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Evaluation of genetic variability, heritability and genetic advance in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.)

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Abstract
A study was conducted to assess the degree of genetic variability, heritability and genetic advance in 35 bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) genotypes, including a check variety, Narendra Rashmi for sixteen quantitative characters. The experiment was carried out in a Randomized Block Design (RBD) with three replications. Significant genetic variability was confirmed by analysis of variance, which revealed considerable variations among genotypes for all traits. A greater magnitude of phenotypic coefficient of variation (PCV) than genotypic coefficient of variation (GCV) for all the traits including fruit length, fruit girth and vine length suggested significant environmental influence. On the other hand, traits like fruit length, fruit girth, vine length and quantity of fruits per plant showed high heritability and genetic advance, indicating the role of additive gene action and the possibility of successful selection. These results offer a solid foundation for choosing desired genotypes for bottle gourd breeding programs in the future and to increase production.

Keywords: Genetic variability, GCV, PCV, heritability, genetic advance, gene action

Introduction
Bottle gourd [*Lagenaria siceraria* (Molina) Standl.; 2n = 2x = 22] is one of the most ancient and economically important vegetable crops in the family Cucurbitaceae, widely cultivated across tropical and subtropical regions including India, Sri Lanka, South Africa, Indonesia and Malaysia (Deore *et al*., 2009) [5]. In India, major producing states include Rajasthan, Uttar Pradesh, Bihar and Tamil Nadu. The crop thrives in warm climates with optimal germination between 25-30°C and performs well in sandy loam soils with a pH of 6-7 (Haque *et al*., 2009) [6]. Flowering typically begins 40-50 days after sowing and exhibits monoecious sex expression, with male flowers generally appearing before female ones (Singh *et al*., 1996) [13]. The reproductive behaviour, including timing of anthesis and stigma receptivity, varies with regional climatic conditions (Nandpuri & Singh, 1967; Joshi & Gaur, 1971) [11, 9]. Its morphological diversity and adaptability make it a suitable subject for genetic studies aimed at crop improvement.

Materials and Methods
Experiment was conducted at Main Experimental Station of Department of Vegetable Science Farm of Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) during *summer* season. The experiment followed a Randomized Block Design (RBD) with three replications to evaluate the performance of thirty-five genotypes. Each treatment included five plants per genotype, spaced at 3.0 × 0.6 cm, with a net plot size of 3.0 × 3.0 cm. The sowing was done on March 28, 2024. Every suggested cultivation practices and crop protection techniques were used to guarantee healthy crop development. Observation was recorded traits like days to first staminate flower appear, days to appearance 50% staminate flowering, days to first pistillate flower appear, days to appearance 50% pistillate flowering, node number at which first staminate flower appear, node number at which first

pistillate flower appear, days to first fruit harvest, number of fruits per plant, number of primary branches per plant, vine length (m), inter nodal length (cm), fruit length (cm), fruit girth (cm), average fruit weight (kg), fruit yield per plant (kg), fruit yield per hectare (q). The recorded data were examined using the analysis of variance method proposed by Panse and Sukhatme (1954) [14], genotypic and phenotypic coefficient of variance by Burton (1952) [2] and Johnson *et al*., (1995) [8] for heritability and genetic advance.

Results and Discussion

According to the analysis of variance, all the traits had highly significant mean sums of squares, suggesting that there was significant variation among the genotypes (Table1).

