-22.20**	-20.71**

*-Significant at 5 per cent probability level
**- Significant at 1 per cent probability level

Table 2: (Contd)

Crosses	Fruit circumference (cm)		Fruit weight (kg)	
	B.P.	**S.V.**	**B.P.**	**S.V.**
P_1XP_2	-2.43	-2.43	-9.42	-9.42
P_1XP_3	-2.82	-2.82	-8.21	-8.21
P_1XP_4	1.11	1.11	-6.69	-6.69
P_1XP_5	-3.07	-3.07	-11.94*	-3.65
P_1XP_6	-0.49	-0.49	-14.59*	-14.59*
P_1XP_7	1.47	5.62	-3.92	-3.04
P_1XP_8	-0.14	-0.14	-11.26*	0.61
P_1XP_9	-31.85**	9.95**	8.82	12.46*
P_2XP_3	10.42**	-0.69	8.00	6.69
P_2XP_4	-11.03**	-11.03**	-19.38**	-20.36**
P_2XP_5	-5.62	-8.44*	-6.94	1.82
P_2XP_6	-11.36**	-14.99**	-15.69*	-16.72**
P_2XP_7	-10.20**	-6.52	2.41	3.34
P_2XP_8	3.84	2.47	-5.09	7.60
P_2XP_9	-23.57**	23.32**	2.94	6.38
P_3XP_4	-15.89**	-15.89**	12.58	3.34
P_3XP_5	-0.50	-3.47	5.00	14.89*
P_3XP_6	1.52	-2.64	24.00**	3.65
P_3XP_7	-9.27**	-5.55	-9.04	-8.21
P_3XP_8	-2.36	-3.65	-8.04	4.26
P_3XP_9	-34.88**	5.07	-0.29	3.04
P_4XP_5	-3.54	-3.54	-5.56	3.34
P_4XP_6	-6.45	-6.45	-12.58	-19.76**
P_4XP_7	-3.67	0.28	-25.30**	-24.62**
P_4XP_8	-7.49*	-7.49*	-19.57**	-8.81
P_4XP_9	-41.99**	-6.40	7.94	11.55
P_5XP_6	-6.42	-9.22**	-21.94**	-14.59*
P_5XP_7	-4.87	-0.97	-6.11	2.74
P_5XP_8	-1.50	-2.80	-16.35**	-5.17
P_5XP_9	-36.22**	2.91	-5.00	3.95
P_6XP_7	-5.67	-1.80	0.30	1.22
P6XP_8	-6.82	-8.05*	-15.55**	-4.26
P_6XP_9	-41.98**	-6.38	0.88	4.26
P_7XP_8	-6.80*	-2.98	-11.26*	0.61
P_7XP_9	-26.80**	18.11**	5.00	8.51
P_8XP_9	-38.15**	-0.21	-9.92	2.13

*-Significant at 5 per cent probability level
**- Significant at 1 per cent probability level

Table 2: (Contd)

