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STUDY OF GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE FOR YIELD RELATED TRAITS IN BOTTLE GOURD (*LAGENARIA SICERARIA* MOL. STANDL.)

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ABSTRACT

The present study investigated genetic variability, heritability, and genetic advance in parents and hybrids for thirteen key traits. Analysis of variance (ANOVA) revealed significant differences among the genotypes, indicating sufficient variability for selection and yield improvement. The mean performance of parents and hybrids varied across traits, with notable differences in flowering time, vine length, fruit characteristics, and yield-related traits. Genetic variability analysis demonstrated high genetic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for fruit yield per plant (20.10% and 20.38%, respectively), supporting its potential for selection. Moderate variability was observed for traits such as node number to first flower appearance, fruit circumference, and vine length. The study recorded high heritability for most traits, ranging from 85.02% to 96.22%, suggesting that these traits are primarily controlled by genetic factors with limited environmental influence. Genetic advance estimates ranged from 3.32 to 40.20, with fruit yield per plant exhibiting the highest genetic advance, followed by fruit circumference and node number to first staminate flower appearance. Traits with moderate genetic advance indicated the presence of non-additive gene action. The findings suggest that selection for high-yielding hybrids can be effectively conducted based on heritability and genetic advance values, thus contributing to the enhancement of crop productivity.
***Keywords*:** Genetic variability, Heritability, Genetic advance, Analysis of Variance, GCV, PCV.

Introduction

Bottle gourd [*Lagenaria siceraria* (Molina) Standl.] is widely cultivated in sub-Saharan Africa (SSA) for multiple uses (Abdin *et al.*, 2014; Gürcan *et al.*, 2015; Mashilo *et al.*, 2015). It is grown for its young and succulent leaves and young fruit which are consumed as cooked vegetable (Morimoto and Mvere, 2004; Hart, 2011; Mashilo *et al.*, 2017). The leaves contain various micro-and macro elements and phytochemical compounds beneficial to human health. Therefore, genotypes with high leaf and fruit yields are preferred for vegetable production. Young and immature fruits of bottle gourd are highly preferred in semi-urban and urban areas as fruit vegetable. The dried fruit of bottle gourd has a hardshell which is ideal for making custom-made containers for decoration and other household uses. For instance, a dried fruit with neck length varying between 8 and 15 cm is valued for making containers to serve traditional beer or water. Also, designer decorative materials are prepared from dried fruits which are widely used in celebration of traditional ceremonies. Small to large oval fruits with thick rind (i.e., 2cm) and fruit neck length of 3 cm is used to prepare decorations and containers. Immature and ripening seeds are consumed with young fruit. The seeds are rich sources of protein, amino acids, and essential micro and-macro elements with health-promoting benefits (Ojiako and Igwe, 2007; Said *et al.*, 2014; Sithole *et al.*, 2015). The number of seeds per fruit is highly variable amongst bottle gourd genotypes (Morimoto *et al.*, 2005) providing opportunities for genotype selection with high seed yield potential.

Dried seeds of bottle gourd are mainly used as roasted snack. Also, commercial uses of the crop (e.g., as a rootstock for watermelon production) is not known in the region limiting the development of bottle gourd as functional food and commercial crop. There are no improved cultivars released in the region for food, feed, value-adding, and for rootstock in watermelon production.

There is need for concerted and collaborative research efforts on bottle gourd among plant breeders, agronomists, geneticists in the region and internationally. This will enable knowledge and germplasm sharing and innovative research to design, develop and release promising and well-adapted bottle gourd cultivars. The next generation of bottle gourd cultivars should encompass product profiles including quality of fruit, nutritional compositions to serve varied value chains the food industry.

Genetic diversity is the range of different inherited traits within a species, which is the prerequisite of the breeding program. Genetic diversity leads to the selection of superior cultivars and their traits. These examples showed that genetic diversity is necessary to develop high yielding genotypes. Genetic diversity between the parental lines increases heterosis, whereas genetic homogeneity between the two parents results in phenotypically uniform F_1 progeny (Liu *et al.*, 2021). The components of genetic variability like h2 and genetic advance (GA) are essential biometric tools for assessing dissimilarity in population for making a selection (Akhter *et al.*, 2021). Narayan *et al.* (1996) studied the higher PCV and GCV for yield and yield-related traits in bottle gourd hybrids and indicated the role of genetic variability in plant selection. This paper provides sound results regarding exploring genetic diversity among bottle gourd genotypes and their hybrids. This can be useful to conduct future studies to identify the high-performing bottle gourd genotypes.

Materials and Methods

The F_1s and parents were evaluated under a randomized complete block design with three replications at the Main Experimental Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, during the Zaid seasons of 2024 and 2025. Geographically, the experimental site falls under a humid subtropical climate and is located between 24.47º and 26.56ºN latitude, and 82.12º and 83.58ºE longitude, at an altitude of 113 meter above mean sea level. The soil type at the experimental site was sandy-loam with an average fertility level and a pH range is varied from 6.5-8.5. Based on their diversity and elite status for different economically important traits, nine promising genotypes was selected for use in the crossing program (Table 1). Crosses were made using a half-diallel mating design, including all possible combinations except reciprocals. A total 36 hybrids, along with their respective parents (obtained by selfing), were harvested separately and raised in a randomized complete block design with three replications. All recommended package practices were followed.

