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Studies of genetic variability in bottle gourd [*Lagenaria siceraria* (Mol.) Standl]

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Abstract
In spite of being in cultivation since ancient times and wide germplasm availability, conscious evaluation and exploitation of germplasm in heterosis breeding has not been attended to until recently. Therefore, the present investigation was caried out to assess the performance of eight parents with their twenty-eight cross combinations and two checks (Pusa Naveen and Arka Bahar) conducted at Vegetable Research Centre, Department of Vegetable Science, G. B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand during the *kharif* season of 2021. Investigation results revealed that the mean sum of squares (MSS) due to genotypes were found to be highly significant for all the characters under studied where, the means data of yield (kg plant^{-1} and q ha^{-1}) revealed the maximum yield was observed in hybrids $P_3 \times P_8$ (12.27 kg plant^{-1}). The estimates of coefficients of variation revealed that magnitude of phenotypic coefficients of variation (PCV) was observe higher than the genotypic coefficient of variation (GCV) for all the characters. On the other hand, mostly all character showed high heritability coupled with high genetic advance where, fruit yield and its attributing characters (fruit length, fruit grith, number of fruits plant^{-1} and average fruit weight) had shown high heritability coupled with high genetic advance under the study which indicated that there are chances of getting improvement by practising selection.

Keywords: Bottle gourd, GCV, genetic advance, genotype, heritability, PCV

1. Introduction
Bottle gourd [*Lagenaria siceraria* (Mol.) Standl] is one of the most versatile cucurbitaceous crops belongs to the family Cucurbitaceae and subfamily Cucurbitoidae having the somatic chromosome 2n = 2x = 22. It is a fast-growing climbing plant which bears hard shelled and bottle shaped fruits and widely cultivated in tropics and subtropics. It is grown in both rainy and summer seasons and its fruits are available in the market throughout the year. Under North-Indian conditions, its cultivation is done in spring-summer and rainy seasons. India is endowed with the wealth of bottle gourd germplasm, comprising of both wild and cultivated species. In final estimate of NHB database 2020-21, India produced 3171.07 thousand metric tonnes of bottle gourd and Bihar is a leading producer (655.55 thousand metric tonnes) with maximum share (20.67%) of total share (APEDA Agri Exchange, 2021) [1]. Due to suitability of growing under limited irrigation and high yield potential, it is widely cultivated in North Konkan region and semi-arid area of Maharashtra.

In spite of being in cultivation since ancient times and wide germplasm availability, conscious evaluation and exploitation of germplasm in heterosis breeding has not been attended to until recently (Harika *et al.*, 2012) [5]. It is a highly cross-pollinated crop with wide genetic variability present within the cultivated varieties throughout the country. In India, no comprehensive systematic research has been done in this crop. The yield potentiality of this crop needs to be improved through an effective breeding program. Studies on the variations of yield and yield contributing characters are of great importance before planning a breeding program. As the yield and its components are quantitative characters, careful assessments of the amount of variation and their association must be analyzed to gain insight into the complexity of the mechanism. Therefore, the present study was planned to estimate the amount of genetic variability, heritability and path-coefficient analysis in the thirty-eight genotypes of bottle gourd for yield and its attributing traits.

2. Materials and Methods
The experimental material for the present study consisted of eight distinct genotypes and important varieties collected from different part of India.

The genotypes Pusa Sandesh (P_1), Pant Lauki-4 (P_2), Angad (P_3), Ghiya Hisar-22 (P_4), Gutka (P_5), Pusa Samridhi (P_6), Pant Lauki-3 (P_7) and Pusa Santusthi (P_8) were used as parents and mating of these parental lines was done in half-diallel fashion (Hayman, 1954) [6] during *zaid* season of 2021. The experiment was conducted in randomized complete block design with three replications to assess the performance of eight parents with their twenty-eight cross combinations and two checks (Pusa Naveen and Arka Bahar) conducted at Vegetable Research Centre, Department of Vegetable Science, G. B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand during the *kharif* season of 2021. The crop was planted in rows spaced at 3.0 meters with plant to plant spacing of 1.0 meter apart. All the recommended agronomic package of practices and plant protection measures were followed to raise a good crop. The observations were recorded on different agro morphological characters *i.e*., days to first staminate flower anthesis, days to first pistillate flower anthesis, node number at which first staminate flower appeared, node number at which first pistillate flower appeared, days to fifty percent flowering, sex ratio (male: female), days to first fruit picking, peduncle length (cm), fruit length (cm), fruit grith (cm), average fruit weight (g), number of fruits plant^{-1}, fruit yield (kg plant^{-1}), fruit yield (q ha^{-1}), vine length (m), number of primary branches plant^{-1}, dry matter (g 100 gm^{-1}), ascorbic acid (mg 100 g^{-1}), reducing sugar (%), non-reducing sugar (%), total sugar (%) and total soluble sugar (ºbrix).