Crosses	No. of fruits per plant		Fruit yield per plant (kg)	
	B.P.	S.V.	B.P.	S.V.
P_1XP_2	1.38	22.56*	-7.68	9.59
P_1XP_3	42.92**	54.31**	40.99**	40.99**
P_1XP_4	15.81	15.81	7.78	7.78
P_1XP_5	16.86*	29.18**	2.82	23.74**
P_1XP_6	8.16	19.28*	0.82	0.82
P_1XP_7	19.10**	52.70**	15.54*	47.43**
P_1XP_8	-13.96	6.56	-22.12**	6.43
P_1XP_9	15.17	15.17	29.24**	29.24**
P_2XP_3	-18.23*	-1.16	-11.08	5.56
P_2XP_4	10.69	33.80**	-10.20	6.61
P_2XP_5	-5.37	14.40	-3.45	16.20*
P_2XP_6	-8.61	10.48	-22.56**	-8.07
P_2XP_7	-1.70	26.03**	1.65	29.71**
P_2XP_8	-19.10*	0.19	-21.61**	7.13
P_2XP_9	-43.59**	-31.81**	-39.16**	-27.78**
P_3XP_4	20.00*	29.56**	47.92**	33.04**
P_3XP_5	-14.59	-5.59	-10.50	7.72
P_3XP_6	14.57	26.35**	44.00**	30.53**
P_3XP_7	25.11**	60.41**	14.85*	46.55**
P_3XP_8	9.24	35.28**	2.78	40.47**
P_3XP_9	-50.24**	-46.27**	-38.69**	-44.85**
P_4XP_5	-33.66**	-26.67**	-37.07**	-24.27**
P_4XP_6	-37.88**	-31.49**	-39.68**	-45.32**
P_4XP_7	14.49*	46.79**	-13.24*	10.70
P_4XP_8	-29.84**	-13.11	-42.02**	-20.76**
P_4XP_9	35.94**	17.42	46.87**	30.29**
P_5XP_6	34.30**	48.46**	4.96	26.32**
P_5XP_7	-5.11	21.66*	-2.11	24.91**
P_5XP_8	-16.76*	3.08	-28.54**	-2.34
P_5XP_9	-16.10	-7.26	-20.07**	-3.80
P_6XP_7	-39.15**	-21.98*	-38.86**	-21.99**
P_6XP_8	-9.55	12.02	-21.61**	7.13
P_6XP_9	-37.41**	-30.98**	-20.90*	-28.30**
P_7XP_8	-3.51	23.71**	-9.16	24.15**
P_7XP_9	11.78	43.32**	21.26**	54.74**
P_8XP_9	-19.41**	-0.19	-25.46**	1.87

*-Significant at 5 per cent probability level

**- Significant at 1 per cent probability level

Table 3: Range of mean value (parents and F_1's) range of per cent heterosis (B.P and S.V.) and three top parents, F_1 hybrids and heterotic F_1 values.

Particulars	Days to first male flower anthesis	Days to first female flower anthesis	Node no. to first male flower appearance	Node no. to first female flower appearance
Range of mean value				
Parents	43.83 to 51.26	45.04 to 50.13	10.17 to 14.76	12.80 to 16.40
F_1's	42.07 to 51.79	42.90 to 54.15	9.97 to 15.04	8.48 to 16.82
Range of heterosis (%) over				
Better parent (B.P.)	-15.93 to 6.90	-12.97 to 8.03	-25.42 to 13.08	-45.92 to2.56
Standerd variety (Pusa Naveen)	-4.02 to 18.16	-4.76 to 20.23	-7.97 to 38.89	-38.67 to 21.59
Three top parents with their mean values				
	P_1 (43.83)	P_1 (45.04)	P_9 (13.28)	P_3 (12.80)
	P_9 (45.91)	P_3 (46.25)	P_3 (10.60)	P_9 (13.28)
	P_2 (47.30)	P_5 (47.18)	P_1 (10.83)	P_1 (13.83)
Three top F_1 hybrids with their mean values				
	P_1XP_2 (42.07)	P_1xP_8 (42.90)	P_2xP_9 (9.97)	P_8xP_9 (8.48)
	P_2XP_3 (43.10)	P_1xP_4 (43.63)	P_1xP_2 (10.41)	P_1xP_2 (11.28)
	P_1XP_8 (43.60)	P_3xP_7 (43.86)	P_8xP_9 (10.50)	P_1xP_9 (11.64)
Three top F_1 hybrids with respect to heterosis (%) over				
Better parent (B.P.)	P_2xP_3 (-15.93)	P_1xP_4 (-12.97)	P_1xP_4 (-25.42)	P_8xP_9 (-45.92)
	P_3xP_9 (-12.00)	P_1xP_2 (-11.07)	P_8xP_9 (-23.86)	P_1xP_2 (-22.89)
	P_3xP_7 (-11.96)	P_1xP_8 (-9.49)	P_1xP_8 (-18.02)	P_5xP_9 (-18.41)
Standerd variety (Pusa Naveen)	P_1xP_2 (-4.02)	P_1xP_8 (–4.76)	P_2xP_9 (-7.97)	P_8xP_9 (-38.67)
	P_2xP_3 (-1.67)	P_1xP_4 (-3.13)	P_1xP_2 (-3.91)	P_1xP_2 (-18.43)
	P_1xP_8 (-0.53)	P3xP7 (-2.63)	P_8xP_9 (-3.02)	P_1xP_9 (-15.83)