Table 1 : List of parents and hybrids used in the study

Parents	Hybrids	Hybrids	Hybrids	Hybrids
Narendra Kamna (P_1)	P_1×P_2	P_2×P5	P3×P9	P6×P7
Narendra Rashmi (P_2)	P_1×P_3	P2×P6	P4×P5	P6×P8
NDBG-619 (P_3)	P_1×P_4	P2×P7	P4×P6	P6×P9
NDBG-83-1 (P_4)	P_1×P_5	P2×P8	P4×P7	P7×P8
Narendra Pooja (P_5)	P_1×P_6	P2×P9	P4×P8	P7×P9
Pant Lauki-$_3$ (P_6)	P_1×P_7	P3×P4	P4×P9	P8×P9
Kashi Ganga (P_7)	P_1×P_8	P3×P5	P5×P6	
Arka Bahar (P_8)	P_1×P_9	P3×P6	P5×P7	
Pusa Naveen (P_9)	P_2×P_3	P3×P7	P5×P8	
Sarita (check)	P_2×P_4	P3×P8	P5×P9	

Statistical analysis

The analysis of variance (ANOVA) for yield-related parameters was carried out using the procedure proposed by Steel and Torrie (1960). The significance level was checked using 5% and 1% probability. The ANOVA was calculated using MSTAT-C software. The values of parents and hybrids were subjected to ANOVA, and a significance level was observed for all traits. ANOVA showed the level of significance for given traits. Likewise, GCV and PCV indicated a significant amount of variability among the genotypes for all the studied characteristics as calculated using the method of Hallauer *et al.* (2010). Genetic advance and h^2 were determined using the method of Hanson *et al.* (1956). Principal component analysis (PCA) for the major traits was carried out using PAST software to simplify the complexity in high-dimensional data while retaining trends and patterns. Pie charts were also made using PAST software. Pearson coefficient analysis was calculated using IBM SPSS 20.

