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Analysis of Genetic Variability, Heritability and Genetic Advance of Yield and Associated Traits in F_3 and F_4 Generations of Bottle Gourd (*Lagenaria siceraria* (Mol.) Standl.)

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A B S T R A C T

The present investigation analyzed the genetic variability, heritability, and genetic advance across five genotypes of bottle gourd, as delineated in Tables 1 and 2. The results indicated highly significant differences among the genotypes for all traits examined, suggesting substantial variance conducive to effective selection within the studied material. Estimates of genetic coefficient of variability (GCV) and phenotypic coefficient of variability (PCV) were notably high for several traits, including vine length, number of branches per vine, number of nodes per plant, number of female flowers per vine, number of fruits per vine, fruit yield per vine, fruit yield per plot, and fruit yield per hectare. Most traits exhibited elevated heritability estimates however, significant genetic advance as a percentage of the mean was particularly observed for vine length, number of nodes per plant, Fruit yield per hectare (q).Conversely, traits such as the number of branches per vine, node of first female flower emergence, days to first female flower appearance, number of female flowers per vine, number of fruits per vine, and fruit yield per vine, Fruit yield per plot (kg)demonstrated lower genetic advance. The observed variability across all traits underscores the potential for simple selection methods to enhance these characteristics in future breeding programs.

Introduction

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl], is a prominent member of the Cucurbitaceae family, characterized by a diploid chromosome number of 2n=22. This species exhibits a predominantly cross-pollinated reproductive system, attributed to its monoecious and and romonoecious floral structures. Nutritionally, bottle gourd serves as a modest source of essential vitamins and minerals. The fruits, which are versatile in culinary applications, are utilized in the preparation of various dishes, including sweets, pickles (notably in hilly regions), kofta, petha, halwa, kopoorkand, paratha, rayata, kheer, pedha, and burfi. Nutritional analysis reveals that the fruits contain vitamin C (11 mg), thiamine (0.044 mg), riboflavin (0.023 mg), niacin (0.33 mg), mineral matter (0.5%), carbohydrates (2.9%), fats (0.5%), protein (0.2%), and moisture content of approximately 96.3%. Additionally, various parts of the plant exhibit a plethora of medicinal properties. The dried, hard shells of the fruit are fashioned into a diverse array of utilitarian items, including bowls, containers, floats for fishing nets, pipes, and musical instruments. Furthermore, both the seeds and the extracted seed oil are consumable. In the realm of plant breeding, understanding the inheritance patterns of heritable traits is crucial for enhancing crop characteristics. Key determinants of crop improvement include genetic advancement, heritability, and variability, which together guide breeders in their efforts to optimize yield and resilience in bottle gourd cultivation.

Materials and Methods

Five bottle gourd genotypes along with seeds of F_3progenies of cross LTR-2xLTR-4(C2:2x4) provided from the previous M.Sc. research work carried out at Instructional-cum Research Farm, Department of Horticulture, College of Agriculture, Latur were grown in a Randomised Block Design in *kharif* 2022 and selfed to obtained F_4 generation. The F_3 and F_4 generation of cross LTR-2xLTR-4were evaluated during *summer* 2023. The experimental plot size was 2 m x 10 m. and seed sown at 2 m x 1 m spacing between rows and plants Randomized Block Design (RBD) for each cross. The recommended dose of fertilizer for bottle gourd is 20 t FYM + 100:50:50 kg NPK per ha was applied.

The dose of FYM 20 tons per hectare and the 50 *per cent* recommended dose of nitrogen (50 kg/ha) and full dose of phosphorus (50 kg/ha) and potassium (50 kg/ha) were incorporated in the soil at the time of preparation of field. The remaining dose of 50 *per cent* of nitrogen (50 kg/ha) was applied one month after sowing. The plant protection measures were applied as per recommendation. The gap filling and thinning was done. The vines were trailed on bower to give support.

Observations were made in F_4 generation on ten randomly chosen plants from each genotype, and the mean value was used for statistical analysis for eleven characters: length of vine (cm), number of branches per vine, number of nodes per plant, node at which first female flower occur, days required for occurrence of first female flower, number of female flowers per vine, days required for first harvest, number of fruits per vine, fruit yield per vine (kg), fruit yield per plot (kg) and fruit yield per hectare (q).