The data were subjected to analysis of variance for randomized block design as suggested by Panse and Sukhatme (1967) [11] and genotypic and phenotypic coefficients of variance were estimated according to Burton and Devane (1953) [3] based on estimate of genotypic and phenotypic variance. The broad sense heritability (h2bs) was estimated by following the procedure suggested by Weber and Moorthy (1952) [14]. Expected genetic advance and genetic advance as percent of mean was estimated by the method proposed by Johnson *et al.* (1955). Statistical analysis was computed using SPSS professional version 13.0 and SAS 9.3 professional version.

3. Result and Discussion

3.1 Analysis of variance (ANOVA)

The perusal data of analysis of variance (ANOVA) for different characters are presented in table 1 and it revealed that the mean sum of squares (MSS) due to genotypes were found to be highly significant for all the characters under studied indicating the preponderance of sufficient genetic variability in the experimental material. The presence of genetic variability in experimental material is very important as sufficient variability indicates that there are chances of crop improvement by selection. For selection to be effective only the presence of variability is not enough but that variability must be heritable also. The presence of significant genetic variability in experimental material for different characters in bottle gourd was also reported by earlier researchers [Khot (2017), Usha and Reddy (2017), Kumar (2018), Kowsalya (2020) and Dubey *et al.* (2022)] [7, 13, 9, 8, 4].

3.2 Variation observed from mean value

The perusal means data of table 2 exposed the *per se* performance of eight parents, thirty-six hybrids and two check (Pusa Naveen & Arka Bhar) for various characters. The table 2 reveled that, means data of days to staminate flower anthesis revealed the range from 28.93 days (P_7) to 49.27 days ($P_1 \times P_2$) with overall mean value of 41.43 days, means data of days to pistillate flower anthesis revealed the range from 37.45 days ($P_5 \times P_6$) to 51.51 days ($P_4 \times P_7$) with overall mean value of 45.33 days, means data of node number at which first staminate flower appeared revealed the range from 4.21 ($P_5 \times P_6$) to 9.21 ($P_2 \times P_8$) with overall mean value of 6.60, means data of node number at which first pistillate flower appeared revealed the range from 8.67 ($P_2 \times P_5$ and $P_3 \times P_7$) to 15.67 (P_8 and $P_2 \times P_8$) with overall mean value of 12.04, means data of days to fifty per cent flowering revealed the range from 47.82 days ($P_1 \times P_3$ and $P_1 \times P_7$) to 56.61 days ($P_1 \times P_5$) and $P_3 \times P_4$ with overall mean value of 52.01 days, means data of sex ratio revealed the range from 5.90 ($P_1 \times P_5$) to 13.50 ($P_1 \times P_6$) with overall mean value of 9.58, means data of days to first fruit picking revealed the range from 52.37 days ($P_5 \times P_6$) to 65.91 days ($P_4 \times P_5$) with overall mean value of 59.30 days, means data of peduncle length revealed the range from 12.50 cm ($P_2 \times P_8$ and $P_4 \times P_6$) to 29.30 cm ($P_5 \times P_7$) with overall mean value of 18.24 cm, means data of fruit length revealed the range from 9.00 cm ($P_1 \times P_4$) to 48.00 cm ($P_3 \times P_8$) with overall mean value of 29.69 cm, means data of fruit girth revealed the range from 9.80 cm ($P_2 \times P_5$) to 65.11 cm (P_1) with overall mean value of 26.22 cm, means data of average fruit weight revealed the range from 504.48 g ($P_4 \times P_8$) to 1006.48 g ($P_2 \times P_7$) with overall mean value of 801.67 g, means data of yield kg plant^{-1} revealed the range from 3.78 kg plant^{-1} ($P_4 \times P_7$) to 12.27 kg plant^{-1} ($P_3 \times P_8$) with overall mean value of 8.87 kg plant^{-1}, means data of yield q ha^{-1} revealed the range from 126.00 q ha^{-1} ($P_4 \times P_7$) to 409.11 q ha^{-1} ($P_3 \times P_8$) with overall mean value of 295.72 q ha^{-1}, means data of vine length revealed the range from 7.83 m ($P_3 \times P_7$) to 15.17 m ($P_4 \times P_6$) with overall mean value of 11.57 m, means data of primary branches revealed the range from 3.20 (P_2) to 14.20 ($P_6 \times P_7$) with overall mean value of 9.14, means data of dry matter revealed the range from 2.76 mg 100g^{-1} ($P_5 \times P_8$) to 6.96 mg 100g^{-1} ($P_4 \times P_8$) with overall mean value of 4.67 mg 100g^{-1}, data of ascorbic acid mean revealed the range from 6.00 mg 100g^{-1} (P_6 and $P_1 \times P_3$) to 10.00 mg 100g^{-1} ($P_2 \times P_6$) with overall mean value of 8.21 mg 100g^{-1}, data of reducing sugar mean revealed the range from 1.75% ($P_4 \times P_8$) to 5.90% (P_4) with overall mean value of 3.49%, data of non-reducing sugar mean ranges from $P_4 \times P_7$ (0.18%) to $P_4 \times P_6$ (3.53%) with mean value of 1.30%, total sugar means ranges from $P_4 \times P_8$ (2.13%) to $P_2 \times P_7$ (7.26%) with mean value of 4.79% and total soluble sugar means ranges from P_3 (4.45 brixº) to P_8 (4.12 brixº) with mean value of 4.22 brixº.