Results

ANOVA indicated the significant differences among the parents and hybrids for all the studied characters. These differences indicated the existence of variability in germplasm and offered opportunities for the improvement of yield and yield related traits via selection (Table 2). The per se performance of parents and hybrids, along with the ranges and grand mean of the pooled data for all thirteen traits, is presented in Table 3. The results are described below under the following headings. Days to first staminate flower anthesis ranged from 46.75 to 55.42 for parents and 47.08 to 56.75 for hybrids. P_4 (46.75) found maximum for days to first steminate flower anthesis among the parents which was followed by P_5 (47.42), P_2 (48.42), P_6 (48.75) and P_9 (49.08). The best F_1 hybrid for days to first steminate flower anthesis was recorded for cross $P_5 \times P_6$ (47.08) followed by $P_1 \times P_2$ and $P_2 \times P_4$ (47.75), $P_3 \times P_6$ and $P_6 \times P_9$ (48.08). Averages over the parental mean (49.49) and averages over the F_1 hybrid mean (50.69) were more or less of the same order, days to first pistillate flower anthesis ranged from 54.75 to 62.50 for parents and 53.92 to 63.75 for hybrids. P_4 (54.75) found maximum for days to first pistillate flower anthesis among the parents which was followed by P_6 (56.08), P_5 (56.33), P_7 (56.83) and P_3 (57.08). The best F_1 hybrid for days to first pistillate flower anthesis was recorded for cross $P_3 \times P_6$ (53.92) followed by $P_1 \times P_2$ (54.67) and $P_2 \times P_4$ and $P_6 \times P_9$ (55.83) and $P_5 \times P_6$ (56.17). Averages over the parental mean (57.47) and averages over the F_1 hybrid mean (58.94) were more or less of the same order, node number to first staminate flower appearance ranged from 5.62 to 10.39 for parents and 5.97 to 10.77 for hybrids. P_5 (5.62) found maximum for node number to first staminate flower appearance among the parents which was followed by P_6 (5.95), P_7 (5.97), P_2 (6.13) and P_4 (6.24). The best F_1 hybrid for node number to first staminate flower appearance was recorded for cross $P_3 \times P_6$ (5.97) followed by $P_2 \times P_4$ (6.33), $P_1 \times P_2$ (6.48), $P_6 \times P_9$ (6.68) and $P_5 \times P_6$ (6.87). Averages over the parental mean (7.47) and averages over the F_1 hybrid mean (8.42) were more or less of the same order, node number to first pistillate flower appearance ranged from 12.45 to 16.89 for parents and 12.47 to 17.27 for hybrids. P_6 (12.45) found minimum for node number to first pistillate flower appearance among the parents which was followed by P_5 (12.46), P_7 (12.47), P_2 (12.66) and P_4 (12.74). The best F_1 hybrid for node number to first pistillate flower appearance was recorded for cross $P_3 \times P_6$ (12.47) followed by $P_2 \times P_4$ (12.83), $P_1 \times P_2$ (12.98), $P_6 \times P_9$ (13.18) and $P_5 \times P_6$ (13.37). The averages of the parental mean (14.01) and the F_1 hybrid mean (14.93) were approximately similar in order, vine length ranged from 3.39 to 6.69 for parents and 4.59 to 6.76 for hybrids. P_8 (6.69) found maximum for vine length among the parents which was followed by P_1 (6.44), P_7 (6.36), P_5 (6.33) and P_3 (6.16). The best F_1 hybrid for vine length was recorded for cross $P_2 \times P_3$ (6.76) followed by $P_1 \times P_7$ (6.71), $P_4 \times P_5$ (6.66), $P_1 \times P_3$ (6.64) and $P_2 \times P_5$ (6.64). The averages of the parental mean (5.88) and the F_1 hybrid mean (6.14) were approximately similar in order, vine length ranged from 3.39 to 6.69 for parents and 4.59 to 6.76 for hybrids. P_8 (6.69) found maximum for vine length among the parents which was followed by P_1 (6.44), P_7 (6.36), P_5 (6.33) and P_3 (6.16). The best F_1 hybrid for vine length was recorded for cross $P_2 \times P_3$ (6.76) followed by $P_1 \times P_7$ (6.71), $P_4 \times P_5$ (6.66), $P_1 \times P_3$ (6.64) and $P_2 \times P_5$ (6.64). The averages of the parental mean (5.88) and the F_1 hybrid mean (6.14) were approximately similar in order, Internodal length ranged from 7.48 to 10.83 for parents and 9.02 to 11.43 for hybrids. P_1 (7.48) found minimum for Internodal length among the parents which was followed by P_3 (9.07), P_6 and P_8 (9.32) and P_2 (9.95). The best F_1 hybrid for Internodal length was recorded for cross $P_2 \times P_9$ (9.02) followed by $P_1 \times P_5$ (9.13), $P_4 \times P_9$ (9.15), $P_1 \times P_2$ (9.23) and $P_1 \times P_7$ (9.30). The averages of the parental mean (9.60) and the F_1 hybrid mean (10.28) were approximately similar in order, days to first fruit harvest ranged from 63.42 to 71.17 for parents and 62.58 to 72.42 for hybrids. P_4 (63.42) found minimum for days to first fruit harvest among the parents which was followed by P_6 (64.75), P_5 (64.83), P_8 (65.50) and P_3 (65.75). The best F_1 hybrid for days to first fruit harvest was recorded for cross $P_3 \times P_6$ (62.58) followed by $P_1 \times P_2$ (63.33), $P_2 \times P_4$, $P_6 \times P_9$ (64.50) and $P_5 \times P_6$ (64.83). The averages of the parental mean (66.10) and the F_1 hybrid mean (67.65) were approximately similar in order, fruit length ranged from 28.73 to 41.23 for parents and 30.23 to 42.60 for hybrids. P_2 (41.23) found maximum for fruit length among the parents which was followed by P_5 (40.87), P_6 (39.70), P_9 (38.53) and P_4 (37.68). The best F_1 hybrid for fruit length was recorded for cross $P_6 \times P_9$ (42.60) followed by $P_5 \times P_8$ (42.47), $P_6 \times P_8$ (41.87), $P_2 \times P_5$ (41.67) and $P_1 \times P_3$ (41.63). The averages of the parental mean (36.59) and the F_1 hybrid mean (37.65) were approximately similar in order, fruit circumference ranged from 5.782 to 7.23 for parents and 5.18 to 10.25 for hybrids. P_9 (7.23) found maximum for Fruit circumference among the parents which was followed by P_5 (6.77), P_2 (6.73), P_3 (6.17) and P_8 (6.15). The best F_1 hybrid for Fruit circumference was recorded for cross $P_4 \times P_8$ (10.25) followed by $P_4 \times P_9$ (10.12), $P_2 \times P_8$ (9.85), $P_5 \times P_8$ (9.52) and $P_4 \times P_7$ (9.22). The averages of the parental mean (6.33) and the F_1 hybrid mean (7.19) were approximately similar in order, average fruit weight ranged from 0.96 to 1.08 for parents and 0.89 to 1.35 for hybrids. P_7 (1.08) found maximum for average fruit weight among the parents which was followed by P_5 (1.06), P_4 and P_6 (1.05) and P_1 (1.02). The best F_1 hybrid for average fruit weight was recorded for cross $P_2 \times P_5$ (1.35) followed by $P_2 \times P_8$ (1.27), $P_3 \times P_4$ (1.22), $P_7 \times P_9$ and $P_1 \times P_8$ (1.18). The averages of the parental mean (1.02) and the F_1 hybrid mean (1.05) were approximately similar in order, number of fruits per plant ranged from 3.42 to 4.71 for parents and 3.27 to 5.32 for hybrids. P_2 (4.71) found maximum for number of fruits per plant among the parents which was followed by P_6 (4.58), P_5 (4.45), P_3 and P_7 (4.44). The best F_1 hybrid for number of fruits per plant was recorded for cross $P_5 \times P_8$ (5.32) followed by $P_2 \times P_9$ (5.31), $P_4 \times P_6$ (5.29), $P_1 \times P_4$ (5.21) and $P_6 \times P_9$ (5.08). The averages of the parental mean (4.27) and the F_1 hybrid mean (4.32) were approximately similar in order and fruit yield per plant ranged from 3.59 to 4.81 kg for parents and 3.08 to 6.65 kg for hybrids. Pant Lauki-3 (4.81kg) found maximum for Fruit yield per plant (%) among the parents which was followed by Kashi Ganga (4.80kg), Narendra Pooja (4.72kg), Narendra Rashmi (4.57kg) and Pusa Naveen (4.50kg). The best F_1 hybrid for Fruit yield per plant (%) was recorded for cross $P_2 \times P_5$ (6.65kg), followed by $P_1 \times P_8$ (5.71 kg). $P_6 \times P_9$ (5.63 kg), $P_2 \times P_8$ (5.62kg) and $P_3 \times P_7$ (5.55 kg). Averages over the parental mean (4.36 kg) and averages over the F_1 hybrid mean (4.37 kg) were more or less of the same order.