The formula of Panse and Sukhatme (1985) will be used to calculate variation for all of the features under consideration. The mean squares from the variance table will be used to determine genotypic and phenotypic variances Johnson *et al.,* (1955). The GCV and PCV will be determined using Burton and De Vane (1953) approach. Heritability (in the broad sense) will be calculated using the method proposed by Allard (1960). Johnson *et al.,* (1955) proposed a formula for calculating genetic advance.

Results and Discussion

Genotypic coefficient of variation was lower than the phenotypic coefficient of variation in all quantitative traits which indicate role of environment in the expression of traits. In F_3 and F_4 generations of cross LTR-2 x LTR-4 (C2: 2 x 4), high values of genotypic and phenotypic coefficient of variations were recorded for the length of vine, number of branches per vine, number of nodes per plant, number of female flowers per vine, number of fruits per vine, fruit yield per vine, fruit yield per plot and fruit yield per hectare. Genetic variability is a crucial part of any system in which selection occurs to evolve superior genotype. As a result, the more the genetic variety in these traits, the greater the potential for improvement through selection. To improve any crop, particularly its yield, it is vital to understand genetic variability and the production-related characteristics. Table 1 and Table 2 displays the data.

The character fruit yield per vine have greater values of GCV and PCV, indicating that there is a significant degree of genetic variability and that the environment has less influence, making them appropriate for selection. Rajawat *et al.,* (2017) and Bahiram *et al.,* (2023) found similar results. All the revealed moderate values of GCV and PCV, indicating a medium range of variability and the effect of environment, which might be misleading at times. Similar findings have been found by Vinithashri *et al.,* (2019). The trait Days required for first harvest estimates lower GCV and PCV, indicating low variability and substantial environmental influence, making selection undesirable. Mahapatra *et al.,* (2022) and Singh *et al.,* (2023) found similar results.

Table.1 Mean, range, GCV, PCV, heritability, genetic advance and per cent mean of genetic advance of two parents and F3 population of cross LTR-2xLTR-4(C2:2x4)

Sr. No.	Character	Mean	Range	GCV(%)	PCV(%)	h^2bs(%)	GA	GAM(%)
1.	Length of Vine(cm)	402.00	173.00-530.00	27.89	29.92	99.93	230.89	**57.46**
2.	Number of branches per vine	4.00	2.00-6.00	24.83	26.96	100.00	2.17	**51.18**
3.	Number of nodes per plant	41.00	22.00-51.00	22.94	23.10	100.00	19.57	**47.26**
4.	Node at which first female flower occurs	10.00	11.00-14.00	6.65	7.72	93.65	1.64	**13.70**
5.	Days required for first female flower	49.00	42.00-53.00	6.73	7.89	92.58	6.77	**13.86**
6.	No. of female flowers per vine	4.00	3.00-7.00	30.07	32.31	90.56	2.89	**61.85**
7.	Days required for first harvest	63.00	56.00-67.00	5.19	6.33	98.23	6.77	**10.68**
8.	No. of fruits per vine	4.00	2.00-6.00	30.40	31.52	97.63	2.30	**62.62**
9.	Fruit yield per vine (kg)	2.99	2.67-3.45	49.66	50.31	98.30	2.96	**58.84**
10.	Fruit yield per plot (kg)	16.07	12.85-18.26	19.09	20.06	99.95	4.86	**43.88**
11.	Fruit yield per hectare (q)	**269.67**	**175.00-375.33**	**26.76**	**28.45**	**100.00**	**49.32**	**46.62**

Table.2 Mean, range, GCV, PCV, heritability, genetic advance and *per cent* mean of genetic advance of two parents and F4 population of cross LTR-2xLTR-4(C2:2x4)