3.3 Analysis of genetic variability, heritability, genetic advance and genetic advance as per cent mean

The estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense (h^2), genetic advance (G.A.) and genetic advance as per cent over mean (G.A.M.) were statistically analysed for different characters and are presented in table 3**.** The range of GCV varied from 4.74% (Days to first fruit picking) to 66.43% (non-reducing sugar). High genotypic coefficient (GCV) (> 20%) was observed in peduncle length (22.75%), fruit length (31.04%), fruit grith (39.42%), number of fruits plant^{-1} (22.34%), fruit yield plant^{-1}(20.97%), fruit yield ha^{-1} (20.97%), number of primary branches plant^{-1} (33.52%), dry matter (20.77%), reducing sugar (23.21%), non-reducing sugar (66.43%) and Total Sugar (25.35%). Moderate genotypic coefficient of variation (10-20%) was observed in days to first staminate flower anthesis (10.76%), node number at which first staminate flower appeared (17.78%), node number at which first pistillate flower appeared (15.71%), sex ratio (18.67%), average fruit weight (16.46), vine length (15.09), ascorbic acid (14.41%) and TSS (13.97%). Low genotypic coefficient of variation (<10%) was observed in days to first pistillate flower anthesis (7.25%), days to fifty percent flowering (4.89%) and days to first fruit picking (4.74). The range of PCV also varied from 5.20% (Days to first fruit picking) to 66.51% (non-reducing sugar). High phenotypic coefficient (PCV) (> 20%) was observed in Dry Matter (21.13%), Peduncle length (23.68%), Fruit yield plant-1 (23.98%), Fruit yield q ha-1 (23.98%), Reducing sugar (24.15%), Number of marketable fruits plant-1 (24.46%), Total Sugar (25.81%), Fruit length (32.23%), Number of primary branches plant-1 (34.00%), Fruit grith (41.26%) and Non-Reducing Sugar (66.51%). Moderate genotypic coefficient of variation (10-20%) was observed in Days to first staminate flower anthesis (11.22%), TSS (14.25%), Ascorbic acid (14.60%), Node number at which first pistillate flower appeared (15.93%), Average fruit weight (17.12%), Vine length (17.71%), Node number at which first staminate flower appeared (18.14%) and Sex ratio (19.37%). Low genotypic coefficient of variation (<10%) was observed in Days 1 fruit picking (5.20%), Days to fifty percent flowering (5.56%) and Days to first pistillate flower anthesis (7.63%).

