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EXPLOITATION OF HETEROSIS FOR YIELD AND QUALITY ENHANCEMENT IN PUMPKIN (*CUCURBITA MOSCHATA* DUCH. EX POIR.) HYBRIDS

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ABSTRACT

The present investigation was carried out to study the heterosis for yield and quality traits in pumpkin through full diallel analysis in randomized block design with three replication. The observation were recorded on six parents and 30 F_1 hybrids for eighteen traits *viz.,* vine length, node number at which first male flower anthesis, node number at which first female flower anthesis, number of primary branches vine^{-1}, days to first male flower anthesis, days to first female flower anthesis, number of male flowers vine^{-1}, number of female flowers vine^{-1}, sex ratio, number of fruits vine^{-1}, fruit weight, polar diameter of fruit, equatorial diameter of fruit, flesh thickness, 100 seed weight, carotene content, total soluble solids and yield vine^{-1}. The analysis revealed that, the cross combinations Ambili x Arka Suryamukhi, CO 1 x Pusa Vishwas and Arka Chandan x Arka Suryamukhi showed positive and significant heterobeltiosis and standard heterosis for yield vine^{-1} and hence they could be used in future breeding programme. In terms of earliness, Pusa Vishwas x Arka Chandan exhibited high *per* se and significant negative heterosis for node of first female flower anthesis and days to first female flower anthesis. For quality traits, the cross combination, CO 1 X CO 2 recorded the maximum *per se* performance with high standard heterosis for polar diameter of fruit, carotene content and total soluble solids followed by CO 2 x CO 1 but with a non significant value for yield plant^{-1}. Hence these combinations could be considered for quality improvement programme.

Keywords: Pumpkin, Full diallel, Mean performance, heterobeltiosis, Standard heterosis, Earliness, Yield and quality

Introduction

Pumpkin (*Cucurbita moschata* Duch. ex Poir.) is the most important seed propagated monoecious vegetable crop that belongs to the family *Cucurbitaceae*, with a chromosome number of 2n = 40. Originated in Central Mexico, it is cultivated in the tropical and subtropical regions of the world and is the principal ingredient in several culinary preparations utilized in both immature and mature fruit stage. The word pumpkin was derived from the Greek word *pepon*, which means “large melon”, something round and large (Singh *et al*, 2019). Pumpkin occupies prominent position among the cultivated cucurbitaceous vegetables because of its higher yield, nutritive value, good storability, long period of availability, amenable to hotter climate and better transport qualities as reported by Seshadri and Parthasarathy (2002).

Pumpkin is considered as a vegetable of immense value because of its high carotene content and good keeping quality. It plays an important role against Vitamin A deficiency, which concerns more than 250 million children of less than five years age in the world. Pumpkin, being a cross pollinated crop, exhibits considerable variation for most economic traits. So far, only few attempts have been made to improve upon the local types in pumpkin and the number of varieties available for commercial cultivation is limited.

Therefore efforts are to be made to develop high yielding varieties or hybrids with high carotene content.

The commercial exploitation of hybrids is easy in pumpkin due to its high seed content and easy seed extraction procedures. Therefore, the present investigation is oriented to gain further knowledge on the genetic aspects of yield and quality components in pumpkin for exploiting heterosis or hybrid vigour. Heterosis can be defined as the superiority of F_1 hybrid over the parents in terms of yield or some other character. In the present investigation, the heterosis of direct and reciprocal cross combinations derived from the six genetically divergent parents through diallel mating design was estimated over mid parent, better parent and standard check variety.

Materials and Methods

The six diverse genotypes *viz*., Arka Chandan (P_1), Ambili (P_2), Arka Suryamukhi (P_3), Pusa Vishwas (P_4), CO 2 (P_5) and CO 1 (P_6) were crossed in diallel mating design including reciprocals during July, 2020 and the resultant 30 F_1 hybrids and six parents were evaluated in randomized block design with two replications. The experiment was conducted in the horticultural farm in the Western block of Pandit Jawaharlal Nehru of Agriculture and Research Institute, Karaikal during summer, 2021.Seeds were sown in polybags and transplanted to the field with a spacing of 2 m x 2 m. The plants were fertilized with 100 g of 6:12:12 (NPK) mixture per pit after 30 days of sowing. The field was irrigated once in a week. The fruits were allowed to mature in the field and harvested periodically.

Data were recorded on five randomly selected vines for eighteen characters *viz*., vine length (m), node of first male flower anthesis, node of first female flower anthesis, number of primary branches vine^{-1}, days to first male flower anthesis, days to first female flower anthesis, number of male flowers vine^{-1}, number of female flowers vine^{-1}, sex ratio, number of fruits vine^{-1}, fruit weight (kg), polar diameter of fruit (cm), equatorial diameter of fruit (cm), flesh thickness (cm), 100 seed weight, carotene content (mg 100g^{-1}), total soluble solids (^{0}brix) and yield vine^{-1}(kg). The data were compiled for analysis of variance of different traits using method suggested by Panse and Sukhatme (1967). Heterosis was estimated over better parent and commercial check by using the formulae (Kempthorne 1957).

Result and Discussion

Heterosis is the superiority of F_1 over the mean of the parents or over the better parent or over the standard check (Hayes *et al*., 1956) with respect to agriculturally useful traits. Three types of heterosis *viz.,* relative heterosis (heterosis over mid-parent), heterobeltiosis (heterosis over better parent) and standard heterosis (heterosis over standard check) were estimated for all the 18 characters and presented character wise in Table 2.

In the present investigation for vine length, the range of heterosis was varied from -52.77 to 6.44% over better parent and from -45.06 to 6.44% over standard check. Out of 30 crosses, positive and significant heterobeltiosis was observed only in two crosses *viz.,* Pusa Vishwas x Ambili (6.44%) and CO 2 x CO 1 (3.08 %) while, crosses Pusa Vishwas x Ambili (6.44 per cent) registered significant and positive standard heterosis. Similar findings were recorded by Rani *et al*. (2014) for vine length, in bitter gourd.