Particulars	Days to first fruit harvest	Vine length (m)	No. of primary branches per plant	Fruit length (cm)
Range of mean value				
Parents	52.81 to 58.53	4.95 to 7.26	12.34 to 25.01	28.91 to 57.56
F_1's	51.50 to 64.16	4.52 to 9.07	11.40 to 31.02	31.42 to 60.00
Range of heterosis (%) over				
Better parent (B.P.)	-12.02 to 9.62	-37.51 to 25.44	-47.06 to 80.17	-30.14 to 20.51
Standerd variety (Pusa Naveen)	-2.48 to 21.50	-25.00 to 50.55	-40.31 to 62.41	-29.28 to 35.05
Three top parents with their mean values				
	P_1 (52.81)	P_6 (7.26)	P_6 (25.01)	P_5 (57.56)
	P_5 (54.53)	P_8 (7.23)	P_2 (21.53)	P_6 (56.45)
	P_8 (55.31)	P_4 (7.16)	P_8 (19.70)	P_2 (50.36)
Three top F_1 hybrids with their mean values				
	P_1xP_8 (51.50)	P_7xP_8 (9.07)	P_6xP_9 (31.02)	P_3xP_6 (60.00)
	P_6xP_7 (51.50)	P_6xP_9 (8.73)	P_7xP_8 (29.56)	P_4xP_5 (59.20)
	P_1xP_7 (52.22)	P_5xP_7 (8.68)	P_2xP_4 (27.16)	P_3xP_7 (57.91)
Three top F_1 hybrids with respect to heterosis (%) over				
Better parent (B.P.)	P_6xP_7 (-12.02)	P_7xP_8 (25.44)	P_3xP_5 (80.17)	P_3xP_8 (20.51)
	P_1xP_4 (-10.82)	P_1xP_3 (24.17)	P_3xP_7 (56.98)	P_3xP_7 (16.53)
	P_1xP_7 (-8.37)	P_5xP_7 (22.88)	P_5xP_7 (52.54)	P_2xP_8 (11.71)
Standerd variety (Pusa Naveen)	P_1xP_8 (-2.48)	P_7xP_8 (50.55)	P_6xP_9 (62.41)	P_3xP_6 (35.05)
	P_1xP_7 (-1.10)	P_6xP_9 (44.86)	P_7xP_8 (54.80)	P_4xP_5 (33.23)
	P_1xP_2 (-0.59)	P_5xP_7 (44.08)	P_2xP_4 (42.20)	P_3xP_7 (30.35)

Particulars	Fruit circumference (cm)	Fruit weight (kg)	No. of fruits per plant	Fruit yield per plant (kg)
Range of mean value				
Parents	21.08 to 38.75	0.91 to 1.24	3.68 to 6.65	3.69 to 7.79
F_1's	20.20 to 29.61	0.82 to 1.26	2.78 to 8.32	3.11 to 8.82
Range of heterosis (%) over				
Better parent (B.P.)	-4199 to 10.42	-25.30 to 24.00	-50.24 to 42.92	-42.02 to 47.92
Standerd variety (Pusa Naveen)	-15.89 to 23.32	-24.62 to 14.89	-46.27 to 60.41	-44.85 to 54.74
Three top parents with their mean values				
	P_9 (38.75)	P_8 (1.24)	P_7 (6.65)	P_8 (7.79)
	P_7 (25.00)	P_5 (1.20)	P_8 (6.42)	P_7 (7.27)
	P_1 (24.01)	P_9 (1.13)	P_2 (6.27)	P_5 (6.86)
Three top F_1 hybrids with their mean values				
	P_2xP_9 (29.61)	P_3xP_5 (1.26)	P_3xP_7 (8.32)	P_7xP_9 (8.82)
	P_7xP_9 (28.36)	P_1xP_9 (1.23)	P_1xP_3 (8.00)	P_1xP_7 (8.40)
	P_1xP_9 (26.40)	P_4xP_9 (1.22)	P_1xP_7 (7.92)	P_3xP_7 (8.35)
Three top F_1 hybrids with respect to heterosis (%) over				
Better parent (B.P.)	P_2xP_3 (10.42)	P_3xP_6 (24.00)	P_1xP_3 (42.92)	P_3xP_4 (47.92)
	P_2xP_8 (3.84)	P_3xP_4 (12.58)	P_4xP_9 (35.94)	P_4xP_9 (46.87)
	P_3xP_6 (1.52)	P_1xP_9 (8.82)	P_5xP_6 (34.30)	P_3xP_6 (44.00)
Standerd variety (Pusa Naveen)	P_2xP_9 (23.32)	P_3xP_5 (14.89)	P_3xP_7 (60.41)	P_7xP_9 (54.74)
	P_7xP_9 (18.11)	P_1xP_9 (12.46)	P_1xP_3 (54.31)	P_1xP_7 (47.43)
	P_1xP_9 (9.95)	P_4xP_9 (11.55)	P_1xP_7 (52.70)	P_3xP_7 (46.55)