In the experiment of *kharif* season 2021, the estimate of broad sense heritability ranged from 72.60% (vine length) to 99.93% (non-reducing sugar) and where the all characters were observed high heritability (>75%) except Vine length. In the experiment of *kharif* season 2021, genetic advance at five percent ranged from 1.28 (TSS) to 261.27 (Average fruit weight). Maximum values of genetic advance were observed for average fruit weight (261.27) followed by fruit yield q ha^{-1} (111.67). Moderate value of genetic advance was observed in Fruit length (18.28), Fruit grith (20.34) and all others characters were observed minimum value of genetic advance. In the experiment of *kharif* season 2021, genetic advance ranged from 8.86% (days to fifty percent flowering) to 136.37% (non-reducing sugar). All characters were observed maximum value of genetic advance as per cent of mean (>20%) except days to first pistillate flower anthesis (14.21%) which exposed moderate genetic advance as per cent of mean (10-20%) and days to fifty percent flowering (8.86%) and days first fruit picking (8.89%) were exposed the minimum value of genetic advance as per cent of mean (<10%).

These results were revealed that the mostly all character showed high heritability coupled with high genetic advance. It indicated that for those characters which observed under high heritability (>75%) coupled with high genetic advance (>20%) there are chances of getting improvement by practising selection. Fruit yield and its attributing characters (fruit length, fruit grith, number of fruits plant^{-1} and average fruit weight) had shown high heritability coupled with high genetic advance under the study. High heritability along with high genetic advance indicated the presence of additive gene action in governing the character and hence selection would be effective for improvement of such characters. Similar kind of studies was also done by other researchers in their experimental material [Usha and Reddy (2017), Mishra *et al.* (2019), Kowsalya (2020), Amangoua *et al.* (2018), Quamruzzaman *et al.* (2020) and Dubey *et al.* (2022)] [13, 10, 8, 2, 12, 4].

Table 1: Analysis of variance (ANOVA) for agro-morphological and biochemical traits in Bottle gourd

S. No.	Characters	Replication	Treatments	Error	CD (5%)	CV (%)
	Degree of Freedom	**2**	**37**	**74**		
1	Days to first staminate flower anthesis	4.44	61.40**	1.73	2.14	3.18
2	Days to first pistillate flower anthesis	1.00	33.57**	1.14	1.74	2.36
3	Node number at which first staminate flower appeared	0.11	4.18**	0.06	0.39	3.60
4	Node number at which first pistillate flower appeared	0.08	10.83**	0.10	0.51	2.61
5	Days to fifty percent flowering	2.07	21.30**	1.89	2.24	2.64
6	Sex ratio (Male: Female)	0.34	9.85**	0.25	0.81	5.18
7	Days to first fruit picking	0.73	25.28**	1.61	2.06	2.14
8	Peduncle length (cm)	9.85	53.10**	1.44	1.95	6.57
9	Fruit length (cm)	1.13	261.48**	6.67	4.20	8.70
10	Fruit grith (cm)	1.19	330.72**	10.21	5.20	12.18
11	Average fruit weight (g)	1129.46	53636.84**	1425.67	61.43	4.71
12	Number of fruits plant^{-1}	1.65	20.03**	1.24	1.82	9.96
13	Fruit yield (kg plant^{-1})	0.10	11.44**	1.07	1.68	11.64
14	Fruit yield (q ha^{-1})	116.16	12718.22**	1184.95	56.00	11.64
15	Vine length (m)	0.05	10.29**	1.15	1.74	9.27
16	Number of primary branches plant^{-1}	0.25	28.41**	0.27	0.84	5.68
17	Dry matter (g 100 gm^{-1})	0.23	3.28**	0.04	0.31	3.86
18	Ascorbic acid (mg 100 g^{-1})	0.09	4.23**	0.04	0.32	2.38
19	Reducing sugar (%)	0.04	2.02**	0.05	0.38	6.66
20	Non-reducing sugar (%)	0.00	2.24**	0.00	0.07	3.34
21	Total sugar (%)	0.04	4.47**	0.05	0.38	4.86
22	Total soluble sugar (°brix)	0.01	1.22**	0.02	0.21	2.79

*****Significant at P = 0.05; **Significant at P = 0.01

Table 2: *Per se* performance of parents and hybrids for agro-morphological and biochemical traits in bottle gourd during *kharif*, 2021