With regards to node of first male flower anthesis, the range was from -37.04 to 37.25% and -9.80 to 58.82% over better parent and standard check, respectively. The heterobeltiosis recorded maximum and negative significant in the hybrid Arka Suryamukhi x Ambili (-37.04%) followed by CO 1 x Arka Suryamukhi (-33.33 %), whereas, cross Arka Suryamukhi x CO 2 (-9.80%) exhibited maximum significant standard heterosis in desirable direction.

In case of node of first female flower anthesis, the extent of heterosis varied from -46.96 to 34.00% over better parent and -37.11 to 49.48% over standard check. The hybrids showing highly significant standard heterosis were Pusa Vishwas x Arka Chandan (-37.11 %) whereas, the hybrids *viz.,* Pusa Vishwas x Arka Chandan (-46.96 %), CO 1 x Arka Suryamukhi (-44.27 %) and Arka Chandan x CO 1 (-40.46 %) were the top three best performing cross combinations over better parent.

With respect to number of primary branches, cross Arka Chandan x CO 2 (27.27) was found to be highly significant for heterobeltiosis and the range was varied from -57.69 to 27.27%. The extent of heterosis over standard check ranged from -47.62 to 47.62% for primary branches, with five hybrids showing significant positive standard heterosis in desirable direction.

In case of days to first male flower anthesis, negative and highly significant heterobeltiosis was observed in 11 hybrids and the range was varied from -

12.90 (Arka Suryamukhi x Arka Chandan) to 2.90 (Pusa Vishwas x CO 2) per cent. Highly significant and negative standard heterosis was exhibited by Arka Suryamukhi x Arka Chandan (-8.35 per cent), followed by Arka Suryamukhi x Ambili (-4.38 per cent). These results were in accordance with Rani *et al*. (2014) and Doloi *et al.* (2018) for days to first male flower anthesis in bitter gourd and bottlr gourd.

Earliness in terms of days to initiation of first female flower is an important trait in cucurbits. The heterobeltiosis for this trait ranged from -22.52 to 6.58 per cent. Out of 30 crosses, 24 crosses exhibited significant negative heterobeltosis for earliness favourably. The hybrid *viz.,* Pusa Vishwas x Arka Chandan (-22.52 per cent), Arka Chandan x CO 2 (-21.62 per cent) and CO 2 x Pusa Vishwas (-17.36 per cent) were the top three best performing cross combinations over the better parent for this character. The hybrid Arka Chandan x CO 2 (-25.83 per cent) was observed to be the earliest over the standard check. These findings were in accordance with the reports of Singh *et al.* (2012), Yadav and Kumar (2012) and Ghuge *et al.* (2016) in bottle gourd.

Heterobeltiosis was the highest for number of male flowers in the hybrid Ambili x CO 1 (4.44) and it ranged from -33.72 to 4.44 per cent. Out of 30 crosses, 12 hybrids showed significant and positive standard heterosis. The highest positive (25.22 per cent) and significant standard heterosis was observed in the hybrid Arka Suryamukhi x Pusa Vishwas. With regards to number of female flower vine^{-1}, the heterobeltiosis was positive and significant for six hybrids among the crosses and it ranged from 22.95 (Ambili x Arka Chandan) to 90.57 (CO 1 x CO 2). The standard heterosis was positive and significant among 12 hybrids. The hybrid Arka Suryamukhi x Ambili (144.90 per cent) had exhibited the highest heterotic expression over standard check.

For sex ratio, the extent of heterosis over better parent ranged from -45.30 to 39.19 per cent. However, significant negative heterobeltiosis was noticed in 17 hybrids and it was the highest in Arka Suryamukhi x Pusa Vishwas (-45.30 %). Negative and significant standard heterosis was observed in 14 hybrids of which, the hybrid Arka Suryamukhi x Ambili (-50.62 per cent) exhibited the maximum value.

Yield is greatly influenced by number of fruits, average fruit weight, polar diameter and equatorial diameter of fruits and for these characters expression of heterosis in positive direction is highly desirable.The heterobeltiosis for number of fruits vine^{-1} was positive and significant for four hybrids among the crosses and it ranged from 40.00 to 72.22 per cent, with the maximum heterobeltiosis found in the cross Arka Suryamukhi x Arka Chandan (72.22 per cent). The range of standard heterosis was recorded from 7.69 to 138.46 per cent. The hybrid Arka Suryamukhi x Arka Chandan (138.46 per cent) exhibited the highest standard heterosis. These results are in agreement with those of Behera (2004) and Thangamani and Pugalendhi (2013) in bitter gourd. With regards to fruit weight, the heterobeltiosis and standard heterosis of positive and significant was noted for four and one out of 30 hybrids respectively. The hybrid Ambili x Arka Suryamukhi exhibited the highest heterobeltiosis (67.23 per cent) and standard heterosis (21.50 per cent) for fruit weight. Similar results were reported by Rani *et al*. (2014) in bitter gourd and Janaranjani *et al*. (2016) for 100 seed weight, flesh thickness, fruit weight in bottle gourd.

Heterobeltiosis for polar diameter ranged from -65.85 to 46.19 per cent. The maximum heterobeltiosis was found in the cross CO 1 x CO 2 (46.19 per cent), while the maximum standard heterosis (5.17 per cent) was found in the hybrid CO 1 x CO 2. In case of equatorial diameter of fruit, out of 30 hybrids, 12 hybrids showed positive and significant heterobeltiosis over the better parent with the maximum value obtained by the cross Arka Chandan x CO 2 (31.17). The highest positive significant heterosis observed over standard check was 18.65 per cent reported in the cross Arka Chandan x CO 2.

In extent of heterosis for flesh thickness varied from -56.71 to 128.52 per cent over better parent. The highest positive and significant value was obtained from the cross CO 2 x Ambili (128.52 per cent). Positive significant standard heterosis was observed in 30 hybrids and it was the highest (11.52 per cent) in Arka Suryamukhi x Arka Chandan. With regards to 100 seed weight, the heterobeltiosis was ranged from -43.75 to 127.78 with the maximum seed weight obtained in the cross Arka Chandan x Arka Suryamukhi (127.78). When compared to standard check, the cross CO 2 x CO 1 (42.37) and CO 1 x CO 2 (42.00) recorded the highest and positive heterosis in desirable direction.

