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ASSESSMENT OF GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE FOR YIELD, QUALITY AND GUMMY STEM BLIGHT RESISTANCE IN BOTTLE GOURD GENOTYPES

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ABSTRACT

Bottle gourd (*Lagenaria siceraria* (Molina) Standl.) is an important cucurbitaceous vegetable crop with considerable variation for yield, quality and disease resistance traits, offering scope for genetic improvement. The present study was conducted to assess genetic variability, heritability and genetic advance as per cent of mean (GAM) among bottle gourd genotypes. Twenty-five genotypes along with two commercial checks were evaluated in a Randomized Block Design with three replications during 2024-2025 at the College orchard, Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. Twenty-three quantitative, qualitative and disease-related traits were recorded. Significant differences among genotypes revealed substantial genetic variability. Estimates of PCV, GCV, heritability and GAM were used to assess the selection potential of traits. High heritability coupled with high GAM indicated the predominance of additive gene effects, suggesting better response to selection for improving yield, quality and gummy stem blight resistance. The identified promising genotypes can serve as valuable breeding resources for developing superior bottle gourd cultivars.

***Key words*:** Bottle gourd, genetic variability, PCV, GCV, heritability, genetic advance, GAM, gummy stem blight.

Introduction

Bottle gourd (*Lagenaria siceraria* (Molina) Standl.) is an economically important cucurbitaceous vegetable crop widely cultivated in tropical and subtropical regions owing to its adaptability, nutritional value and commercial significance (Mkhize *et al*., 2021). The crop exhibits considerable variability for vegetative growth, flowering behaviour, fruit characteristics, yield attributes and quality traits, providing valuable opportunities for genetic improvement. The availability of diverse genetic resources and their systematic evaluation are essential for developing superior cultivars with improved productivity and desirable quality attributes (Chouhan, 2017).

Genetic variability forms the foundation of any crop improvement programme, as selection efficiency depends on the magnitude of inheritable variation present in the breeding material. Quantitative traits such as yield and its contributing characters are highly influenced by environmental conditions; therefore, estimation of genetic parameters is essential to understand the nature and extent of variation. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) provide an insight into the relative influence of genetic and environmental factors governing trait expression (Burton and Devane, 1953). Studies in bottle gourd have reported significant variability among genotypes for growth, yield and quality traits, indicating good scope for selection and hybridization programmes (Chikkeri *et al*., 2018).

Heritability is an important parameter that indicates the proportion of phenotypic variation attributable to genetic factors and helps in predicting the effectiveness of selection. However, heritability alone may not provide an accurate estimate of expected genetic improvement; hence, it is generally considered together with genetic advance as per cent of mean (GAM). High heritability associated with high GAM indicates the predominance of additive gene effects and suggests that direct selection would be effective for improving desirable traits (Johnson *et al*., 1955 and Duhan *et al*., 2022).

Apart from yield improvement, development of disease-resistant cultivars is a major objective in bottle gourd breeding. Gummy stem blight caused by *Stagonosporopsis cucurbitacearum* is an important disease affecting cucurbit crops, causing considerable reduction in plant growth, yield and fruit quality (Bhardwaj *et al*., 2018). Therefore, simultaneous evaluation of yield, quality and disease resistance traits along with genetic parameters is essential for identifying promising breeding lines.

Hence, the present investigation was undertaken to estimate genetic variability, heritability and genetic advance as per cent of mean for yield, quality and gummy stem blight resistance traits among diverse bottle gourd genotypes, with the objective of identifying superior genetic resources for future breeding programmes.

Materials and Methods

The study was conducted during 2024-2025 at the College Orchard, Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. Twenty-five bottle gourd genotypes collected from Tamil Nadu and Telangana, along with two commercial checks (Bottle Gourd Hybrid CO 1 and Arka Bahar), were evaluated in a Randomized Block Design (RBD) with three replications. Observations were recorded on three randomly selected plants per replication for 23 traits, including vegetative growth, flowering, yield, fruit quality and gummy stem blight resistance parameters. The recorded data were subjected to analysis of variance (ANOVA) to determine the significance of differences among genotypes. Further Range, GCV, PCV, Heritability, and Genetic advance were estimated as described below.