S. No.	Genotypes	D1MF	D1FF	1NMF	1NFF	50% FL	SR (M/F)	D1FP	PL	FL	FG	AFW
Parents												
1	P_1	45.69	47.36	7.99	9.26	48.80	7.85	59.06	21.20	11.80	65.11	726.10
2	P_2	42.37	46.36	5.74	11.20	53.68	11.47	57.51	16.50	37.40	20.45	627.29
3	P_3	40.43	46.40	7.88	13.00	49.78	8.93	62.70	18.60	32.30	22.86	895.72
4	P_4	43.40	45.33	5.83	12.11	51.73	9.25	55.76	22.00	22.40	27.11	763.39
5	P_5	39.27	42.33	5.55	14.67	48.80	8.36	62.64	21.50	40.80	20.91	752.29
6	P_6	36.17	39.94	6.63	14.42	50.75	9.54	57.45	19.70	29.50	25.99	836.60
7	P_7	28.93	38.39	7.40	12.01	49.77	7.83	57.95	14.50	39.00	28.91	871.50
8	P_8	38.23	40.33	7.46	15.67	52.70	8.68	55.45	20.20	26.40	42.07	866.37
	Mean	39.31	43.31	6.81	12.79	50.75	8.99	58.57	19.28	29.95	31.68	792.41
Hybrids												
1	$P_1 \times P_2$	49.27	50.88	6.63	13.33	54.65	9.38	62.68	16.80	26.00	21.31	760.24
2	$P_1 \times P_3$	48.57	50.15	6.09	9.67	47.82	7.83	58.87	14.40	27.70	25.72	644.98
3	$P_1 \times P_4$	44.43	46.27	6.55	13.67	49.78	8.98	57.12	25.00	9.00	43.20	937.56
4	$P_1 \times P_5$	43.40	46.37	8.05	13.11	56.61	5.90	58.53	20.80	20.40	30.09	989.91
5	$P_1 \times P_6$	40.30	43.27	7.55	11.68	48.80	13.50	60.58	21.30	14.20	47.92	607.66
6	$P_1 \times P_7$	45.47	50.49	6.22	13.67	47.82	8.33	61.19	17.10	26.70	26.98	954.03
7	$P_1 \times P_8$	43.40	46.36	5.53	12.23	55.63	8.47	58.45	18.30	13.00	45.59	951.32
8	$P_2 \times P_3$	46.33	48.42	6.24	10.67	50.75	9.78	60.45	12.50	30.00	19.62	749.70
9	$P_2 \times P_4$	41.17	44.30	7.55	12.33	51.73	12.75	56.87	15.00	41.00	25.15	686.23
10	$P_2 \times P_5$	34.93	40.82	5.16	8.67	49.77	11.24	57.06	20.50	38.80	9.80	825.30
11	$P_2 \times P_6$	42.20	43.27	6.01	14.33	54.66	8.01	55.45	19.70	45.20	21.69	934.92
12	$P_2 \times P_7$	39.26	46.90	8.55	11.00	53.68	9.28	63.42	27.60	34.00	33.25	1006.48
13	$P_2 \times P_8$	39.95	44.30	9.21	15.67	54.66	9.97	60.45	12.50	23.50	18.84	848.46
14	$P_3 \times P_4$	35.13	44.27	8.88	11.33	56.61	10.79	61.70	15.80	40.40	21.22	837.96
15	$P_3 \times P_5$	40.30	46.36	5.74	10.67	53.68	8.66	61.42	17.30	28.40	16.77	824.38
16	$P_3 \times P_6$	41.33	44.30	7.00	12.67	54.66	7.69	57.50	19.50	26.60	17.23	657.12
17	$P_3 \times P_7$	38.23	41.21	5.69	8.67	48.80	10.50	56.37	16.10	16.60	21.59	965.45
18	$P_3 \times P_8$	41.34	47.40	7.53	10.67	48.80	13.18	57.86	15.00	48.00	22.73	737.33
19	$P_4 \times P_5$	45.47	48.43	8.55	10.15	51.73	11.69	65.91	12.80	32.20	28.54	724.27
20	$P_4 \times P_6$	44.43	45.87	6.03	9.25	55.63	9.80	55.45	12.50	30.00	25.93	674.35
21	$P_4 \times P_7$	47.53	51.51	5.94	10.84	55.63	7.08	64.91	14.80	26.30	18.78	589.14
22	$P_4 \times P_8$	46.50	49.45	5.88	9.00	50.75	9.46	60.53	19.30	29.10	18.19	504.48
23	$P_5 \times P_6$	29.97	37.45	4.21	14.25	48.80	7.49	52.37	13.40	38.20	16.59	859.35
24	$P_5 \times P_7$	44.43	48.43	4.55	11.62	55.63	9.48	59.79	29.30	39.50	17.20	962.30
25	$P_5 \times P_8$	44.43	46.36	5.66	12.23	53.68	13.11	58.45	26.20	32.00	31.74	835.40
26	$P_6 \times P_7$	39.27	44.30	5.72	14.23	52.70	9.91	58.53	19.20	25.60	21.16	671.20
27	$P_6 \times P_8$	41.33	44.97	6.44	13.76	50.75	12.43	62.64	20.70	34.60	21.42	583.90
28	$P_7 \times P_8$	37.20	43.27	7.19	12.48	51.73	9.25	61.78	16.30	39.80	27.22	965.09
	Mean	41.98	45.91	6.58	11.85	52.35	9.78	59.51	18.20	29.89	24.84	796.02
Checks												
1	Pusa Naveen	41.33	44.30	5.93	11.23	53.68	10.24	60.36	15.44	25.20	24.56	881.41
2	Arka bahar	43.07	46.36	6.03	11.93	50.75	8.09	58.14	13.70	26.78	23.08	954.35
	Mean	41.43	45.33	6.60	12.04	52.01	9.58	59.30	18.24	29.69	26.22	801.67
	C.V. (%)	3.18	2.36	3.60	2.61	2.64	5.18	2.14	6.57	8.70	12.18	4.71
	S.Em+	0.76	0.62	0.14	0.18	0.79	0.29	0.73	0.69	1.49	1.84	21.80
	C.D. (5%)	2.14	1.74	0.39	0.51	2.24	0.81	2.06	1.95	4.20	5.20	61.43
	C.D. (1%)	2.84	2.31	0.51	0.68	2.97	1.07	2.74	2.59	5.58	6.90	81.51