With regards to yield, the heterosis over better parent was positive and significant in three crosses and the highest hetrobeltiosis was observed in the cross Ambili x Arka Suryamukhi (88.24 per cent). Highest positive and significant standard heterosis (93.38 per cent) was observed in the cross Ambili x Arka Suryamukhi. Regarding carotene content, the standard heterosis was positive and significant in three combinations and it was ranged from -86.00 to 92.80

per cent. The hybrid CO 1 x CO 2 depicted the positive heterobeltiosis (53.99 per cent) and standard heterosis (92.80 per cent) in desirable direction. These finding are in accordance with Doloi *et al.* (2018) for yield plant^{-1} in bottle gourd.

In case of total soluble solids, the heterobeltiosis was significant and positive in 12 out of 30 crosses. The range for heterobeltiosis was -70.98 to 207.02 per cent. The maximum heterobeltiosis was found in the cross CO 2 x Arka Suryamukhi (207.02 per cent). The highest and positive significant standard heterosis (86.48 per cent) was obtained from the cross CO 1 x CO 2.

In terms of yield, Ambili x Arka Suryamukhi exhibited high *per se* and standard heterosis for fruit weight and yield plant^{-1}. The hybrids CO 1 x Pusa Vishwas and Arka Chandan x Arka Suryamukhi also exhibited high yield plant^{-1} but possessed average performance for number of female flowers plant^{-1}, number of fruits plant^{-1} and fruit weight.

Conclusion

From the present investigation, it was concluded that heterosis is not only responsible for fruit yield but also for early maturity and quality characters. In terms of earliness, Pusa Vishwas x Arka Chandan exhibited high *per* se and heterosis for node of first female flower anthesis and days to first female flower anthesis. The cross combinations Ambili x Arka Suryamukhi, CO 1 x Pusa Vishwas and Arka Chandan x Arka Suryamukhi showed best performance for yield and yield contributing traits and hence they could be used in future breeding programme. For quality traits, the cross combination, CO 1 X CO 2 recorded the maximum *per se* performance with high standard heterosis for polar diameter of fruit, carotene content and total soluble solids followed by CO 2 x CO 1 but with a non significant value for yield plant^{-1}. Hence these combinations could be considered for quality improvement programme.

Table 1: Mean performance of parents and crosses for eighteen characters in pumpkin

Genotypes	Vine length	Node of first male flower anthesis	Node of first female flower anthesis	Number of primary branches vine^{-1}	Days to first male flower anthesis	Days to first female flower anthesis	Number of male flowers vine^{-1}	Number of female flowers vine^{-1}	Sex ratio
P_1 x P_2	3.18	5.60	10.30	2.40	47.90	40.10	86.00	**4.50**	19.45
P_1 x P_3	3.17	5.90	9.10	1.90	48.60	43.00	82.30	4.80	17.62
P_1 x P_4	3.58	6.20	11.40	2.00	47.50	41.50	80.20	5.10	15.06
P_1 x P_5	3.41	**8.10**	7.20	2.80	47.00	**35.90**	74.30	5.10	14.85
P_1 x P_6	3.27	7.80	7.80	1.90	48.30	41.30	83.50	4.80	17.79
P_2 x P_1	3.97 **	6.80	11.70	2.70	49.90	44.00	82.50	7.50	18.66
P_2 x P_3	3.38	7.80	11.40	2.10	48.00	44.20	88.60	11.00	20.33
P_2 x P_4	4.37 **	7.80	12.10	2.10	48.30	42.20	82.30	8.50	17.48
P_2 x P_5	4.10 **	7.40	12.20	2.20	47.40	43.10	83.60	7.90	19.67
P_2 x P_6	3.95 **	6.50	**14.50**	2.30	48.70	**51.80**	89.30	8.00	**20.47**
P_3 x P_1	2.73	5.10	8.30	2.00	**43.90**	44.80	96.30	9.20	10.72
P_3 x P_2	2.65	5.10	8.60	**1.10**	45.80	43.00	99.70	**12.00**	**8.12**
P_3 x P_4	3.06	5.30	13.60	1.60	46.30	48.10	**101.80**	11.60	8.99
P_3 x P_5	2.41	**4.60**	10.50	1.70	46.60	48.40	98.80	11.10	9.24
P_3 x P_6	**2.39**	5.40	12.70	**3.10**	49.10	46.00	96.90	11.00	9.06
P_4 x P_1	4.12**	7.00	**6.10**	1.50	47.10	37.50	74.50	4.50	17.13
P_4 x P_2	4.63 **	5.10	13.40	2.40	48.20	45.30	67.30	5.20	13.50
P_4 x P_3	2.52	5.70	11.80	2.10	47.10	44.50	84.80	4.80	18.07
P_4 x P_5	4.27 **	5.90	12.30	2.40	50.20	43.90	71.10	5.30	13.63
P_4 x P_6	**4.39** **	6.00	11.50	1.90	49.70	44.00	71.60	4.50	16.11
P_5 x P_1	3.25	7.10	10.60	2.30	48.40	42.00	68.70	5.30	13.40
P_5 x P_2	4.01 **	5.50	11.90	1.90	**50.90**	44.10	**63.30**	5.40	12.07
P_5 x P_3	3.60	6.30	10.70	2.50	47.50	45.90	80.50	4.60	17.74
P_5 x P_4	4.21 **	6.70	8.00	1.90	47.00	40.00	82.60	5.30	15.83
P_5 x P_6	3.68	7.30	10.30	2.40	48.80	43.10	85.60	4.70	18.23
P_6 x P_1	3.29	7.30	11.30	2.30	49.10	43.00	74.20	4.80	15.76
P_6 x P_2	3.49	5.40	11.80	2.00	48.60	43.50	76.50	4.60	16.89