Table 3 : Mean performance for parents and hybrids

S. No.	Parent/Hybrids	DFSFA	DFPFA	NNFSFA	NNFPFA	NPBPP	VL (m)	IL (cm)	DFFH	FL (cm)	FC (cm)	AFW (kg)	NFPP	FYPP (kg)
							Parents							
1	Narendra Kamna (P1)	49.42	58.25	8.76	15.26	8.99	6.44	7.48	66.92	28.73	5.72	1.02	4.25	4.34
2	Narendra Rashmi (P2)	48.42	57.50	6.13	12.66	8.82	6.01	9.95	66.17	41.23	6.73	0.97	4.71	4.57
3	NDBG-619 (P3)	50.08	57.08	8.23	14.73	7.48	6.16	9.07	65.75	33.17	6.17	0.96	4.44	4.26
4	NDBG-7 (P4)	46.75	54.75	6.24	12.74	9.24	3.39	9.95	63.42	37.67	6.02	1.05	3.42	3.59
5	Narendra Pooja (P5)	47.42	56.33	5.62	12.46	8.98	6.33	10.20	64.83	40.87	6.77	1.06	4.45	4.72
6	Pant Lauki-3 (P6)	48.75	56.08	5.95	12.45	9.15	5.83	9.32	64.75	39.70	6.12	1.05	4.58	4.81
7	Kashi Ganga (P7)	50.08	56.83	5.97	12.47	7.65	6.36	10.83	65.50	35.87	6.10	1.08	4.44	4.80
8	Arka Bahar (P8)	55.42	62.50	10.39	16.89	8.99	6.69	9.32	71.17	33.57	6.15	0.97	3.74	3.63
9	Pusa Naveen (P9)	49.08	57.75	9.97	16.47	9.02	5.68	10.32	66.42	38.53	7.23	1.02	4.41	4.50
							Hybrids							
10	P1×P2	47.75	54.67	6.48	12.98	8.00	5.93	9.23	63.33	30.23	6.20	0.94	3.41	3.22
11	P1×P3	50.67	57.58	9.75	16.25	10.16	6.64	9.35	66.25	41.63	5.18	1.07	4.38	4.71
12	P1×P4	49.75	59.50	7.51	14.01	6.56	5.74	10.23	68.17	33.97	5.92	1.02	5.21	5.34
13	P1×P5	53.42	61.00	9.40	15.90	8.79	6.56	9.13	69.67	37.03	6.12	1.06	4.38	4.65
14	P1×P6	49.75	58.17	7.58	14.08	10.30	5.73	10.35	66.83	41.03	5.42	0.90	3.40	3.08
15	P1×P7	49.42	58.75	7.28	13.78	8.66	6.71	9.30	67.42	39.00	5.33	1.00	4.42	4.41
16	P1×P8	49.08	59.67	7.51	14.01	6.65	5.43	11.18	68.33	36.20	6.37	1.18	4.81	5.71
17	P1×P9	56.75	63.25	9.81	16.31	9.00	6.63	9.32	71.75	34.80	5.77	1.01	4.39	4.46
18	P2×P3	48.42	58.17	9.91	16.75	10.02	6.76	10.23	66.83	39.47	5.92	0.92	3.71	3.42
19	P2×P4	47.75	55.83	6.33	12.83	7.92	6.46	9.32	64.50	34.13	5.65	1.12	4.36	4.89
20	P2×P5	52.42	60.17	10.77	17.27	5.89	6.64	10.35	68.83	41.67	6.57	1.35	4.91	6.65
21	P2×P6	49.42	58.75	7.18	13.68	5.00	5.69	11.02	67.42	35.07	6.25	0.91	4.41	4.01
22	P2×P7	54.08	61.42	8.82	15.32	5.27	6.61	9.68	70.08	37.53	8.85	0.95	3.37	3.21
23	P2×P8	48.42	57.67	7.71	14.21	7.57	6.26	9.35	66.33	41.20	9.85	1.27	4.42	5.62
24	P2×P9	50.08	59.83	7.42	13.92	10.06	6.56	9.02	68.50	39.93	5.65	0.98	5.31	5.23
25	P3×P4	50.00	59.75	7.04	13.54	5.97	5.49	10.35	68.42	39.40	7.90	1.22	4.27	5.21
26	P3×P5	54.42	62.33	9.77	16.27	7.79	6.43	11.35	71.00	32.37	8.90	1.00	3.27	3.32
27	P3×P6	48.08	53.92	5.97	12.47	9.48	6.56	11.43	62.58	39.57	6.17	1.09	4.35	4.74
28	P3×P7	50.00	58.83	7.85	14.68	8.86	6.36	10.02	67.50	30.30	7.78	1.11	5.01	5.55
29	P3×P8	52.08	59.17	9.39	15.89	5.34	6.26	11.23	67.83	41.30	6.65	1.04	4.42	4.60
30	P3×P9	49.75	57.67	8.62	15.12	6.73	5.93	11.35	66.33	36.77	5.55	1.05	3.75	3.94
31	P4×P5	54.08	60.67	8.68	15.18	9.34	6.66	11.35	69.33	38.17	7.58	1.02	4.41	4.52
32	P4×P6	50.83	57.33	7.77	14.27	7.35	5.84	11.25	66.00	40.87	6.63	1.04	5.29	5.51
33	P4×P7	51.75	59.67	9.50	16.00	9.32	6.51	9.68	68.33	41.03	9.22	1.06	4.31	4.58
34	P4×P8	50.08	61.00	9.57	16.07	6.59	5.33	10.82	71.33	37.17	10.25	1.04	3.38	3.52
35	P4×P9	54.75	63.33	10.52	17.02	8.30	6.46	9.15	72.00	35.60	10.12	1.14	4.40	5.04