Range

Range is expressed as maximum and minimum values recorded for each trait.

Genotypic and phenotypic variance

Genotypic and phenotypic variances were computed through the formulae of Lush, (1940).

Environmental variance (Ve) = Me

$$\text{Genotypic variance (Vg)} = \frac{Mg - Me}{r}$$

Phenotypic (Vph) = Vg + Ve

Where,

Mg = Mean square for genotype.

Me = Mean square for error (Ve).

r = Number of replications.

GCV and PCV

GCV and PCV were estimated by utilizing the following formulae given by Burton, (1953).

$$GCV = \frac{\sqrt{\text{Genotypic variation}}}{\text{Mean}} \times 100$$

$$PCV = \frac{\sqrt{\text{Phenotypic variation}}}{\text{Mean}} \times 100$$

As per Sivasubramaniam and Menon, (1973) GCV and PCV were classified as mentioned below:

Category	GCV and PCV
Low	<10 %
Moderate	Between 10 – 20 %
High	>20 %

Heritability

Heritability (h^2) was computed through the following formulae given by Lush (1940).

$$h^2 \text{ (Broad sense)} = \frac{\text{Genotypic variance}}{\text{phenotypic variance}} \times 100$$

Category	Heritability
Low	0-30%
Moderate	31 – 60%
High	>60%

Genetic advance

Genetic advance was estimated according to Johnson *et al.*, (1955) by using following formula:

$$\text{Genetic advance (GA)} = \frac{genotypic\ variance}{phenotypic\ standard\ deviation} \times k$$

Genetic advance expressed as percent of mean

$$\text{Genetic advance as per cent of mean (GAM)} = \frac{Genetic\ advance}{Grand\ mean} \times 100$$

GAM was categorized as mentioned below according to Johnson *et al.*, (1955).

Category	GAM
<10%	Low
Between 10 – 20 %	Moderate
>20%	High

Results and Discussion

Range of Variation

The evaluation of twenty-five bottle gourd genotypes along with two check varieties revealed substantial variability for all the twenty-three traits studied, indicating the presence of a broad genetic base (Table 1). Vegetative traits showed considerable variation, with vine length ranging from 4.36 to 7.19 m, primary branches per vine from 6.43 to 12.11 and internodal length from 9.09 to 16.09 cm, which is consistent with the findings of Husna *et al*., (2011) and Deepthi *et al*., (2016). Flowering traits also exhibited appreciable variability, with days to first male and female flower appearance ranging from 48.22-57.33 and 53.89-66.66 days, respectively, while the first male and female flowering nodes varied from 8.66-17.77 and 11.66-21.89, corroborating earlier reports of Husna *et al*., (2011) and Deepthi *et al*., (2016).

Yield-contributing traits exhibited wider variation than vegetative and flowering traits. Fruits per vine ranged from 2.77 to 10.00, fruit set from 18.60 to 43.47%, fruit length from 9.62 to 42.16 cm, fruit circumference from 22.37 to 52.45 cm, average fruit weight from 110.23 to 1290.90 g, yield per vine from 0.54 to 12.04 kg and yield per hectare from 2.39 to 53.50 t ha^{-1}, indicating substantial scope for selecting superior yielding genotypes (Husna *et al*., 2011; Deepthi *et al*., 2016). Quality traits also displayed considerable variation, with TSS ranging from 1.60 to 4.25 °Brix, ascorbic acid from 4.70 to 10.00 mg 100 g^{-1}, protein from 0.13 to 0.53% and crude fibre from 0.52 to 1.32% similar results were reported by Singh *et al*. (2021).

Disease-related traits exhibited marked variation, with percent disease index ranging from 17.28 to 97.97 and disease incidence from 60 to 100%, indicating differential responses to gummy stem blight. Similar variation in disease reaction among bottle gourd germplasm has been reported by Bhardwaj *et al*., (2018) and Dhananjaya *et al*., (2023). Overall, the observed variability provides valuable opportunities for the selection of superior genotypes for yield improvement and disease resistance breeding.