Sr. No.	Character	Mean	Range	GCV(%)	PCV(%)	h^2bs(%)	GA	GAM(%)
1.	Length of Vine(cm)	585.00	173.00-831.00	37.88	38.93	93.63	456.90	**78.04**
2.	Number of branches per vine	6.00	2.00-9.00	37.77	39.86	91.58	4.34	**77.80**
3.	Number of nodes per plant	46.00	22.00-60.00	26.01	29.33	94.33	24.70	**53.59**
4.	Node at which first female flower occurs	13.00	12.00-14.00	4.82	5.91	94.11	1.24	**9.94**
5.	Days required for first female flower	50.00	47.00-53.00	4.34	6.39	100.00	4.43	**8.94**
6.	No. of female flowers per vine	5.00	3.00-8.00	32.52	35.59	93.63	3.18	**66.99**
7.	Days required for first harvest	64.00	61.00-67.00	3.36	4.42	95.36	4.43	**6.92**
8.	No. of fruits per vine	5.00	3.00-6.00	32.55	35.59	100.00	2.42	**67.05**
9.	Fruit yield per vine (kg)	3.09	2.98-3.95	50.66	52.31	98.30	2.96	**58.84**
10.	Fruit yield per plot (kg)	17.67	13.85-19.20	20.09	23.86	98.95	5.16	**48.98**
11.	Fruit yield per hectare (q)	**259.90**	**179.00-385.33**	**28.06**	**29.95**	**100.00**	**49.99**	**49.72**

GCV and PCV have a significant trait difference, indicating that these traits are heavily influenced by environmental influences and the lower difference between GCV and PCV showing environmental influence on trait expression and revealed that most of the features are mostly under genetic control.

The magnitude of PCV values was greater than GCV for all traits, showing that all characters played a dominant role and that the environment had an influence on these traits. Variability is a requirement for any breeding effort aimed at increasing yield and other yield contributing characteristics.

All eleven traits demonstrated high heritability as a percentage of mean. This suggests that heritability is caused by additive gene effects and that selection may be effective. Similar results were achieved by Korat *et al.,* (2009).

In the F_4 and F_5 generations the trait for length of vine (cm), number of nodes per plant, fruit yield per hectare (q) shows high heritability along with high genetic advance which showing a diverse genetic background and predomince of additive gene control for these thereby providing a great scope for selection. Similar result was found by Rambabu *et al.,* (2017); Rashid *et al.,* (2020); Dubey *et al.,* (2022); Mahapatra *et al.,* (2022).

All remaining trait in the F_4 and F_5 generations there was limited genetic advancement and high heritability. It suggests that genes function in an non-additive manner. Selection would therefore not be feasible.

For this parameter a pedigree technique is to be applied rather than selection. Rajawat *et al.,* (2017) and Triveni *et al.,* (2021) discovered similar results.

In bottle gourd, traits such as length of vine, number of branches per vine, number of nodes per plant, number of female flowers per vine, number of fruits per vine, fruit yield per vine, fruit yield per plot and fruit yield per hectare displayed the high phenotypic and genotypic coefficients of variation (PCV and GCV). In contrast, the remaining traits showed moderate PCV and GCV in the cross LTR-2 x LTR-4 (C2: 2 x 4).

The trait Days required for first harvest estimates lower GCV and PCV, indicating low variability and substantial environmental influence, making selection undesirable. In the F_4 and F_5 generations, the phenotypic coefficient of variation (PCV) was consistently greater than the corresponding genotypic coefficient of variation (GCV) for all characters suggesting that environmental factors were influencing the expression of these traits to some extent.

A small difference between PCV and GCV indicates that these traits are minimally affected by environmental factors, while a larger gap between PCV and GCV highlights the significant role of environmental influences on these traits.

In the F_4 and F_5 generations the trait for length of vine (cm), number of nodes per plant, fruit yield per hectare (q) shows high heritability along with high genetic advance which showing a diverse genetic background and predomince of additive gene control for these thereby providing a great scope for selection.

Author Contributions

S. N. Band: Investigation, formal analysis, writing—original draft. V. S. Jagtap: Validation, methodology, writing—reviewing. P. D. Bele:—Formal analysis, writing—review and editing. V. D. Satpute: Investigation, writing—reviewing. K. N. Gavhale: Resources, investigation writing—reviewing. M. S. Malve: Validation, formal analysis, writing—reviewing. A. A. Talhar: Conceptualization, methodology, data curation, supervision, writing—reviewing the final version of the manuscript. S. B. Sarvade: Investigation, formal analysis, writing—original draft.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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