36	P5×P6	47.08	56.17	6.87	13.37	9.29	5.96	9.98	64.83	39.23	6.93	1.14	4.37	4.99
37	P5×P7	48.42	58.33	7.90	14.40	7.33	6.56	10.34	67.00	31.20	8.67	1.01	4.41	4.45
38	P5×P8	51.75	58.83	10.11	16.61	9.57	5.23	11.34	67.50	42.47	9.52	1.03	5.32	5.50
39	P5×P9	49.42	57.17	7.70	14.20	7.34	5.79	10.68	65.83	34.00	8.20	1.11	4.41	4.90
40	P6×P7	51.08	58.42	9.92	16.42	9.10	4.59	10.34	67.08	37.97	6.62	0.98	3.31	3.24
41	P6×P8	50.08	57.83	8.29	14.79	9.29	6.09	9.59	66.50	41.87	6.62	0.89	4.40	3.95
42	P6×P9	48.08	55.83	6.68	13.18	8.70	6.36	9.68	64.50	42.60	6.77	1.11	5.08	5.63
43	P7×P8	49.08	58.67	8.46	14.96	6.97	5.74	10.82	67.33	37.97	7.92	0.91	4.41	4.04
44	P7×P9	55.42	63.75	9.66	16.16	8.37	6.39	11.07	72.42	35.67	7.52	1.18	3.75	4.43
45	P8×P9	51.42	58.92	9.24	15.74	10.75	6.18	11.33	67.58	37.03	8.20	1.05	4.41	4.63
46	Sarita (check)	50.83	59.33	9.01	15.51	9.67	5.49	10.38	68.00	32.37	7.48	0.97	4.39	4.26
	Mean	50.46	58.66	8.24	14.77	8.25	6.07	10.15	67.36	37.33	7.03	1.04	4.31	4.37
	Min	46.75	53.92	5.62	12.45	5.00	3.39	7.48	62.58	28.73	5.18	0.89	3.27	3.08
	Max	56.75	63.75	10.77	17.27	10.75	6.76	11.43	72.42	42.60	10.25	1.35	5.32	6.65
	SE(d) ±	0.54	0.60	0.28	0.48	0.27	0.19	0.33	2.02	1.14	0.22	0.03	0.13	0.15
	C.D.at 5%	1.07	1.19	0.56	0.96	0.54	0.38	0.66	4.02	2.27	0.44	0.06	0.27	0.30
	C.V. (%)	7.31	8.24	6.14	9.99	8.01	9.84	9.99	5.68	3.74	3.81	3.78	3.81	4.20

DSFA= Days to first staminate flower anthesis, DFPFA=Days to first pistillate flower anthesis, NNFSFA = Node number to first staminate flower appearance, NNFPFA=Node number to first pistillate flower appearance, NPBPP = Number of primary branches per plant, VL= Vine length(m), IL= Internodal length (cm), DFFH=Days to first fruit harvest, FL= Fruit length (cm), FC= Fruit circumference (cm), AFW= Average Fruit weight (kg), NFPP= No of Fruit per plant, FYPP= Fruit yield per plant (kg).

The results of genetic variability indicated that the highest GCV and PCV were observed for Fruit yield per plant (kg) (20.10% and 20.38%), which exhibited the existence of large genetic variability and demonstrated the effective selection for the given traits. The moderate values of GCV and PCV were recorded for Node no to first staminate flower appearance (17.43% and 17.92%) followed by Node no to first pistillate flower appearance (10.15% and 10.31%), Number of primary branches per plant (17.17% and 17.64%), Vine length (10.08% and 10.79%), Fruit circumference (19.24% and 19.61%) and No of Fruit per plant (12.51% and 13.08%), respectively. The lowest values of GCV and PCV were recorded for Days to first staminate flower anthesis (4.72% and 4.90%) followed by Days to first pistillate flower anthesis (3.81% 4.01%), Internodal length (8.26% and 9.17%), Days to first fruit harvest (2.72% and 4.57%), Fruit length (9.47% and 9.80%) and Average Fruit weight (8.84% and 9.61%) respectively, which exhibited a huge impact of the environment on the trait (Table 4).

The highest degree of heritability was observed for the characters Days to first staminate flower anthesis (92.90%), Days to first pistillate flower anthesis (90.36%), Node no to first staminate flower appearance (94.65%), Node no to first pistillate flower appearance (85.02%), Number of primary branches per plant (94.83%), Vine length(m) (87.31%), Internodal length(cm) (81.07%), Fruit length (86.54%), Fruit circumference (96.22%), Average Fruit weight (kg) (84.55%), No of Fruit per plant (91.53%), Fruit yield per plant (95.76%), while moderate heritability was observed for Days to first fruit harvest (35.29%). In the present study, estimates of genetic advance ranged from 3.32 to 40.20. Highest estimate of genetic advance was recorded for Fruit yield per plant (kg) (40.20), Fruit circumference (38.88), Node no to first staminate flower appearance (34.93), Number of primary branches per plant (34.45), No of Fruit per plant (24.66), while moderate genetic advance for Vine length(m) (19.40), Fruit length (cm) (18.16), Average Fruit weight (kg) (16.74), Internodal length(cm) (15.32) and Days to first staminate flower anthesis (9.37), Days to first pistillate flower anthesis (7.46), Days to first fruit harvest (3.32) revealed moderate genetic advance as a % of the mean which stated non-additive gene action.