Where, P: Parent, P_1: Pusa Sandesh, P_2: Pant Lauki-4, P_3: Angad, P_4: Ghiya Hisar-22, P_5: Gutka, P_6: Pusa Samridhi, P_7: Pant Lauki-3, P_8: Pusa Santusthi, D1MF: Days to first staminate flower anthesis, D1FF: Days to first pistillate flower anthesis, 1NMF: Node number at which first staminate flower appeared, 1NFF: Node number at which first pistillate flower appeared, 50% FL: Days to fifty percent flowering, SR (M/F): Sex ratio (Male: Female), D1FP: Days to first fruit picking, PL: Peduncle length (cm), FL: Fruit length (cm), FG: Fruit grith (cm), AFW: Average fruit weight (g), NFP^{-1}: Number of fruits plant^{-1}, Y (KG P-1): Fruit yield (kg plant^{-1}), Y (Q HA-1): Fruit yield (q ha^{-1}), VL: Vine length (m), PBP^{-1}: Number of primary branches plant^{-1}, DM: Dry matter (g 100 gm^{-1}), AA: Ascorbic acid (mg 100 g^{-1}), RS: Reducing sugar (%), NRS: Non-reducing sugar (%), TS: Total sugar (%), TSS: Total soluble sugar (^{o}brix)