P_6 x P_3	3.09	6.30	7.30	2.80	49.30	41.20	73.90	5.20	14.50
P_6 x P_4	3.90 **	5.60	12.60	2.30	49.70	45.70	66.10	9.70	14.55
P_6 x P_5	3.50	6.10	12.80	2.80	48.00	46.00	85.20	10.10	13.13
Range	**2.39-4.63**	**4.60-8.10**	**6.10-14.50**	**1.10-3.10**	**43.90-50.90**	**35.90–51.80**	**63.30-101.80**	**4.50-12.00**	**8.12–20.47**
P_1	3.60	**5.10**	11.50	2.20	**47.60**	45.80	83.90	5.10	**18.86**
P_2	4.14	**8.10**	10.00	2.60	49.40	**43.50**	85.50	6.10	14.61
P_3	**5.06**	5.60	10.20	**1.90**	**50.40**	48.20	**111.50**	**11.50**	**9.37**
P_4	4.35	**5.10**	9.70	2.10	47.90	48.40	**81.30**	**4.90**	16.44
P_5	3.57	6.50	**7.80**	2.10	49.70	45.80	84.30	5.10	16.80
P_6	**3.15**	6.10	**13.10**	**3.50**	48.30	**48.60**	85.20	5.30	16.47
Range	**3.15 - 5.06**	**5.10-8.10**	**7.80-13.10**	**1.90-3.50**	**47.60-50.40**	**43.50-48.60**	**81.30-111.50**	**4.90-11.50**	**9.37-18.86**
Grand Mean	3.59	6.27	10.72	2.21	48.22	44.09	82.36	6.78	15.29
C.D. 0.05%	0.10	0.57	2.81	0.49	2.51	3.84	3.25	0.84	1.82
SE	0.04	0.20	0.98	0.17	0.88	1.34	1.13	0.29	2.44

* Significant at 5 per cent level ** Significant at 1 per cent level
Bold values indicates lowest mean value and underlined bold values indicates highest mean value
P_1 - Arka Chandan, P_2 – Ambili, P_3 - Arka Suryamukhi, P_4 - Pusa Vishwas, P_5 - CO 2, P_6 - CO 1

Table 1: Cont…

Genotypes	Number of fruits vine^{-1}	Fruit weight	Polar diameter of fruit	Equatorial diameter of fruit	Flesh thickness	100 seed weight	Yield vine^{-1}	Carotene content	Total soluble solids
P_1 x P_2	1.70	3.23**	11.35	27.01	5.14**	14.23	5.13	0.87**	4.05
P_1 x P_3	2.00	2.86	12.41	20.08	3.32	13.12	5.17	0.57	5.22**
P_1 x P_4	1.50	2.78	12.20	25.06	4.64**	14.48	3.79	0.75	6.04**
P_1 x P_5	1.40	3.03*	13.22	**27.23**	5.44**	11.79	3.79	0.52	7.48**
P_1 x P_6	1.40	2.11	11.50	20.09	3.71	10.71	2.89	0.79	4.23
P_2 x P_1	1.80	2.44	12.40	22.13	3.44	13.15	3.75	0.62	5.17**
P_2 x P_3	2.80**	**4.46****	13.69	24.07	4.44**	11.18	4.89	0.32	3.87
P_2 x P_4	2.30	3.08*	13.16	23.18	4.71**	**8.55**	4.25	0.53	5.68**
P_2 x P_5	2.00	2.73	10.40	23.65	3.74	14.74	3.64	**0.17**	2.29
P_2 x P_6	1.70	3.41**	14.29	23.57	4.44**	16.28	4.04	0.46	3.72
P_3 x P_1	**3.10****	0.89	7.12	15.72	**6.09****	11.76	2.05	0.97**	4.71
P_3 x P_2	2.00	0.75	**6.20**	13.77	2.72	9.45	1.31	0.83**	5.39**
P_3 x P_4	1.70	0.72	6.67	**12.55**	4.10**	12.77	1.11	0.71	5.06**
P_3 x P_5	1.50	**0.51**	6.27	14.00	3.63	9.49	**0.69**	0.82	**1.63**
P_3 x P_6	1.80	0.56	6.81	14.79	3.25	12.65	0.99	0.93**	2.48
P_4 x P_1	1.50	3.35**	15.19	24.08	4.45**	12.22	4.59	0.70	5.08**
P_4 x P_2	1.60	2.61	12.42	22.88	4.08**	13.76	3.98	0.84**	4.83**
P_4 x P_3	1.40	2.88	12.17	18.93	2.65	14.15	3.96	0.75	3.03
P_4 x P_5	1.50	2.76	14.10	21.74	3.80	12.13	4.08	0.48	2.09
P_4 x P_6	1.60	2.39	10.35	22.67	4.60**	11.12	3.71	0.36	4.42
P_5 x P_1	1.90	1.97	9.55	22.86	2.56	13.28	3.56	0.48	8.73**
P_5 x P_2	1.80	2.08	10.66	22.28	5.85**	13.11	4.19	0.27	2.04
P_5 x P_3	1.60	2.43	10.27	26.46	3.66	9.69	3.55	0.25	2.15
P_5 x P_4	1.80	2.46	10.95	21.77	3.66	18.62	4.20	0.96**	3.78
P_5 x P_6	1.70	2.18	10.13	20.88	**2.45**	**19.17**	3.59	0.36	9.21**
P_6 x P_1	1.60	2.65	12.20	20.68	4.76**	13.06	3.93	1.74**	6.32**
P_6 x P_2	1.90	2.92	12.19	20.80	3.73	13.14	4.68	1.36**	7.11**
P_6 x P_3	**1.30**	2.90	10.03	18.67	2.76	15.66	4.82	1.07**	5.25**
P_6 x P_4	2.30	3.08*	13.40	20.61	4.26**	10.17	**6.08****	1.17**	4.77*
P_6 x P_5	2.50*	2.11	**20.54**	24.07	3.97	19.12	4.55	**2.41****	**9.38****
Range	**1.30-3.10**	**0.51-4.46**	**6.20-20.54**	**12.55-27.23**	**2.45-6.09**	**8.55-19.17**	**0.69-6.08**	**0.17-2.41**	**1.63-9.38**
P_1	1.80	2.05	**15.66**	16.01	**5.75****	**5.11**	4.17	1.27**	3.24

