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Genetic Variability for Quantitative Traits in Bottle Gourd (*Lagenaria siceraria* (Mol.) Standl.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The selection of the superior traits in plants is one of the important phenomena of natural selection. Genetic variability in plants is also considered one of the important bases of natural selection, which can open a new way of trait selection in crops. The present investigation was carried out during *Zaid* 2022, with the aims of estimating genetic variability and working out heritability in a broad

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sense and genetic advance in per cent of mean to determine the scope of improvement among 30 genotypes, including a check variety Narendra Pooja in bottle gourd. The experiment was sown on 10 March 2022. All the recommended agronomic package of practices and plant protection measures were followed to raise a good crop. Observations were recorded on 16 quantitative characters. The highest phenotypic and genotypic coefficient of variation was observed for the number of seeds per fruit, followed by seed weight per fruit, seed yield per plant, internodal length, vine length, mature fruit equatorial circumference, and node at first pistillate flower appearance. Heritability ranged from 20 per cent (days to 50% staminate flower anthesis) to 99.50 per cent (seed weight per fruit), and genetic advance in per cent of mean ranged from 3.28 per cent (days to 50% staminate flower anthesis) to 157.27 per cent (Number of seeds per fruit). The estimates of high heritability seed yield per plant, 100 seeds weight, number of seeds per fruit, seed weight per fruit, inter-nodal length, number of nodes per vine, number of primary branches, vine length, mature fruit equatorial circumference, mature fruit polar length, and edible fruit equatorial circumference. Therefore, from the above obtained results, it is possible to deduce that the characteristics will result in successful crop improvement for better seed yield and yield-attributing characters. The characters showing high heritability, coupled with genetic advances, provide a broad way for the improvement in genotypes for specific characters. The information may further help the breeders in formulating appropriate strategies aimed at getting higher yields and character improvement in bottle gourd.

Keywords: Variability; GCV; PCV; heritability; genetic advance; bottle gourd (Lagenaria siceraria).

1. INTRODUCTION

“Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.) is one of the members of the family Cucurbitaceae, having chromosome number 2n=22 with the center of origin in South Africa. Bottle gourd fruits come in cylindrical, circular-oval, and oblong shapes. Bottle gourds may be grown in any type of soil, although they grow best in thoroughly manured loam soil” (Singh et al., 2023; Soltan et al., 2025). “The six related species of bottle gourds are *Lagenaria siceraria, Lagenaria spherica, Lagenaria abyssinica, Lagenaria guineensis, Lagenaria rufa and Lagenaria breviflora. Lagenaria siceraria* is the only cultivated species in the tropical region of the world. In India, bottle gourd is also known as the white flowered gourd, Lauki or Ghiya. It requires a well-drained soil with a pH between 6-7 for optimum growth. It may thrive in a variety of soil types, but loamy or sandy loam soils are said to be the best. It is also found as an escape, especially along riversides and lakeshores. It needs a well-distributed rainfall of 600 to 1500 mm and is adapted to semi-arid conditions. The optimum temperature for germination is 20–25°C, and the germination rate is affected below 15°C and above 35°C. It can tolerate low temperatures, but if the temperature drops below 10°C, flowering is reduced. Short days and humid climate promote femaleness while high temperatures and long days reduce the sex ratio, low temperatures and drought lead to flower and fruit abortion. The total area covered under bottle gourd cultivation in India is 193 thousand hectares, with a production of 3171 thousand metric tonnes” (Anonymous, 2020-21). Bihar, Uttar Pradesh, Madhya Pradesh, Haryana, and Chhattisgarh states are the top producers of bottle gourd. Bottle gourd is a remarkably lucrative crop, capable of generating substantial income for farmers within a short timeframe of just two to three months. Beyond the conventional criteria of novelty, inventive step, and industrial applicability, bottle gourd innovations might also be considered for protection based on their different uses (Singh et al., 2023).

Traditional breeding has always been proven to be an indispensable link between the availability of natural variation and the development of new high-yielding cultivars. However, it mainly involves the improvement of agronomic traits on the basis of phenotypic selection (Sun et al., 2024). The nature and extent of genetic diversity in the breeding material with which the plant breeder is working are critical to the success of any crop improvement work. The genetic make-up of the plant, the environment all have a role in the phenotypic expression of the plant's character. As a result, genetic variability investigations utilizing relevant biometrical instruments such as the coefficient of variability, heritability, and genetic advance have become critical in breeding programs for getting concrete results of desired values. As a result, the current study sought to determine the level of variability and potential areas for improvement in bottle gourds.