Genetic Variability

Very high GCV and PCV values were recorded for yield per vine (64.63 and 64.79%), yield per hectare (64.63 and 64.79%), percent disease index (47.09 and 47.10%), number of fruits per vine (41.35 and 41.45%), protein content (38.73 and 38.82%), average fruit weight (38.62 and 38.72%), total soluble solids (32.74 and 32.89%), fruit length (30.42 and 30.55%), fruit circumference (28.70 and 28.79%), crude fibre content (28.55 and 28.70%), sex ratio (26.49 and 26.79%), fruit set percentage (26.21 and 26.48%), number of female flower (21.33 and 21.46), ascorbic acid (21.24 and 21.42). High GCV and PCV estimates indicate the presence of substantial genetic variability for these traits, providing greater scope for improvement through direct phenotypic selection. The consistently narrow differences between GCV and PCV further suggest that environmental effects on trait expression were minimal, indicating that the observed phenotypic variability was predominantly governed by genetic factors. Therefore, selection based on these characters is expected to be highly effective in crop improvement programmes. Similar findings were reported by Varalakshmi *et al*., (2018); Chouhan *et al*., (2020) and Duhan *et al*., (2022). Comparable observations were also made by Harika *et al*., (2012) and Rambabu *et al*., (2020), who reported high variability for yield and its contributing traits in bottle gourd.

Moderate GCV and PCV values were observed for node at first male flower appearance (17.32 and 17.53), number of primary branches per vine (16.36 and 18.88), vine length (15.26 and 15.45), node at first female flower appearance (14.71 and 14.94), internodal length (14.65 and 14.75), and disease incidence (12.67 and 12.91). Moderate estimates of variability indicate the existence of adequate genetic variation for these traits, suggesting that improvement through selection is possible, although the magnitude of genetic gain may be comparatively lower than that observed for highly variable traits. The close correspondence between GCV and PCV further indicates that these traits were less influenced by environmental conditions and were largely controlled by genetic factors. Similar results were reported by Singh *et al*., (2017) and Chouhan *et al*., (2020). These findings are also in agreement with those of Harika *et al*., (2012) and Singh *et al*., (2021) (Table 1).

Low GCV and PCV estimates were recorded for days to first female flower appearance (5.12 and 5.78), days to first male flower appearance (4.94 and 5.58), and number of staminate flowers per vine (2.86 and 4.01), indicating relatively low genetic variability among the evaluated genotypes for these traits. The limited variability suggests a narrow genetic base, thereby restricting the effectiveness of direct selection for their improvement. Such traits generally require the creation of additional variability through hybridization or the evaluation of diverse germplasm to achieve substantial genetic improvement. Similar findings were reported by Singh *et al*., (2017) and Duhan *et al*., (2022). Comparable observations were also documented by Harika *et al*., (2012) in bottle gourd (Table 1).

Table 1: Range, Variability, heritability and genetic advance as per cent of mean for different characters of bottle gourd genotypes.