P_2	**2.00**	2.67	12.07	21.17	2.56	15.20	**4.89**	0.55	**7.03****
P_3	1.70	**0.85**	**6.31**	**14.02**	3.16	5.76	**1.31**	**0.44**	**1.32**
P_4	**1.30**	**3.67****	**19.53**	22.95	5.46**	13.46	4.76	1.25**	5.03**
P_5	1.50	2.47	9.65	20.76	**2.24**	13.35	3.24	0.93**	4.11
P_6	1.60	3.27**	14.05	**26.96**	5.66**	**16.74**	4.79	**1.56****	1.71
Range	**1.30-2.00**	**0.85-3.67**	**6.31-19.53**	**14.02-26.96**	**2.24-5.75**	**5.11-16.74**	**1.31-4.89**	**0.44-1.56**	**1.32-7.03**
Grand Mean	**1.79**	**2.42**	**11.64**	**21.06**	**4.02**	**12.84**	**3.84**	**0.81**	**4.65**
C.D. 5%	**0.62**	**0.53**	**0.62**	**0.31**	**0.04**	0.50	**1.58**	**0.01**	**0.08**
SE	0.21	0.18	**0.22**	**0.11**	0.01	0.18	0.55	0.003	0.03

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

Bold values indicates lowest mean value and underlined bold values indicates highest mean value

P_1 - Arka Chandan, P_2 – Ambili, P_3 - Arka Suryamukhi, P_4 - Pusa Vishwas, P_5 - CO 2, P_6 - CO 1

Table 2 : Extent of heterosis in pumpkin for vine length, Node of first male flower anthesis, Node of first female flower anthesis, Number of primary branches vine^{-1}, Days to first male flower anthesis and Days to first female flower anthesis.

S. No.	**Hybrid**	**Vine length**		**Node of first male flower anthesis**		**Node of first female flower anthesis**		**Number of primary branches vine^{-1}**		**Days to first male flower anthesis**		**Days to first female flower anthesis**	
		HB	**SH**	**HB**	**SH**	**HB**	**SH**	**HB**	**SH**	**HB**	**SH**	**HB**	**SH**
1.	**P_1 x P_2**	-23.19**	-26.90**	-30.86**	9.80**	-10.43	6.19	-7.69	14.29	-3.04	0.00	-12.45**	-17.15**
2.	**P_1 x P_3**	-37.35**	-27.13**	5.36	15.69**	-20.87**	-6.19	-13.64	-9.52	-3.57*	1.46	-10.79**	-11.16**
3.	**P_1 x P_4**	-17.70**	-17.70**	21.57**	21.57**	-0.87	17.53	-9.09	-4.76	-0.84	-0.84	-14.26**	-14.26**
4.	**P_1 x P_5**	-5.28**	-21.61**	24.62**	**58.82****	-37.39**	-25.77**	**27.27****	33.33**	-5.43**	-1.88	-21.62**	**-25.83****
5.	**P_1 x P_6**	-9.17**	-24.83**	27.87**	52.94**	-40.46**	-19.59*	-45.71**	-9.52	0.00	0.84	-15.02**	-14.67**
6.	**P_2 x P_1**	-4.11**	-8.74**	-16.05**	33.33**	1.74	20.62*	3.85	28.57**	1.01	4.18*	-3.93	-9.09**
7.	**P_2 x P_3**	-33.20**	-22.30**	-3.70	52.94**	11.76	17.53	-19.23**	0.00	-4.76**	0.21	-8.30**	-8.68**
8.	**P_2 x P_4**	0.46	0.46	-3.70	52.94**	21.00*	24.74**	-19.23**	0.00	-2.23	0.84	-12.81**	-12.81**
9.	**P_2 x P_5**	-0.97	-5.75**	-8.64**	45.10**	22.00*	25.77**	-15.38*	4.76	-4.63**	-1.04	-5.90*	-10.95**
10.	**P_2 x P_6**	-4.59**	-9.20**	-19.75**	27.45**	10.69	**49.48****	-34.29**	9.52	-1.42	1.67	**6.58****	**7.02****
11.	**P_3 x P_1**	-46.05**	-37.24**	-8.93**	0.00	-27.83**	-14.43	-9.09	-4.76	**-12.90****	**-8.35****	-7.05**	-7.44**
12.	**P_3 x P_2**	-47.63**	-39.08**	**-37.04****	0.00	-15.69	-11.34	**-57.69****	**-47.62****	-9.13**	-4.38**	-10.79**	-11.16**
13.	**P_3 x P_4**	-39.53**	-29.66**	-5.36	3.92	**33.33****	40.21**	-23.81**	-23.81**	-8.13**	-3.34*	-0.62	-0.62
14.	**P_3 x P_5**	-52.37**	-44.60**	-29.23**	**-9.80****	2.94	8.25	-19.05*	-19.05*	-7.54**	-2.71	0.41	0.00
15.	**P_3 x P_6**	**-52.77****	**-45.06****	-11.48**	5.88	-3.05	30.93**	-11.43*	**47.62****	-2.58	2.51	-5.35*	-4.96*
16.	**P_4 x P_1**	-5.29**	-5.29**	**37.25****	37.25**	**-46.96****	**-37.11****	-31.82**	-28.57**	-1.67	-1.67	**-22.52****	-22.52**
17.	**P_4 x P_2**	**6.44****	**6.44****	-30.86**	9.80**	34.00**	38.14**	-7.69	14.29	-2.43	0.63	-6.40*	-6.40*
18.	**P_4 x P_3**	-50.20**	-42.07**	1.79	11.76**	15.69	21.65*	0.00	0.00	-6.55**	-1.67	-8.06**	-8.06**
19.	**P_4 x P_5**	-1.84*	-1.84*	-9.23**	15.69**	26.80**	26.80**	14.29	14.29	1.01	4.80**	-9.30**	-9.30**
20.	**P_4 x P_6**	0.92	0.92	-1.64	17.65**	-12.21	18.56*	-45.71**	-9.52	**2.90**	3.76*	-9.47**	-9.09**
21.	**P_5 x P_1**	-9.72**	-25.29**	9.23**	39.22**	-7.83	9.28	4.55	9.52	-2.62	1.04	-8.30**	-13.22**
22.	**P_5 x P_2**	-3.14**	-7.82**	-32.10**	7.84*	19.00*	22.68*	-26.92**	-9.52	2.41	**6.26****	-3.71	-8.88**
23.	**P_5 x P_3**	-28.85**	-17.24**	-3.08	23.53**	4.90	10.31	19.05*	19.05*	-5.75**	-0.84	-4.77	-5.17*
24.	**P_5 x P_4**	-3.22**	-3.22**	3.08	31.37**	-17.53	-17.53	-9.52	-9.52	-5.43**	-1.88	-17.36**	-17.36**
25.	**P_5 x P_6**	3.08**	-15.40**	12.31**	43.14**	-21.37**	6.19	-31.43**	14.29	-1.81	1.88	-11.32**	-10.95**
26.	**P_6 x P_1**	-8.61**	-24.37**	19.67**	43.14**	-13.74*	16.49	-34.29**	9.52	1.66	2.51	-11.52**	-11.16**
27.	**P_6 x P_2**	-15.70**	-19.77**	-33.33**	5.88	-9.92	21.65*	-42.86**	-4.76	-1.62	1.46	-10.49**	-10.12**
28.	**P_6 x P_3**	-38.93**	-28.97**	3.28	23.53**	-44.27**	-24.74**	-20.00**	33.33**	-2.18	2.92	-15.23**	-14.88**
29.	**P_6 x P_4**	-10.34**	-10.34**	-8.20**	9.80**	-3.82	29.90**	-34.29**	9.52	**2.90**	3.76*	-5.97*	-5.58*
30.	**P_6 x P_5**	-1.96*	-19.54**	-3.08	23.53**	-2.29	31.96**	-20.00**	33.33**	-3.42*	0.21	-5.35*	-4.96*