Conclusion

The mean square due to genotypes, parents, hybrids and parents vs hybrids were almost highly significant for all the 12 characters, except for days to first fruit harvest, days to first female flower anthesis, node number of first male flower appearance, fruit length and vine length only due to parents vs hybrids indicating therefore, significant differences among these source of variations with respect to the traits under study.

Heterosis for fruit yield per plant ranged from -42.02 to 47.92 per cent over better parent and -45.32 to 54.74 per cent over standard variety Pusa Naveen. For number of fruits and fruit weight it ranged from -50.24 to 42.92 per cent and -25.30 to 24.00 per cent over better parent and -46.27 to 60.41 per cent and -24.62 to 14.89 per cent over standard parent, respectively.

Regarding fruit length the heterosis ranged from -30.14 to 20.51 per cent over better parent and -29.28 to 35.05 per cent over standard variety. The heterosis for days to first fruit harvest as most important maturity trait ranged from -12.02 to 9.62 per cent and -2.48 to 21.50 per cent over better parent and standard variety, respectively.

Significant better parent (BP) and standard parent heterosis (SV) were found for all the traits except for days to first male flower anthesis, days to first female flower anthesis, node number to first male flower appearance and days to first fruit harvest over standard parent. For fruit yield per plant P_7 x P_9, P_1 x P_7, P_3 x P_7 were found as best heterotic F_1 with 54.74, 47.43 and 46.55 per cent heterosis over standard variety Pusa Naveen, respectively. These crosses also showed high significant and positive heterosis for number of fruits per plant.

References

1. Allard RW. Principles of Plant Breeding. John Wiley and Sons, Inc., New York, 1960, 227-228.

2. Choudhury B, Singh B. Two high yielding bottle gourd hybrids. Indian J. Hort. 1971; 18:15-32.
3. Cutler HC, Whitaker TW. History and distribution of the cultivated Cucurbits in the Americas. American Antiquity. 1961; 26:469-485
4. Dubey SK, Maurya IB. Manifestation of heterosis in bottle gourd (*Lagenaria siceraria* (Mol.) standl.). Annals Agri. Research. 2004; 25(4):550-553.
5. Hayes HK, Jones DF. First generation crosses in cucumber. Rep. Conn. Agric. Expt. Sta. Pt. 1916; 9:319-322.
6. Hayes HK, Immer F, Smith DC. Methods of plant breeding. Mc. Graw-Hill Book Co., Inc. New York, 1955, 52-66.
7. Sharma NK, Dhankar BS, Tewatia AS. Line x tester analysis for combining ability studies in bottle gourd. Haryana J. Hort. Sci. 1993; 22:324-327.
8. Sharma N, Sharma NK, Malik YS. Estimation of genetic variation in bottle gourd. National seminar on recent trends in Horticulture crops-Issues and strategies for research and development, March, 22-24, CCS HAU, Hisar, 2010, 26.
9. Sharma N, Malik YS, Sharma NK. Heterobeltiotic effects in long fruited bottle gourd. Haryana J. Hort. Sci. 2004; 33(1-3):109-112.
10. Sharma BR, Singh S, Singh D. Genetical studies in bottle gourd. Veg. Sci. 1983; 10:102-111.
11. Sirohi PS, Ghorui S. Inheritance of some quantitative characters in bottle gourd. Veg. Sci. 1993; 20:173-176.
12. Sirohi PS, Sivakami N, Choudhary B. Heterosis in long-fruited bottle gourd. Ann. Agric. Res. 1985; 6:210-214.