Discussion

Bottle gourd is one of the most important vegetables worldwide, presenting a high added value. In the past, many breeders have significantly contributed to the yield by increasing the genetic variability in given bottle gourd populations or cultivars (Duhan *et al*., 2022). The exploitation of genetic diversity is critical to enhancing bottle gourd production by developing high yielding cultivars (Mladenovi´ *et al*., 2012). Genetic advance, h^2, and genetic variability are used to improve the selection of parents and hybrids. All traits had a higher magnitude of h^2, which shows that these traits are highly heritable. Earlier investigators, such as Abhishek *et al.* (2020), studied significant variations for numerous traits in bottle gourd. The conclusion in the current study aligned with the earlier research outcomes (Rashid *et al*., 2020). Days to first staminate and pistillate flowering indicated an early maturing attitude of parents/hybrids. Early flowering genotypes lead to early fruit maturity and escape the threats of many abiotic stresses. Genotypes with early flowering and early maturity attributes must have high-yielding potential, and it depends on the combination of strong and vigorous early growth, nutrients, water usage efficiency (WUE), stable photosynthesis and respiration and all ending in high yield (Venkatraman and Haripriya, 2021). The hybrid, $P_5 \times P_6$ secured the lowest day to first flowering (53.92) and this hybrid could be used to develop an early maturing bottle gourd cultivar. The minimum days to fruit maturity were secured by NDBG-7 (63.42), which was regarded as an early maturing parent. In some cases, early maturing cultivars may lead to a high yield and improved quality of bottle gourd. These characters are the most significant for the selection criteria. These findings could help future researchers improve bottle gourd early flowering and fruit-maturing traits to reduce the risk of diseases and shorten the growth duration. The results obtained from the study are in close conformity with the results of previous researchers result as reported in bottle gourd by Singh *et al.* (2021)). The genotypic and phenotypic coefficients of variability, h^2 and genetic advance are essential biometric tools used to assess the genetic divergence among the genotypes Chouhan *et al.* (2020): Genetic variability is the basis for any selection strategy because the larger the genetic variability in the existing population, the greater will be the scope of selection for the improvement of genotypes for the given traits (Panigrahi and Duhan, 2018).

Table 2 : ANOVA (mean squares) for a set of 9 x 9 diallel cross for different traits in bottle gourd (Pooled)

Source	df	DFSFA	DFPFA	NNFSFA	NNFPFA	NPBPP	VL (m)	IL (cm)	DFFH	FL (cm)	FC (cm)	AFW (kg)	NFPP	FYPP (kg)
		P	P	P	P	P	P	P	P	P	P	P	P	P
Rplications	2	1.17	2.25	0.13	0.17	0.03	0.001	0.018	0.79	1.27	0.01	0.002	0.013	0.01
Genotypes	44	17.85**	15.82**	6.41**	6.36**	6.13**	1.182**	2.321**	16.51**	38.65**	5.67**	0.027**	0.921**	2.35**
Parents	8	18.58**	13.93**	10.60**	10.14**	1.29**	2.904**	2.842**	14.10**	51.57**	0.67	0.006**	0.530**	0.66**
Hybrids	35	17.30**	15.34**	5.09**	5.16**	7.19**	0.780**	1.983**	16.05**	36.11**	6.52**	0.032**	1.035**	2.21**
Parents Vs Hybrids	1	31.02**	48.07**	19.22**	18.30**	7.82**	1.510**	9.990**	51.77**	24.14**	15.77**	0.024**	0.055	20.71**
EROR	88	0.44	0.54	0.12	0.35	0.10	0.055	0.162	6.07	1.99	0.07	0.002	0.027	0.03
Total	134	6.17	5.58	2.18	2.32	2.08	0.425	0.869	9.42	14.01	1.91	0.010	0.321	0.79

*, ** significant at 5% and 1% level, respectively

DSFA= Days to first staminate flower anthesis, DFPFA=Days to first pistillate flower anthesis, NNFSFA = Node number to first staminate flower appearance, NNFPFA=Node number to first pistillate flower appearance, NPBPP = Number of primary branches per plant, VL= Vine length(m), IL= Internodal length (cm), DFFH=Days to first fruit harvest, FL= Fruit length (cm), FC= Fruit circumference (cm), AFW= Average Fruit weight (kg), NFPP= No of Fruit per plant, FYPP= Fruit yield per plant (kg).

Table 4 : Genetic variability

Genotypes	Mean	Min	Max	Heritability (%)	GA% mean	GCV (%)	PCV (%)
Days to first staminate flower anthesis	50.46	46.75	56.75	92.90	9.37	4.72	4.90
Days to first pistillate flower anthesis	58.66	53.92	63.75	90.36	7.46	3.81	4.01
Node no to first staminate flower appearance	8.24	5.62	10.77	94.65	34.93	17.43	17.92
Node no to first pistillate flower appearance	14.77	12.45	17.27	85.02	18.06	9.51	10.31
Number of primary branches per plant	8.25	5.00	10.75	94.83	34.45	17.17	17.64
Vine length(m)	6.07	3.39	6.76	87.31	19.40	10.08	10.79
Internodal length(cm)	10.15	7.48	11.43	81.07	15.32	8.26	9.17
Days to first fruit harvest	67.36	62.58	72.42	35.29	3.32	2.72	4.57
Fruit length (cm)	37.33	28.73	42.60	86.54	18.16	9.47	10.18
Fruit circumference (cm)	7.03	5.18	10.25	96.22	38.88	19.24	19.61
Average Fruit weight (kg)	1.04	0.89	1.35	84.55	16.74	8.84	9.61
No of Fruit per plant	4.31	3.27	5.32	91.53	24.66	12.51	13.08
Fruit yield per plant (kg)	4.37	3.08	6.65	95.76	40.20	20.10	20.38