* Significant at 5 per cent level; ** Significant at 1 per cent level

P_1 - Arka Chandan, P_2 – Ambili, P_3 - Arka Suryamukhi, P_4 - Pusa Vishwas, P_5 - CO 2, P_6 - CO 1

Table 3 : Extent of heterosis in pumpkin for Number of male flowers vine $^{-1}$, Number of female flowers vine $^{-1}$, Sex ratio, Number of fruits vine^{-1}, Fruit weight and Polar diameter of fruit.

S. No.	Hybrid	Number of male flowers vine $^{-1}$		Number of female flowers vine $^{-1}$		Sex ratio		Number of fruits vine^{-1}		Fruit weight		Polar diameter of fruit	
		HB	SH	HB	SH	HB	SH	HB	SH	HB	SH	HB	SH
1.	P_1 x P_2	0.58	5.78**	-26.23**	-8.16	3.13	18.30**	-15.00	30.77*	20.97**	-12.11**	-27.52**	-41.88**
2.	P_1 x P_3	-26.19**	1.23	-58.26**	-2.04	-6.60*	7.15*	11.11	53.85**	39.17**	-22.18**	-20.75**	-36.46**
3.	P_1 x P_4	-4.41**	-1.35	-0.00	4.08	-20.14**	-8.39*	-16.67	15.38	-24.35**	-24.35**	-37.53**	-37.53**
4.	P_1 x P_5	-11.86**	-8.61**	-0.00	4.08	-21.28**	-9.70**	-22.22*	7.69	22.42**	-17.55**	-15.58**	-32.31**
5.	P_1 x P_6	-2.00	2.71*	-9.43	-2.04	-5.70	8.18*	-22.22*	7.69	-35.42**	-42.45**	-26.56**	-41.12**
6.	P_2 x P_1	-3.51**	1.48	22.95**	53.06**	-1.09	13.47**	-10.00	38.46*	-8.43	-33.47**	-20.82**	-36.51**
7.	P_2 x P_3	-20.54**	8.98**	-4.35	124.49**	39.19**	23.65**	40.00**	115.38**	67.23**	21.50**	13.42**	-29.90**
8.	P_2 x P_4	-3.74**	1.23	39.34**	73.47**	6.29	6.29	15.00	76.92**	-16.19**	-16.19**	-32.62**	-32.62**
9.	P_2 x P_5	-2.22	2.83*	29.51**	61.22**	17.08**	19.64**	0.00	53.85**	2.43	-25.58**	-13.84**	-46.75**
10.	P_2 x P_6	4.44**	9.84**	31.15**	63.27**	24.28**	24.51**	-15.00	30.77*	4.27	-7.07	1.71	-26.83**
11.	P_3 x P_1	-13.63**	18.45**	-20.00**	87.76**	-43.15**	-34.78**	72.22**	138.46**	-56.45**	-75.65**	-54.53**	-63.54**
12.	P_3 x P_2	-10.58**	22.63**	4.35	144.90**	-44.42**	-50.62**	0.00	53.85**	-71.72**	-79.46**	-48.63**	-68.25**
13.	P_3 x P_4	-8.70**	25.22**	0.87	136.73**	-45.30**	-45.30**	0.00	30.77*	-80.27**	-80.27**	-65.85**	-65.85**
14.	P_3 x P_5	-11.39**	21.53**	-3.48	126.53**	-45.02**	-43.81**	-11.76	15.38	-79.39**	-86.12**	-35.03**	-67.90**
15.	P_3 x P_6	-13.09**	19.19**	-4.35	124.49**	-45.01**	-44.91**	5.88	38.46*	-82.75**	-84.63**	-51.53**	-65.13**
16.	P_4 x P_1	-11.20**	-8.36**	-11.76*	-8.16	-9.17**	4.20	-16.67	15.38	-8.71	-8.71	-22.22**	-22.22**
17.	P_4 x P_2	-21.29**	-17.22**	-14.75**	6.12	-17.88**	-17.88**	-20.00*	23.08	-28.98**	-28.98**	-36.41**	-36.41**
18.	P_4 x P_3	-23.95**	4.31**	-58.26**	-2.04	9.91**	9.91**	-17.65	7.69	-21.63**	-21.63**	-37.69**	-37.69**
19.	P_4 x P_5	-15.66**	-12.55**	3.92	8.16	-18.86**	-17.09**	0.00	15.38	-24.76**	-24.76**	-27.80**	-27.80**
20.	P_4 x P_6	-15.96**	-11.93**	-15.09**	-8.16	-2.19	-2.01	-0.00	23.08	-34.83**	-34.83**	-47.00**	-47.00**
21.	P_5 x P_1	-18.51**	-15.50**	3.92	8.16	-28.94**	-18.49**	5.56	46.15**	-20.40**	-46.39**	-39.02**	-51.10**
22.	P_5 x P_2	-25.96**	-22.14**	-11.48**	10.20	-28.18**	-26.60**	-10.00	38.46*	-21.91**	-43.27**	-11.68**	-45.42**
23.	P_5 x P_3	-27.80**	-0.98	-60.00**	-6.12	5.59	7.91*	-5.88	23.08	-1.82	-33.88**	6.42**	-47.41**
24.	P_5 x P_4	-2.02	1.60	3.92	8.16	-5.77	-3.71	20.00	38.46*	-32.93**	-32.93**	-43.93**	-43.93**
25.	P_5 x P_6	0.47	5.29**	-11.32*	-4.08	8.51*	10.88**	6.25	30.77*	-33.44**	-40.68**	-27.90**	-48.13**
26.	P_6 x P_1	-12.91**	-8.73**	-9.43	-2.04	-16.46**	-4.17	-11.11	23.08	-19.08**	-27.89**	-22.09**	-37.53**
27.	P_6 x P_2	-10.53**	-5.90**	-24.59**	-6.12	2.52	2.71	-5.00	46.15**	-10.69*	-20.41**	-13.24**	-37.58**
28.	P_6 x P_3	-33.72**	-9.10**	-54.78**	6.12	-11.99**	-11.83**	-23.53*	0.00	-11.45*	-21.09**	-28.61**	-48.64**
29.	P_6 x P_4	-22.42**	-18.70**	83.02**	97.96**	-11.65**	-11.49**	43.75**	76.92**	-16.19**	-16.19**	-31.39**	-31.39**
30.	P_6 x P_5	-21.95**	-18.20**	90.57**	106.12**	-21.87**	-20.16**	56.25**	92.31**	-35.42**	-42.45**	46.19**	5.17**