Genetic variability

The fundamental requirement for a plant breeder to start any breeding program is genetic variability. Among the traits (Table 2), days to first male flower anthesis and days to first female flower anthesis registered considerable variability between 45.67 to 51.33 and 48.33 to 53.67 respectively. Days to the appearance of 50% male flowers and days to the appearance of 50% female flowers was recorded between 52.33 to 55.33 and 54.00 to 59.00, node number to first male flower appearance was recorded between 6.97 to 10.67, node number to first female flower appearance was recorded between 10.17 to 14.13, days to first fruit harvest ranged from 59.67 to 65.33, number of fruits per plant between 4.67 to 8.33, number of primary branches per plant ranging from 5.13 to 8.17, vine length ranged from 3.69 to 6.41 (m), internodal length ranged from 7.30 to 14.40, fruit length ranged from between 16.72 to 46.74(cm), fruit girth was recorded between 21.44 to 48.08 (cm), average fruit weight ranged from 0.89 to 1.19 (kg), fruit yield per plant was recorded between 4.56 to 7.60 (kg) and fruit yield per hectare was recorded between 236.23 to 399.33 (q). Therefore, a broad range of variability for these features was noted in the current study. This outcome is promising since a large degree of variability in the attributes has been linked to a greater probability of improvement. Several researchers such as Husna *et al.* (2011) [7] have documented significant diversity for similar traits in bottle gourd.

Table 1: Analysis of variance (mean squares) for quantitative characters in bottle gourd

S. No.	Traits	Source of variation		
	D.F.	Replication	Treatments	Error
		2	34	68
1.	Days to first staminate flower anthesis	1.80	5.19**	1.78
2.	Days to the appearance of 50% staminate flowers	2.21	3.26*	1.15
3.	Days to first pistillate flower anthesis	3.94	5.38**	2.44
4.	Days to the appearance of 50% pistillate flowers	2.92	4.31**	2.01
5.	Node no. at which first staminate flower appearance	1.46	2.41**	0.32
6.	Node no. at which first pistillate flower appearance	1.65	2.84**	0.62
7.	Days to first fruit harvest	1.47	7.66**	2.75
8.	Number of fruits per plant	0.181	3.407**	0.554
9.	No of primary branches per plant	0.388	1.815**	0.103
10.	Vine length (m)	0.170	2.186**	0.218
11.	Internodal length (cm)	1.358	6.583**	0.511
12.	Fruit length (cm)	7.72	168.18**	2.28
13.	Fruit girth (cm)	3.68	87.90**	2.59
14.	Average fruit weight (kg)	0.005	0.020**	0.003
15.	Fruit yield per plant (kg)	0.608	2.550**	0.279
16.	Fruit yield per hectare (q)	128.36	5931**	324.69

Table 2: Estimates of variability, heritability, expected genetic advances per cent of mean

Characters	Mean	Min	Max	GCV (%)	PCV (%)	Heritability (%)	GA	GA% mean
Days to first staminate flower anthesis (Days)	48.70	45.67	51.33	2.19	3.51	38.92	1.37	2.81
Days to the appearance of 50% staminate flowers	53.82	52.33	55.33	1.56	2.53	37.95	1.06	1.98
Days to first pistillate Flower anthesis (Days)	51.51	48.33	53.67	1.92	3.59	28.67	1.09	2.12
Days to the appearance of 50% pistillate flowers	56.76	54.00	59.00	1.54	2.94	27.53	0.95	1.66
Node no. at which first male flower appearance	8.81	6.97	10.67	9.47	11.46	68.23	1.42	16.11
Node no. at which first female flower appearance	11.68	10.17	14.13	7.37	9.98	54.49	1.31	11.20
Days to first fruit harvest	62.73	59.67	65.33	2.04	3.34	37.31	1.61	2.57
Number of fruits per plant	6.30	4.67	8.33	15.49	19.49	63.22	1.60	25.38
Number of primary branches / plants	6.41	5.13	8.17	11.78	12.80	84.70	1.43	22.34
Vine Length (m)	4.99	3.69	6.41	16.24	18.75	75.03	1.45	28.97
Internodal length (cm)	12.37	7.30	14.40	11.50	12.87	79.85	2.62	21.18
Fruit length (cm)	35.37	16.72	46.74	21.02	21.45	96.04	15.01	42.44
Fruit girth (cm)	27.16	21.44	48.08	19.63	20.51	91.64	10.52	38.71
average fruit weight (kg)	1.03	0.89	1.19	7.31	8.81	68.82	0.13	12.49
Fruit yield per plant (kg)	6.49	4.56	7.60	13.41	15.68	73.10	1.53	23.61
Fruit yield per hectare (q)	326.47	236.23	399.33	13.24	14.35	85.20	82.21	25.18