SI. No.	Characters	Range		Variability (%)			H^2(BS) percent	GAM
		Minimum	Maximum	GCV	PCV	ECV		
1.	VL (m)	4.36	7.19	15.26	15.45	2.42	97.56	31.05
2.	NPBPV	6.43	12.11	16.36	18.88	9.44	75.03	29.19
3.	INL (cm)	9.09	16.09	14.65	14.75	1.66	98.74	30.00
4.	DFMF	48.22	57.33	4.94	5.58	2.59	78.36	9.00
5.	DFFF	53.89	66.66	5.12	5.78	2.68	78.54	9.34
6.	NFMF	8.66	17.77	17.32	17.53	2.68	97.66	35.26
7.	NFFF	11.66	21.89	14.71	14.94	2.61	96.95	29.84
8.	NMF	92.55	104.55	2.86	4.01	2.81	50.98	4.21
9.	NFF	12	23.77	21.33	21.46	2.35	98.8	43.67
10.	SR	3.94	8.72	26.49	26.79	3.98	97.8	53.97
11.	NFPV	2.77	10.00	41.35	41.45	2.91	99.51	84.97
12.	FS (%)	18.6	43.47	26.21	26.48	3.82	97.92	53.42
13.	FL (cm)	9.62	42.16	30.42	30.55	2.79	99.17	62.41
14.	FC (cm)	22.37	52.45	28.7	28.79	2.23	99.4	58.95
15.	AFW (g)	110.23	1290.9	38.62	38.72	2.77	99.49	79.35
16.	YPV (kg)	0.54	12.04	64.63	64.79	4.54	99.51	132.82
17.	YPH (t/ha)	2.39	53.50	64.63	64.79	4.55	99.51	132.8
18.	TSS (° Brix)	1.6	4.25	32.74	32.89	3.22	99.04	67.11
19.	AA (mg/100g)	4.70	10.00	21.24	21.42	2.78	98.32	43.39
20.	PR (%)	0.13	0.53	38.73	38.82	2.71	99.51	79.58
21.	CF (%)	0.52	1.32	28.55	28.7	2.92	98.96	58.51
22.	PDI	17.28	97.97	47.09	47.1	1.09	99.95	96.98
23.	DI	60	100	12.67	12.91	2.48	96.31	25.6

PCV-Phenotypic coefficient of variation, **ECV** -Environmental coefficient of variation, **GCV**-Genotypic coefficient of variation, **GAM**-Genetic advance as percent of mean. **VL**-Vine length, **NPBPV**-Number of primary branches/vine, **INL**-Inter nodal length, **DFMF**-Days for first male flower, **DFFF**-Days for first female flower, **NFMF**-Node at first male flower, **NFFF**-Node at first female flower, **NMFPV**-Number of male flowers/vine, **NFFPV**-Number of female flowers/vine, **SR**-Sex ratio, **NFPV**-Number of fruits/vine, **FS**-Fruit set, **FL**-Fruit length, **FC**-Fruit circumference, **AFW**-Average fruit weight, **TSS**-Total soluble Solids, **AA**-Ascorbic acid content, **PR**-Protein content, **CF**-Crude fibre content, **PDI**-Percent disease incidence, **DI**-percent disease incidence.

Heritability

Broad-sense heritability estimates ranged from 50.98 to 99.95%, indicating considerable variation in the extent of genetic control among the studied traits (Table 1). High heritability (>95%) was recorded for percent disease index (99.95%), followed by number of fruits per vine (99.51%), yield per vine (99.51%), yield per hectare (99.51%) and protein content (99.51%), average fruit weight (99.49%), fruit circumference (99.40%), fruit length (99.17%), total soluble solids (99.04%), crude fibre (98.96%), number of pistillate flowers (98.80%), internodal length (98.74%), ascorbic acid (98.32%), fruit set percentage (97.92%), sex ratio (97.80%), node at first male flower appearance (97.66%), vine length (97.56%), node at first female flower appearance (96.95%) and disease incidence (96.31%). The predominance of high heritability for these traits indicates that their phenotypic expression was largely governed by genetic factors with minimal environmental influence. Consequently, phenotypic performance provides a reliable estimate of the genetic potential of these traits and making direct selection highly effective. When high heritability is associated with high genetic advance, it generally reflects the predominance of additive gene action, thereby facilitating rapid genetic improvement through simple selection (Burton and DeVane, 1953; Johnson *et al*., 1955). Similar observations were reported by Deepthi *et al*., (2016); Chouhan *et al*., (2020); Duhan *et al*., (2022); Mahapatra *et al*., (2023) and Khateeb *et al*., (2024).

Moderately high heritability was observed for days to first female flower appearance (78.54%), days to first male flower appearance (78.36%) and number of primary branches per vine (75.03%). Moderate heritability indicates that both genetic and environmental factors contributed to the phenotypic variation of these characters. Although selection for these traits is feasible, the expected response would be comparatively lower than for highly heritable traits, and greater breeding efficiency can be

achieved through selection in later generations. Similar findings were reported by Harika *et al*., (2012) Singh *et al*., (2017) and Duhan *et al*., (2022).