A higher magnitude of GCV and PCV indicated the scope of selection as more variation results in an effective selection plan (Islam *et al.*, 2022). Usually, the magnitudes of PCV were, to some extent, higher than those of GCV for the given traits, demonstrating the role of the environment in the appearance of the trait. In the current study, Fruit yield per plant (Kg) had the highest GCV and PCV. The moderate values of GCV and PCV were recorded for Node no to first staminate flower appearance followed by Node no to first pistillate flower appearance, Number of primary branches per plant, Vine length, Fruit circumference and No of Fruit per plant. These findings indicated the naturally occurring differences among the parents. They permitted an enormous scope of selection to develop potential cultivars, allow parents/hybrids to adopt environmental changes, and maintain a high-yielding attitude. In the current study, most traits had moderate to higher magnitudes of GCV and PCV. The results obtained from the study are in close conformity with the results of previous researchers result as reported in bottle gourd by Sherpa *et al.* (2014); Srikanth *et al.* (2017); Sultana *et al.* (2018).

A high h^2 indicates that genetics describes a lot of the variation in a trait between different parents and a low heritability, which is nearly zero, specifies that most of the difference is not genetic. A high h^2 alone is not considered an essential standard for selection, but the likelihood of effective selection increases with high genetic advance Abhishek *et al.* (2020). An effective breeding program to improve quantitative traits needs reliable h^2 estimates Singh *et al.* (2021). Days to first staminate flower anthesis (92.90%), Days to first pistillate flower anthesis (90.36%), Node no to first staminate flower appearance (94.65%), Node no to first pistillate flower appearance (85.02%), Number of primary branches per plant (94.83%), Vine length(m) (87.31%), Internodal length(cm) (81.07%), Fruit length (86.54%), Fruit circumference (96.22%), Average Fruit weight (kg) (84.55%), No of Fruit per plant (91.53%), Fruit yield per plant recorded higher h^2 estimates in the current study so that genetic variation can be exploited and these traits can be improved using this selection criterion Anoj and Yadav (2022). Damor *et al.* (2016) and Kandasamy *et al.* (2019) also detected higher h^2 estimates for, which strongly supported the validity of our results.

High genetic advance and high h^2 revealed that the environment plays a negligible role in the expression of particular traits as indicated by additive gene action. Hence, these traits can be improved via natural selection. Highest estimate of genetic advance was recorded for Fruit yield per plant (kg), Fruit circumference, Node no to first staminate flower appearance, Number of primary branches per plant, No of Fruit per plant, while moderate genetic advance for Vine length(m), Fruit length (cm), Average Fruit weight (kg), Internodal length(cm) and Days to first staminate flower anthesis, Days to first pistillate flower anthesis, Days to first fruit harvest revealed moderate genetic advance as a % of the mean which stated non-additive gene action. The above estimates gave an indication that substantial genetic improvement can be achieved in these characters Yadav *et al.* (2008).

A high-yielding hybrid, $P_2 \times P_5$, is one of the core findings of the current study, which showed that this hybrid could be used for varietal development. Further studies are required to enhance the genetic variability to improve the selection program. Hence, the breeder should implement an appropriate breeding procedure to use both additive and non-additive gene effects simultaneously since varietal and hybrid development will go a long way in the breeding programs, especially in the case of bottle gourd.

References

Abdin, B. M., Arya, L., Sureja, D. S. A. K., & Verma, M. (2014). Population structure and genetic diversity in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] germplasm from India assessed by ISSR markers. *Plant Syst. Evol.*, **300**, 767–773. https://doi.org/10.1007/s00606-014-1000-5

Abhishek, V. R., Kumar, J., & Tomar, S. (2020). Study of genetic variability, heritability and genetic advance among the characters of bottle gourd. *Plant Arch.*, **20**, 506–509.

Anoj, & Yadav, G. C. (2022). Studies on heritability and genetic advance for quantitative traits in bottle gourd (*Lagenaria siceraria*) under salt affected soil. *Pharma Innov. J.*, **11**(2), 1630–1632.

Chouhan, G. S., Kushwah, S. S., Singh, O. P., & Sharma, R. K. (2020). Genetic variability and correlation analysis for fruit yield and quality traits in bottle gourd. *Ind. J. Hort.*, **77**(2), 287–292.

Damor, A. S., Patel, J. N., Parmar, H. K., & Vyas, N. D. (2016). Genetic variability, heritability and genetic advance for yield and quality traits in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] genotypes. *Int. J. Sci. Environ. Technol.*, **5**(4), 2301–2307.

Duhan, D. S., Gill, V., Panghal, V. P. S., & Karande, P. J. (2022). Genetic variability, heritability, genetic advance and character association in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. *Veg. Sci.*, **49**(2), 204–210.