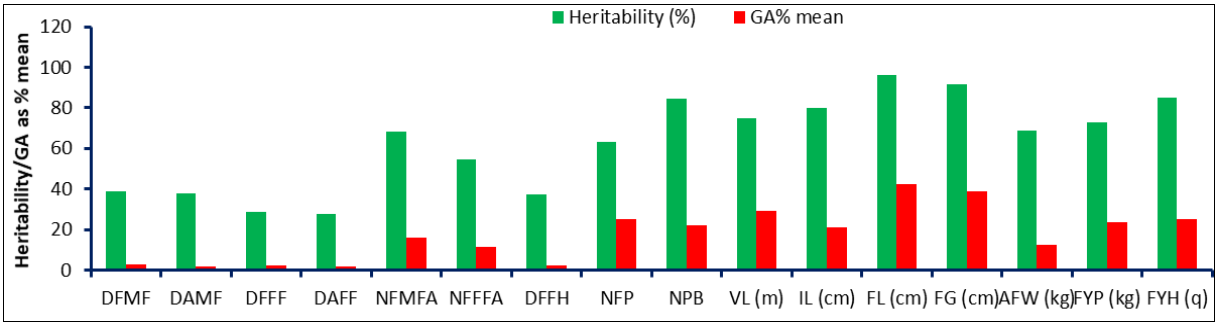

Fig 1: Bar graph showing Heritability (%) and Genetic Advance as% mean for quantitative traits bottle gourd genotypes.

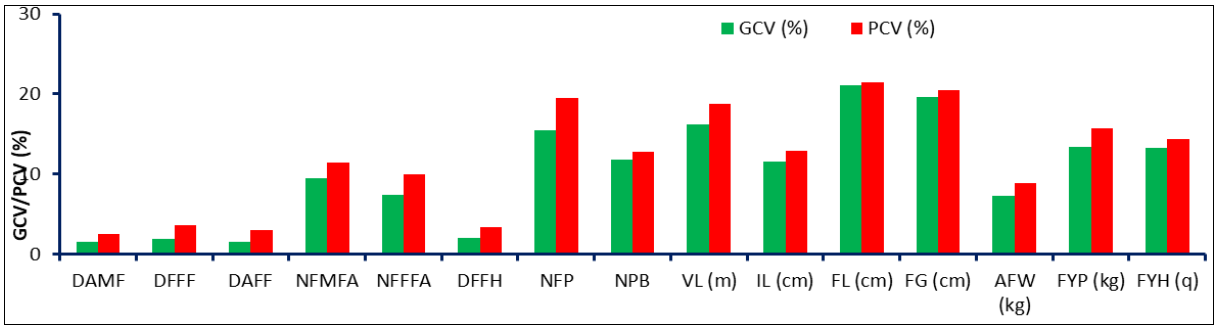

Fig 2: Bar graph showing GCV & PCV for sixteen characters in bottle gourd genotype

Fig: GCV & PCV for sixteen characters in bottle gourd genotype: Bar graph showing Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV) for different traits in bottle gourd genotypes**.**

Phenotypic coefficient of variation

The analysis of variation coefficients indicated that the phenotypic coefficient of variation (PCV) was consistently greater than the genotypic coefficient of variation (GCV) across all the traits studied. Traits such as fruit length (21.45%) followed by fruit girth (20.51%), showed high PCV values. Moderate phenotypic values were recorded for traits like number of fruits per plant (19.49%), vine length (18.75%), fruit yield per plant (15.68%), fruit yield per hectare (14.35%), inter-nodal length (12.87%), number of primary branches per plant (12.80%) and number of nodes at which staminate flowers appear (11.46%). However low phenotypic coefficient of variation was observed for number of nodes at which pistillate flowers appear (9.98%), average fruit weight (8.81%), days to first pistillate flower appearance (3.59%), days to first staminate flower appearance (3.51%), days to first fruit harvest (3.34%), days to appearance 50% staminate flower (2.94%) and days to appearance 50% pistillate flower (2.53%). These were in accordance with the findings of Singh and Kumar (2002) [12].