Table 2: Cont…

S. No.	Genotypes	NFP^{-1}	Y (KG P^{-1})	Y (Q HA^{-1})	VL	PBP^{-1}	DM	AA	RS	NRS	TS	TSS
Parents												
1	P_1	9.84	8.23	274.22	11.47	4.80	6.33	8.10	3.92	0.88	4.80	4.23
2	P_2	10.90	9.61	320.33	9.70	3.20	4.41	8.10	2.46	0.83	3.29	4.40
3	P_3	14.50	9.09	303.00	14.72	12.80	4.21	9.80	3.30	0.94	4.24	4.45
4	P_4	10.41	7.95	264.92	13.07	5.60	5.01	8.10	5.90	1.54	7.44	3.83
5	P_5	10.56	7.94	264.61	13.90	11.20	3.25	7.90	4.00	0.63	4.63	5.01
6	P_6	10.01	8.97	298.85	11.44	7.20	6.05	6.00	4.61	0.26	4.87	3.96
7	P_7	9.90	8.61	287.13	9.76	8.80	3.86	8.00	4.03	0.79	4.82	3.72
8	P_8	10.64	9.50	316.55	11.34	8.00	5.05	8.28	4.16	1.32	5.48	4.12
	Mean	10.84	8.74	291.20	11.93	7.70	4.77	8.04	4.05	0.90	4.95	4.22
Hybrids												
1	$P_1 \times P_2$	9.07	7.08	236.11	8.64	10.40	5.17	7.90	3.14	0.52	3.66	4.12
2	$P_1 \times P_3$	7.29	4.75	158.33	12.41	12.00	5.36	6.00	2.87	1.21	4.08	3.83
3	$P_1 \times P_4$	11.27	10.63	354.21	9.28	7.20	6.96	6.10	3.72	1.46	5.18	4.23
4	$P_1 \times P_5$	7.55	7.38	246.11	11.20	14.40	5.68	7.20	2.47	0.87	3.34	3.64
5	$P_1 \times P_6$	14.66	8.83	294.22	12.57	11.20	4.72	8.00	4.10	1.05	5.15	4.13
6	$P_1 \times P_7$	10.67	10.03	334.34	9.28	13.60	4.12	7.10	3.73	1.05	4.78	4.10
7	$P_1 \times P_8$	10.66	10.18	339.34	11.68	4.80	5.32	7.10	3.60	3.14	6.74	3.89
8	$P_2 \times P_3$	12.64	9.24	307.97	12.64	8.80	5.56	9.00	3.67	1.67	5.34	4.33
9	$P_2 \times P_4$	16.10	11.04	368.11	9.25	7.20	4.04	8.90	2.28	0.46	2.74	4.68
10	$P_2 \times P_5$	13.99	11.71	390.36	10.78	11.20	6.96	8.00	3.40	1.90	5.30	4.63
11	$P_2 \times P_6$	7.54	7.09	236.43	12.70	13.60	5.44	10.00	3.60	0.31	3.91	4.10
12	$P_2 \times P_7$	11.71	11.79	393.11	12.48	7.20	6.92	9.80	4.53	2.73	7.26	5.12
13	$P_2 \times P_8$	12.57	10.68	356.11	11.33	13.60	5.04	7.20	3.10	0.45	3.55	5.08
14	$P_3 \times P_4$	13.63	11.42	380.67	11.19	8.00	5.36	7.90	4.06	1.75	5.81	4.95
15	$P_3 \times P_5$	10.93	9.01	300.38	13.94	12.00	4.84	8.10	3.34	1.25	4.59	5.18
16	$P_3 \times P_6$	9.72	6.38	212.66	10.96	4.80	4.68	8.90	4.00	1.23	5.23	5.08
17	$P_3 \times P_7$	8.88	8.57	285.55	7.83	7.20	3.80	8.20	3.50	1.86	5.36	5.88
18	$P_3 \times P_8$	16.65	12.27	409.11	12.03	6.40	4.64	8.10	4.14	1.95	6.09	6.28
19	$P_4 \times P_5$	14.77	10.69	356.37	14.48	12.00	5.20	8.10	2.34	3.36	5.70	4.67
20	$P_4 \times P_6$	8.58	5.79	193.00	12.29	4.80	4.96	9.80	2.94	3.53	6.47	5.47
21	$P_4 \times P_7$	6.42	3.78	126.00	12.46	7.20	3.56	8.90	3.64	0.18	3.82	4.03
22	$P_4 \times P_8$	11.95	6.03	201.00	15.17	9.60	6.96	9.90	1.75	0.38	2.13	4.56
23	$P_5 \times P_6$	9.47	8.13	271.02	8.43	8.80	5.08	9.80	3.60	0.31	3.91	5.13
24	$P_5 \times P_7$	8.18	7.87	262.32	11.84	11.20	3.48	9.80	3.40	1.32	4.72	5.06
25	$P_5 \times P_8$	14.04	11.72	390.67	8.97	10.40	2.76	6.00	4.30	1.98	6.28	4.23
26	$P_6 \times P_7$	12.51	8.40	280.00	11.04	14.40	4.32	7.10	1.80	0.67	2.47	3.74
27	$P_6 \times P_8$	15.70	9.17	305.67	11.02	7.20	6.24	8.00	3.70	1.07	4.77	3.46
28	$P_7 \times P_8$	9.48	9.14	304.67	13.68	12.00	4.36	9.80	3.40	1.87	5.27	4.78
	Mean	11.31	8.89	296.21	11.41	9.69	5.05	8.24	3.36	1.41	4.77	4.59
Checks												
1	Pusa Naveen	12.44	9.03	300.89	10.56	6.40	5.54	7.20	2.29	2.17	4.46	5.00
2	Arka bahar	9.84	9.39	313.11	14.10	8.00	4.89	9.80	3.80	1.54	4.27	4.84
	Mean	11.20	8.87	295.72	11.57	9.14	5.00	8.21	3.49	1.30	4.79	4.53
	C.V. (%)	9.96	11.64	11.64	9.27	5.68	3.86	2.38	6.66	3.34	4.86	2.79
	S.Em+	0.64	0.60	19.87	0.62	0.30	0.11	0.11	0.13	0.03	0.13	0.07
	C.D. (5%)	1.82	1.68	56.00	1.74	0.84	0.31	0.32	0.38	0.07	0.38	0.21
	C.D. (1%)	2.41	2.23	74.31	2.31	1.12	0.42	0.42	0.50	0.09	0.50	0.27