2. MATERIALS AND METHODS

The present research work entitled "Genetic variability for quantitative traits and scope of their improvement in bottle gourd (*Lagenaria siceraria (*Mol.) Standl.)" was carried out during *Zaid* 2022 at the Main Experimental Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya (U.P). The experiment was conducted in Randomized Block Design with three replications to assess the performance of 30 genotypes, including 1 check. Each entry was sown in one row with 3 m length spaced 3 m with plant-to-plant spacing of 0.5 m in each replication. The experiment was sown on 10 March 2022. All the recommended agronomic package of practices and plant protection measures were followed to raise a good crop. Observations were recorded on 16 quantitative characters *viz*., days to 50% staminate flower anthesis, days to 50% pistillate flower anthesis, node at first staminate flower anthesis, node at first pistillate flower anthesis, edible fruit polar length (cm), edible fruit equatorial circumference (cm), mature fruit polar length (cm), mature fruit equatorial circumference (cm), vine length (m), number of primary branches, number of nodes per vine, internodal length (cm), seed weight per fruit (g), number of seeds/ fruit, 100 seed weight (g) and seed yield per plant (g). The analysis of variance was carried out as per Panse and Sukhatme (1984), genotypic and phenotypic coefficient of variance by Burton and de Vane (1953), heritability and genetic advance as per method suggested by Hanson et al*.,* (1963) and Johnson et al*.,* (1955), respectively.

3. RESULTS AND DISCUSSION

The mean sum of squares in ANOVA revealed high variability among the 30 genotypes for all characters at 5% and 1% probability. The highly significant differences may be attributed to their genetic makeup of germplasm line and various regions from where they have been collected, as presented under Table 1. The characters under investigation were analysed for genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (Broad sense) and genetic advance as a percentage of the mean. The estimate of the genotypic coefficient of variation is of prime importance to the breeder because genetic variance alone does not allow a decision to which characters were showing the highest degree of variability. Therefore, accurate relative comparisons can be made with the help of phenotypic and genotypic coefficients of variation. In general, the phenotypic coefficients of variability were higher than the genotypic coefficients of variability for all the characters under study, which indicates that the environment played a very important role in the expression of the traits.

The estimates of genotypic and phenotypic coefficient of variation for 16 characters of bottle gourd germplasm have been presented in Table 2. High magnitude of genotypic coefficient of variation was recorded for the characters *viz.* number of seeds per fruit (76.53%), seed weight per fruit (71.48%), seed yield per fruit (57.76%), inter-nodal length (24.43%), vine length (21.90%), mature fruit equatorial circumference (21.22 %) and node at first pistillate flower appearance (21.19 %) while moderate genotypic coefficient of variation were observed for the characters number of nodes per vine (19.93%), number of primary branches (18.75%), node at first staminate flower appearance (17.83%), edible fruit polar length (16.95%), 100 seed weight (16.51%), edible fruit equatorial circumference (15.78) and mature fruit polar length (15.72%). However low genotypic coefficient of variation was observed in character, viz., days to 50% pistillate flower anthesis (5.44%) and days to 50% staminate flower anthesis (3.57%). Pandit et al. (2009), Ahmad et al*.* (2019), Gupta et al*.* (2020), Chandramouli et al. (2021), and Dhuan et al*.* (2022) also got similar findings.

"Heritability in the broad sense of a character is important to the breeder since it indicates the possibility and extent to which improvement is possible through selection. It also indicates the direction of selection pressure to be applied for a trait during selection because it measures the relationship between parents and their progeny, hence widely used in determining the degree to which a character may be transmitted from parents to offspring. However, high heritability alone is not enough to make efficient selection in advanced generation unless accompanied by a substantial amount of genetic advance" (Burton, 1952). High estimates of heritability, along with high genetic advance, provide good scope for further improvement in advanced generations.

Estimates of heritability and genetic advance for sixteen characters are presented in Table 2. The heritability in a broad sense ranged from 20 % (days to 50% staminate flower anthesis to 99.50 % (Number of seed per fruit). The estimates of high heritability (>75%) was calculated for the characters like number of seeds per fruit (99.50%), seed weight per fruit and seed yield per fruit (99%), mature fruit equatorial circumference (95%), number of nodes per vine (93%), edible fruit polar length (91%), node at first pistillate flower appearance and mature fruit polar length (90%), vine length (87%), edible fruit equatorial circumference, internodal length and 100 seed weight (86%), number of primary branches (79%), node at first staminate flower appearance (77%) except days to 50% pistillate flower anthesis (54%) and days to 50% staminate flower anthesis (20%). Kumar and Pal (2007), Ahamad et al. (2019), Gupta et al. (2020), and Chandramouli et al. (2021) also reported similar results.

The genetic advance in per cent of mean varied from 3.28% (days to 50% staminate flowering anthesis) to 157.27% (number of seeds per fruit). The high genetic advance in per cent of mean (>20%) were calculated for number of seeds per fruit (157.27 %), seed weight per fruit (146.79 %), seed yield per fruit (118.40 %), internodal length (46.65%), mature fruit equatorial circumference (42.49%), node at first pistillate flower appearance (41.44%), vine length (41.19%), number of nodes per vine (39.66%), number of primary branches (34.22%), edible fruit polar length (33.22%), node at first staminate flower appearance (32.29%), 100 seed weight (31.45%), mature fruit polar length length (30.65%) and edible fruit equatorial circumference (30.11%). It is to be noticed that these traits also showed high estimates of broad-sense heritability. The low values of genetic advance in per cent of mean (0-10%) showed for days to 50% staminate flower anthesis (3.28%) and days to 50% pistillate flower anthesis (8.25%). Similar results were reported by Damor et al. (2017) and Yadav et al. (2008), Ahamad et al. (2019), Gupta et al. (2020), and Chandramouli et al. (2021). High heritability coupled with high genetic advance were observed for most of the traits except days to 50% staminate flower anthesis and days to 50% pistillate flower anthesis. The traits like number of seeds per fruit, seed weight per fruit and seed yield per fruit showed comparatively higher value of PCV, GCV, heritability (broad sense) and genetic advance in per cent of mean and exhibits that these traits are governed through additive gene effect and they can be improved by selection, similar results were also reported by Gupta et al. (2020) Chandramouli et al. (2021).