Gürcan, K., Say, A., & Yetişir, H. (2015). Genetic diversity in bottle gourd [*Lagenaria siceraria* (Molina) Standl.] population and implications for historical origins. *Genet. Resour. Crop Evol.*, **62**, 321–333. https://doi.org/10.1007/s10722-015-0224-8

Hallauer, A. R., Carena, M. J., & Miranda Filho, J. D. (2010). *Quantitative genetics in maize breeding*. Springer.

Hanson, C. H., Robinson, H. F., & Comstock, R. E. (1956). Biometrical studies of yield in segregating populations of Korean lespedeza. *Agron. J.*, **48**, 268–272. https://doi.org/10.2134/agronj1956.00021962004800060008x

Hart, T. G. B. (2011). Significance of African vegetables in ensuring food security for South Africa's rural poor. *Agric. Hum. Values*, **28**, 321–333. https://doi.org/10.1007/s10460-010-9256-z

Kandasamy, R., Arivazhagan, E., & Bharathi, S. S. (2019). Variability and heritability studies in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. *Plant Arch.*, **19**(2), 3263–3266.

Liu, Z., Jiang, J., Ren, A., Xu, X., Zhang, H., & Zhao, T. (2021). Heterosis and combining ability for fruit yield, earliness and quality in tomato. *Agronomy*, **11**, 807. https://doi.org/10.3390/agronomy11040807

Mashilo, J., Shimelis, H., & Odindo, A. (2015). Genetic diversity of bottle gourd landraces assessed by morphological traits and SSR markers. *SA J. Plant Soil*, **33**, 113–124. https://doi.org/10.1080/02571862.2015.1090024

Mashilo, J., Shimelis, H., & Odindo, A. (2017). Phenotypic and genotypic characterization of bottle gourd: Implications for breeding. *Sci. Hort.*, **222**, 136–144. https://doi.org/10.1016/j.scienta.2017.05.020

Mladenović, E., Berenji, J., Ognjanov, V., Ljubojević, M., & Čukanović, J. (2012). Genetic variability and morphological characterization of bottle gourd. *Arch. Biol. Sci.*, **64**, 573–583. https://doi.org/10.2298/ABS1202573M

Morimoto, Y., & Mvere, B. (2004). *Lagenaria siceraria*. In G. J. H. Grubben & O. A. Denton (Eds.), *Vegetable plant resources of tropical Africa* (Vol. 2, pp. 353–358). Backhuys/CTA.

Morimoto, Y., Maundu, P., Fujimaki, H., & Morishima, H. (2005). Diversity of landraces of white-flowered gourd in Kenya. *Genet. Resour. Crop Evol.*, **52**, 737–747. https://doi.org/10.1007/s10722-004-6119-8

N. (2021). Genetic variability and multivariate analysis in tomato genotypes. *Plant Cell Biotech. Mol. Biol.*, **22**, 46–59.

Narayan, R., Singh, S. P., Sharma, D. K., & Rastogi, K. B. (1996). Genetic variability and selection parameters in bottle gourd. *Ind. J. Hort.*, **53**, 53–58.

Ojiako, O. A., & Igwe, C. U. (2007). Nutritional and anti-nutritional composition of bottle gourd seeds. *J. Med. Food*, **10**, 735–738. https://doi.org/10.1089/jmf.2007.625

Panigrahi, I., & Duhan, D. S. (2018). Variability and morphological characterization of bottle gourd genotypes. *Int. J. Chem. Stud.*, **6**(1), 1863–1866.

Rashid, M., Wani, K. P., Hussain, K., Dar, Z. A., Singh, P. K., Khalil, A., Ali, G., Farwah, S., Hussain, S. M., & Rizvi, S. (2020). Genetic variability, heritability and genetic advance in bottle gourd (*Lagenaria siceraria*). *Int. J. Chem. Stud.*, **8**(3), 455–458.

Said, P. P., Pradhan, R. C., & Rai, B. N. (2014). Green separation of *Lagenaria siceraria* seed oil. *Ind. Crops Prod.*, **52**, 796–800. https://doi.org/10.1016/j.indcrop.2013.12.009

Sherpa, P., Pandiarana, N., Shende, V. D., Seth, T., Mukherjee, S., & Chattopadhyay, A. (2014). Estimation of genetic parameters in exotic tomato genotypes. *Electron. J. Plant Breed.*, **5**(3), 552–562.

Singh, R., Singh, B., Prakash, S., Kumar, M., Kumar, V., Chand, P., & Vaishali. (2021). Genetic variability, heritability and genetic advance in bottle gourd. *Ann. Hort.*, **14**(1), 72–78.

Sithole, J. N., Modi, A. T., & Pillay, K. (2015). Mineral and protein contents in bottle gourd landraces. *J. Hum. Ecol.*, **51**, 279–286. https://doi.org/10.1080/09709274.2015.11906923

Srikanth, M., Bharad, S. G., Thulasiram, L. B., & Potdukhe, N. R. (2017). Genetic variability and heritability in pumpkin. *Int. J. Curr. Microbiol. App. Sci.*, **6**(6), 1416–1422.

Steel, R. G. D., & Torrie, J. H. (1960). *Principles and procedures of statistics*. CABI.

Sultana, S., Rahman, M. S., Ferdous, J., Ahamed, F., & Chowdhury, A. K. (2018). Genetic variability and interrelationship in bottle gourd. *Int. J. Agril. Res. Innov. Tech.*, **8**(1), 14–17.

Venkatraman, M., & Haripriya, K. (2021). Genetic variability, heritability and genetic advance in bottle gourd genotypes. *Ann. Plant Soil Res.*, **23**(2), 200–203.