Where, P: Parent, P_1: Pusa Sandesh, P_2: Pant Lauki-4, P_3: Angad, P_4: Ghiya Hisar-22, P_5: Gutka, P_6: Pusa Samridhi, P_7: Pant Lauki-3, P_8: Pusa Santusthi, D1MF: Days to first staminate flower anthesis, D1FF: Days to first pistillate flower anthesis, 1NMF: Node number at which first staminate flower appeared, 1NFF: Node number at which first pistillate flower appeared, 50% FL: Days to fifty percent flowering, SR (M/F): Sex ratio (Male: Female), D1FP: Days to first fruit picking, PL: Peduncle length (cm), FL: Fruit length (cm), FG: Fruit grith (cm), AFW: Average fruit weight (g), NFP^{-1}: Number of fruits plant^{-1}, Y (KG P-1): Fruit yield (kg plant^{-1}), Y (Q HA-1): Fruit yield (q ha^{-1}), VL: Vine length (m), PBP^{-1}: Number of primary branches plant^{-1}, DM: Dry matter (g 100 gm^{-1}), AA: Ascorbic acid (mg 100 g^{-1}), RS: Reducing sugar (%), NRS: Non-reducing sugar (%), TS: Total sugar (%), TSS: Total soluble sugar (^{o}brix)

Table 3: Genetic variability, heritability and genetic advance for agro-morphological and biochemical traits in Bottle gourd

S. No.	Characters	GCV	PCV	h²	G. A.	G. A. M.
		2021	2021	2021	2021	2021
1	Days to first staminate flower anthesis	10.76	11.22	92.00	8.81	21.27
2	Days to first pistillate flower anthesis	7.25	7.63	90.45	6.44	14.21
3	Node number at which first staminate flower appeared	17.78	18.14	96.10	2.37	35.89
4	Node number at which first pistillate flower appeared	15.71	15.93	97.30	3.84	31.93
5	Days to fifty percent flowering	4.89	5.56	77.40	4.61	8.86
6	Sex ratio (Male: Female)	18.67	19.37	92.90	3.55	37.05
7	Days to first fruit picking	4.74	5.20	83.00	5.27	8.89
8	Peduncle length (cm)	22.75	23.68	92.30	8.21	45.03
9	Fruit length (cm)	31.04	32.23	92.70	18.28	61.57
10	Fruit grith (cm)	39.42	41.26	91.30	20.34	77.57
11	Average fruit weight (g)	16.46	17.12	92.40	261.27	32.59
12	Number of fruits plant^{-1}	22.34	24.46	83.40	4.71	42.04
13	Fruit yield (kg plant^{-1})	20.97	23.98	76.40	3.35	37.76
14	Fruit yield (q ha^{-1})	20.97	23.98	76.40	111.67	37.76
15	Vine length (m)	15.09	17.71	72.60	3.07	26.49
16	Number of primary branches plant^{-1}	33.52	34.00	97.20	6.22	68.08
17	Dry matter (g 100 gm^{-1})	20.77	21.13	96.70	2.11	42.07
18	Ascorbic acid (mg 100 g^{-1})	14.41	14.60	97.30	2.40	29.28
19	Reducing sugar (%)	23.21	24.15	92.40	1.60	45.96
20	Non-reducing sugar (%)	66.43	66.51	99.93	1.78	136.67
21	Total sugar (%)	25.35	25.81	96.50	2.46	51.29
22	Total soluble sugar (°brix)	13.97	14.25	96.20	1.28	28.23

Where, GCV: Genotypic coefficient of variation, PCV: Phenotypic coefficient of variation, h²: Heritability in broad Sense, G. A.: Genetic advance, G. A. M.: Genetic advance as per cent over mean

4. Conclusion

The knowledge of genetic variability is pre-requisite for improvement in any breeding programme. For development of superior genotype, more diverse breeding population are needed. The present study, concluded that the all genotypes have sufficient amount of genetic variability for all characters. Where, the genotype $P_3 \times P_8$ was observed best for yield. Therefore, these genotypes have ample scope for varietal development and can be used for improvements in Bottle gourd germplasms through heterosis breeding.

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