Genotypic coefficient of variation (GCV)

The genotypic coefficient of variation, ranged from 1.54% (days to appearance 50% pistillate flower) to 21.02% (fruit length) for various characters studied. Highest genotypic coefficient of variation was noted for fruit length (21.02%). while moderate genotypic values were found for fruit girth (19.63%) followed by vine length (16.24%), number of fruits per plant (15.49%), fruit yield per plant (13.41%), fruit yield per hectare (13.24%), number of primary branches per plant (11.78%) and inter-nodal length (11.50%). Additionally, low genotypic was also recorded for node at which first staminate flower appearance (9.47%), node at which first pistillate flower appearance (7.37%), average fruit weight (7.31%), days to first staminate flower appearance (2.19%), days to first fruit harvest (2.04%), days to first pistillate flower appearance (1.92%), days to appearance 50% staminate flower (1.56%) and days to appearance 50% pistillate flower (1.54%).

Heritability and Genetic Advance

Result presented in (table 2), revealed that the heritability estimates of high heritability (>80%) was calculated for the characters fruit length (96.04%) followed by fruit girth (91.64%), fruit yield per hectare (85.20%), number of primary branches per plant (84.70%). Apart from this moderate heritability (>60% to <80%) were recorded in internodal length (79.85%), followed by vine length (75.03%), fruit yield per plant (73.10%), average fruit weight (68.82%), node at which first staminate flower appearance (68.23%), number of fruits per plant (63.22%). Low heritability (<60%) was recorded in node at which first pistillate flower appearance (54.49%), days to first staminate flower appearance (38.92%), days to appearance 50% staminate flower (37.95%), days to first fruit harvest (37.31%), days to first pistillate flower appearance (28.67%), days to appearance 50% pistillate flower (27.53%). These findings align with those reported by Ahamad *et al*. (2019) and Chandramouli *et al*. (2021) [2] have likewise observed comparable finding.

The percentage of genetic advance over the mean varied from 1.66% (days to appearance 50% pistillate flower) to 42.44% (fruit length). The high genetic advance in per cent of mean (>20%) were calculated for fruit length (42.44%) followed by fruit girth (38.71%), vine length (28.97%), number of fruits per plant (2538%), fruit yield per hectare (25.18%), fruits yield per plant (23.61%), number of primary branches per plant (22.34%), inter-onodal length (21.18%). It is to be noticed that these traits also showed high estimates of broad sense heritability. Moderate genetic advance as per cent of mean was calculated for node at first staminate flower appearance (16.11%), average fruit weight (12.49%), node at which first pistillate flower appearance (11.20%). Low values of genetic advance in percent of mean (0-10%) was calculated for days to first staminate flower appearance (2.81%), days to first fruit harvest (2.57%), days to

first pistillate flower appearance (2.12%), days to appearance 50% staminate flower (1.98%), days to appearance 50% pistillate flower (1.66%). Similar results were reported by Damor *et al*. (2017) [4] and Ahamad *et al*. (2019).

Conclusion

The present study revealed significant genetic variability among 35 bottle gourd genotypes for all the traits evaluated, indicating a broad scope for selection and improvement. The greater PCV values compared to GCV for all traits indicate that the environment has a significant impact on phenotypic expression. Nonetheless, characters like fruit length, fruit girth, vine length and fruit number per plant demonstrated substantial genotypic coefficients of variation, heritability and genetic advance, underscoring their strong additive genetic control and selection reliability. Therefore, there is a good chance that these traits could be improved genetically by direct selection. The results give bottle gourd breeding programmes a useful genetic foundation for developing desirable high-yielding cultivars.

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