Table 1. Analysis of variance (mean squares) for sixteen quantitative characters in bottle gourd germplasm

S. No.	Characters	Source of variation		
		Replications	Treatments	Error
	d.f.	**2**	**29**	**58**
1.	Days to 50% staminate flower anthesis	9.62	482.62*	553.04
2.	Days to 50% pistillate flower anthesis	46.49*	779.96**	343.51
3.	Node at first staminate flower appearance	3.13	288.05**	51.47
4.	Node at first pistillate flower appearance	9.09*	1037.03**	72.98
5.	Edible fruit polar length	7.62	3260.98**	221.64
6.	Edible fruit equatorial circumference	26.22*	1597.87**	167.15
7.	Mature fruit polar length	45.76*	3680.77**	275.33
8.	Mature fruit equatorial circumference	35.50**	4354.81**	165.19
9.	Vine length	0.68	96.97**	8.94
10.	Number of primary branches	0.44	423.92**	71.01
11.	Number of nodes per vine	29.84	9828.50**	457.42
12.	Internodal length	2.81	485.22**	50.13
13.	Seed weight per fruit	65.00**	51087.20**	214.33
14.	Number of seeds /fruits	623.49	2593061.96**	8144.51
15.	100 seed weight	17.35**	489.19**	52.37
16.	Seed yield per plant	117.77*	112494.53**	756.23

**, ** Significant at 5% and 1% per cent probability level, respectively*

Table 2. Estimate of range, grand mean, phenotypic (PCV), genotypic (GCV) and environmental (ECV) coefficient of variation, heritability in broad sense (h^2bs), genetic advance (Ga) and genetic advance in per cent of mean for sixteen characters in bottle gourd

S No.	Genetic parameters Characters	Range		Grand mean	PCV (%)	GCV (%)	ECV (%)	Heritability in broad sense (%) (h^2_{bs})	Genetic advance	Genetic advance in per cent of mean
		Lowest	Highest							
1.	Days to 50% staminate flower anthesis	39.00	47.33	43.09	8.01	3.57	7.17	20.00	1.41	3.28
2.	Days to 50% pistillate flower anthesis	43.33	54.00	48.58	7.40	5.44	5.01	54.00	4.01	8.25
3.	Node at first staminate flower appearance	6.80	13.10	9.74	20.29	17.83	9.67	77.00	3.14	32.29
4.	Node at first pistillate flower appearance	10.57	23.77	16.01	22.32	21.19	7.01	90.00	6.63	41.44
5.	Edible fruit polar length	22.77	47.57	35.49	17.83	16.95	5.51	91.00	11.79	33.22
6.	Edible fruit equatorial circumference	19.93	37.67	26.44	17.04	15.78	6.42	86.00	7.96	30.11
7.	Mature fruit polar length	28.27	52.67	40.59	16.61	15.72	5.37	90.00	12.44	30.65
8.	Mature fruit equatorial circumference	23.37	52.57	33.03	21.82	21.22	5.11	95.00	14.03	42.49
9.	Vine Length	2.50	6.90	4.82	22.90	21.40	8.15	87.00	1.99	41.19
10.	Number of primary branches	7.53	16.17	11.27	21.17	18.75	9.82	79.00	3.86	34.22
11.	Number of nodes per vine	35.77	79.43	52.71	20.63	19.93	5.33	93.00	20.91	39.66
12.	Inter-nodal length	5.21	15.05	9.42	26.35	24.43	9.87	86.00	4.39	46.65
13.	Seed weight per fruit	8.57	107.50	33.87	71.71	71.48	5.68	99.50	49.71	146.79
14.	Number of seeds per fruit	40.67	746.00	225.42	76.71	76.53	5.26	99.00	354.53	157.27
15.	100 seed weight	9.97	18.90	13.97	17.86	16.51	6.80	86.00	4.39	31.45
16.	Seed yield per plant	17.13	131.45	62.15	58.06	57.76	5.81	99.00	73.58	118.40

4. CONCLUSION

The results for analysis of variance showed that the mean square due to genotypes was highly significant for all the traits, indicating significant genetic variation, which enables us to utilise it in the improvement programmes. The characters showing high heritability coupled with genetic advances provide a broad way for the improvement in genotypes for specific characters. The information may further help the breeders in formulating appropriate strategies aimed at getting higher yields and character improvement in bottle gourd. Thus, there great scope for improvement in available germplasm to develop improved varieties of bottle gourd in future.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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