The lowest heritability was recorded for number of staminate flowers (50.98%), indicating a comparatively greater environmental influence on its phenotypic expression. The moderate level of genetic control suggests that direct phenotypic selection for this trait would be less efficient, and improvement may require recurrent selection, hybridization involving diverse parents or evaluation across multiple environments. Similar observations were reported by Singh *et al*., (2017).

Genetic Advance as Per Cent of Mean (GAM)

Genetic advance expressed as percentage of mean (GAM) ranged from 4.21 to 132.82%, indicating considerable variation in the expected response to selection among the studied traits (Table 1).

High GAM was recorded for yield per vine (132.82%), followed by yield per hectare (132.80%), percent disease index (96.98%), number of fruits per vine (84.97%), protein content (79.58%), average fruit weight (79.35%), total soluble solids (67.11%), fruit length (62.41%), fruit circumference (58.95%), crude fibre content (58.51%), sex ratio (53.97%), fruit set percentage (53.42%), number of pistillate flowers (43.67%) and ascorbic acid (43.39%). High heritability associated with high GAM observed for yield, quality and disease resistance traits indicates the predominance of additive gene action, suggesting that these characters can be effectively improved through direct selection. Similar findings were reported by Deepthi *et al*., (2016); Chouhan *et al*., (2020); Duhan *et al*., (2022); Mahapatra *et al*., (2023) and Khateeb *et al*., (2024), who also observed high genetic advance for economically important traits in bottle gourd.

Moderately high GAM was observed for node at first male flower appearance (35.26%), vine length (31.05%), internodal length (30.00%), node at first female flower appearance (29.84%), number of primary branches per vine (29.19%) and disease incidence (25.60%). Moderate genetic advance indicates that, improvement of these traits through selection is feasible, but greater progress may be achieved through recurrent selection or by combining superior parents in breeding programmes. Similar observations were reported by Harika *et al*., (2012); Singh *et al*., (2017); and Singh *et al*., (2021).

Low GAM was recorded for days to first male flower appearance (9.00%), days to first female flower appearance (9.34%) and number of staminate flowers (4.21%). The comparatively low genetic advance for these flowering traits suggests limited additive genetic variance and indicates that non-additive gene effects and environmental factors may play a relatively greater role in their inheritance. Consequently, direct selection for these traits may be less effective, and breeding approaches such as hybridization followed by selection in later generations may be more appropriate for their improvement. Similar findings were reported by Harika *et al*., (2012); Singh *et al*., (2017) and Duhan *et al*., (2022).

Overall, the combination of high GCV, high heritability and high GAM for economically important traits such as yield per vine, yield per hectare, number of fruits per vine, average fruit weight, fruit dimensions, quality parameters and gummy stem blight resistance demonstrates that these traits are predominantly governed by additive gene action. Therefore, they can serve as reliable selection criteria for the development of high-yielding, quality-rich and disease-resistant bottle gourd cultivars.

The present study revealed substantial genetic variability among the bottle gourd genotypes for growth, yield, quality and gummy stem blight resistance traits. High heritability coupled with high genetic advance as per cent of mean was observed for economically important characters such as yield per vine, yield per hectare, number of fruits per vine, average fruit weight, fruit length, fruit circumference, total soluble solids, protein content and percent disease index, indicating the predominance of additive gene action. These traits are therefore amenable to effective improvement through direct phenotypic selection. The identified variability parameters provide valuable information for selecting superior parental lines and formulating efficient breeding strategies aimed at developing high-yielding, quality-rich and gummy stem blight-resistant bottle gourd cultivars.

Author contribution

GR: Conducted the research and prepared the original draft. **MK**: Helped with the methodology and validation. **MN**: Helped with data analysis and manuscript editing. **IC, TC** and **VS** helped in manuscript edit.

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