* Significant at 5 per cent level; ** Significant at 1 per cent level

P_1 - Arka Chandan, P_2 – Ambili, P_3 - Arka Suryamukhi, P_4 - Pusa Vishwas, P_5 - CO 2, P_6 - CO 1

Table 4 : Extent of heterosis in pumpkin for Equatorial diameter of fruit, Flesh thickness, 100 seed weight, Yield vine^{-1}, Carotene content and Total soluble solids.

S. No.	Hybrid	Equatorial diameter of fruit		Flesh thickness		100 seed weight		Yield vine^{-1}		Carotene content		Total soluble solids	
		HB	SH	HB	SH	HB	SH	HB	SH	HB	SH	HB	SH
1.	P_1 x P_2	27.59**	17.69**	-10.61**	-5.86**	-6.38**	5.68**	4.91	7.77	-31.76**	-30.40**	-42.39**	-19.48**
2.	P_1 x P_3	25.42**	-12.51**	-42.26**	-39.19**	127.78**	-2.56**	23.98*	8.61	-55.29**	-54.40**	61.11**	3.78**
3.	P_1 x P_4	9.19**	9.19**	-19.30**	-15.02**	7.54**	7.54**	-20.38*	-20.38*	-41.18**	-40.00**	20.08**	20.08**
4.	P_1 x P_5	31.17**	18.65**	-5.39**	-0.37	-11.65**	-12.40**	-8.99	-20.27	-59.22**	-58.40**	82.00*	48.71**
5.	P_1 x P_6	-25.48**	-12.46**	-35.48**	-32.05**	-36.02**	-20.46**	-39.73**	-39.29**	-49.52**	-36.80**	30.56**	-15.90**
6.	P_2 x P_1	4.53**	-3.57**	-40.17**	-37.00**	-13.49**	-2.34**	-23.31*	-21.22*	-50.98**	-50.00**	-26.46**	2.78**
7.	P_2 x P_3	13.70**	4.88**	40.51**	-18.68**	-26.45**	-16.97**	88.24**	93.38**	-41.82**	-74.40**	-44.95**	-23.06**
8.	P_2 x P_4	1.00*	1.00*	-13.74**	-13.74**	-43.75**	-36.50**	-12.99	-10.61	-57.60**	-57.60**	-19.20**	12.92**
9.	P_2 x P_5	11.71**	3.05**	46.09**	-31.50**	-3.03**	9.47**	-25.46*	-23.42*	-81.28**	-86.00**	-67.43**	-54.47**
10.	P_2 x P_6	-12.57**	2.70**	-21.55**	-18.68**	-2.75**	20.91**	-17.28	-15.02	-70.29**	-62.80**	-47.08**	-26.04**
11.	P_3 x P_1	-1.81**	-31.50**	5.91**	11.54**	104.17**	-12.66**	-50.72**	-56.83**	-23.92**	-22.40**	45.37**	-6.36**
12.	P_3 x P_2	-34.96**	-40.00**	-13.92**	-50.18**	-37.83**	-29.82**	-73.21**	-72.48**	50.91**	-33.60**	-23.33**	7.16**
13.	P_3 x P_4	-45.32**	-45.32**	-24.91**	-24.91**	-5.16**	-5.16**	-76.68**	-76.68**	-43.20**	-43.20**	0.60	0.60
14.	P_3 x P_5	-32.56**	-39.00**	14.87**	-33.52**	-28.91**	-29.52**	-78.74**	-85.50**	-12.30**	-34.40**	-60.34**	-67.59**
15.	P_3 x P_6	-45.14**	-35.56**	-42.58**	-40.48**	-24.43**	-6.05**	-79.35**	-79.20**	-40.26**	-25.20**	45.03**	-50.70**

16.	**P_4 x P_1**	4.92**	4.92**	-22.61**	-18.50**	-9.25**	-9.25**	-3.47	-3.47	-45.10**	-44.00**	0.99	0.99
17.	**P_4 x P_2**	-0.31	-0.31	-25.27**	-25.27**	-9.47**	2.19**	-18.61	-16.39	-32.80**	-32.80**	-31.29**	-3.98**
18.	**P_4 x P_3**	-17.52**	-17.52**	-51.47**	-51.47**	5.09**	5.09**	-16.70	-16.70	-39.60**	-39.60**	-39.76**	-39.76**
19.	**P_4 x P_5**	-5.27**	-5.27**	-30.40**	-30.40**	-9.91**	-9.91**	-14.18	-14.18	-61.20**	-61.20**	-58.45**	-58.45**
20.	**P_4 x P_6**	-15.91**	-1.22**	-18.73**	-15.75**	-33.54**	-17.38**	-22.52*	-21.95*	-76.68**	-70.80**	-12.13**	-12.13**
21.	**P_5 x P_1**	10.12**	-0.39	-55.48**	-53.11**	-0.52**	-1.37**	-14.51	-25.11*	-61.96**	-61.20**	112.41**	73.56**
22.	**P_5 x P_2**	5.24**	-2.92**	128.52**	7.14**	-13.75**	-2.64**	-14.21	-11.87	-70.59**	-78.00**	-70.98**	-59.44**
23.	**P_5 x P_3**	27.46**	15.29**	15.82**	-32.97**	-27.42**	-28.04**	9.55	-25.32*	-72.73**	-79.60**	-47.69**	-57.26**
24.	**P_5 x P_4**	-5.14**	-5.14**	-32.97**	-32.97**	38.28**	38.28**	-11.76	-11.76	-22.80**	-22.80**	-24.85**	-24.85**
25.	**P_5 x P_6**	-22.55**	-9.02**	-56.71**	-55.13**	14.52**	42.37**	-25.13*	-24.58*	-61.98**	-52.40**	124.09**	83.10**
26.	**P_6 x P_1**	-23.29**	-9.89**	-17.22**	-12.82**	-21.95**	-2.97**	-17.94	-17.33	11.50**	39.60**	95.06**	25.65**
27.	**P_6 x P_2**	-22.85**	-9.37**	-34.10**	-31.68**	-21.51**	-2.41**	-4.29	-1.68	-13.10**	8.80**	1.14**	41.35**
28.	**P_6 x P_3**	-30.75**	-18.65**	-51.24**	-49.45**	-6.45**	16.30**	0.63	1.37	-31.31**	-14.00**	207.02**	4.37**
29.	**P_6 x P_4**	-23.55**	-10.20**	-24.73**	-21.98**	-39.25**	-24.47**	26.90*	27.84**	-24.92**	-6.00**	-5.17**	-5.17**
30.	**P_6 x P_5**	-10.72**	4.88**	-29.86**	-27.29**	14.22**	42.00**	-5.01	-4.31	53.99*	92.80**	128.22**	86.48**

* Significant at 5 per cent level; ** Significant at 1 per cent level

P_1 - Arka Chandan, P_2 – Ambili, P_3 - Arka Suryamukhi, P_4 - Pusa Vishwas, P_5 - CO 2, P_6 - CO 1

References

Doloi, N., Patel, J.N. and Acharya, R.R. (2018). Heterosis Studies in bottle gourd (*Lagenaria siceraria* (Mol) Standl). *Vegetos.,* **31**(1): 1-3.

Ghuge, M.R., Syamal, M. M. and Karcho, S. (2016). Heterosis in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.). *Int. J. Agric. Res* **50**: 466-470.

Hayes, J.D., Immer, F.F. and Smith, D.C. (1956). Methods of plant breeding. *McGraw Hill Book Publishing Company Inc.,* New Delhi.

Janaranjani, K.G., Kanthaswamy, V. and Ramesh, K. (2016). Heterosis, Combining Ability and Character Association in Bottle Gourd for Yield Attributes. *Int. J. Veg. Sci*., pp: 1- 26.

Kempthorne, O. (1957). An introduction to Genetic Statistics. *John Wiley and Sons, Inc*., New York.

Panse, V.G. and Sukhatme, P.V. (1957). Statistical Methods for Agricultural Workers. *Indian Council of Agricultural Research*, New Delhi. pp.97.

Rani, K. R., Raju, C.S. and Reddy, K.R. (2014). A study on heterosis for yield and earliness in bitter gourd. *Ind. J. Sci. Res. and Tech.*, **2**(3): 89-97.

Seshadri, V.S. and Parthasarathy, V.A. (2002). Cucurbits. In: Vegetable crops (Vol. I), Bose T.K.J. Kabir., T.K. Maithy, and V.A. Parthasarathy and M.G. Som (Eds) Naya prakash, Calcutta, India. pp. 493-648.

Singh, M.K., Singh, V.B., Yadav, G.C. and Kumar, P. (2019). Studies on variability, heritability (Narrow sense) and genetic advance analysis for growth, yield and quality traits in pumpkin (*Cucurbita moschata* Duch. ex. Poir). *J. Pharmacogn. Phytochem.,* **8**(3): 3621-3624.

Singh, S.K., Upadhyay, A. K., Pandey, J. and Pandey, A.K. (2012). Studies on heterosis and combining ability in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) for yield traits. *Ann. Hort* **5**: 246-251.

Thangamani, C. and Pugalendhi, L. (2013). Heterosis studies in bitter gourd for yield and related characters. *Intl. J. Veg. Sci.* **19**(2):109-125.

Yadav, Y. C and Kumar, S. (2012). Heterosis in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.). *Indian. J. Agric. Res.,* **50**: 466-470.