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Assesement of Genetic Variability, Heritability and Genetic Advance among the Characters of Sponge Gourd (*Luffa cylindrica* L. Roem)

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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 present study examined sixteen sponge gourd germplasms that were arranged in a Randomized Block design (RBD) with three replications in order to evaluation of genetic variability, heritability and genetic advance among the characters during the spring-summer (March–June) and rainy (July–October) seasons of 2019 at the Vegetable Research Farm of the College of Horticulture, Banda University of Agriculture and Technology, Banda. The parameters were observed for nineteen traits. Analysis of variance showed significant differences among genotype for all the traits. The results indicated to the growing environment had an impact on the characteristics' expression in addition to genetics when it came to apparent variety. In the spring, summer, and rainy season, estimates of the number of branches, fruit diameter and number of fruits per plant were made for high GCV & PCV, heritability, and genetic advance as a percentage of mean.

Keywords: Sponge gourd; genetic variability; heritability and genetic advance.

1. INTRODUCTION

Vegetables play a crucial role in maintaining a balanced diet as they offer not only energy but also essential protective nutrients such as minerals and vitamins. Referred to as protective foods, their consumption is associated with preventing various diseases. In contemporary diets, Cucurbitaceous vegetables constitute a significant and sizable portion of vegetable crops, holding importance due to their nutritional contributions.

The sponge gourd [*Luffa cylindrica* (L.) Roem syn. *Luffa aegyptiaca*] belongs to the family Cucurbitaceae with diploid chromosome number 2n = 2x = 26. It is locally known by different names in India such as Gilki/ Chikani Turai (Hindi), Bhol (Assamese), Jhinga (Bengali), Janhi (Oriya), Gisoda (Gujrati) and Pirkanga (Tamil). It is one of the most popular cucurbit grown as both summer and rainy season vegetable throughout tropical and sub-tropical parts of the country. The species *L. hermaphrodita*, popularly known as *satputia* bears hermaphrodite flowers and is also cultivated species in minor areas of India [1].

Sponge gourd is a yearly climbing plant, characterized by its herbaceous nature and reliance on cross-pollination. It yields fruits containing a fibrous vascular system, and its robust vines bear cylindrical fruits with ten angles. The green, immature fruits are commonly used in cooking. Within the cucurbit family, sponge gourd stands out for its capacity to provide biological water and easy digestibility, making it suitable even for individuals who are unwell, weak, or suffering from conditions like malaria or seasonal fevers. Recognized for its high nutritional value, this vegetable boasts a composition of 93.2 grams of moisture, 1.2 grams of protein, 0.20 grams of fat, 2.9 grams of carbohydrates, along with vitamins such as thiamin (0.02 mg), riboflavin (0.06 mg), niacin (0.4 mg), and carotene (120 mg). Additionally, it contains minerals like calcium (36 mg), phosphorus (19 mg), and iron (1.1 mg), as well as 0.20 grams of dietary fiber per 100 grams of the edible portion [2].

Variability is essential before commencing any crop enhancement initiative. Creating promising genotypes relies significantly on the level of genetic variation present for the targeted traits. Currently, enhancing productivity to meet growing national demands is a priority. The progress in crop improvement hinges on the extent of genetic variability and the heritability of desirable traits. Consequently, the analysis of genetic variability holds great significance for breeders in determining the ultimate selection of genotypes to improve the yield of sponge gourd.

2. MATERIALS AND METHODS

The present investigation entitled “Assesment of genetic variability, heritability and genetic advance among the characters of sponge gourd (*Luffa cylindrica* L. Roem)” was conducted at Vegetable Research Farm of College of Horticulture, Banda University of Agriculture and Technology, Banda during spring-summer (March-June) and rainy (July to October) seasons of 2019. The experimental materials comprised of 16 genotypes of sponge gourd *viz*., Pant Tori-1, BUAT SG -18-1, BUAT SG -18-2, CHSG -1, CHSG -2, JLSH -55, Kashi Divya, Kashi Shreya, Kashi Jyoti, KSG -14, Kalyanpur Hari Chikani, NSG -8, PSG -9, Pusa Sneha, Pusa Supriya and Phule Prajakta collected from different parts of India. The experiment was laid out in a Randomized Block Design with three replications. The observations were recorded on five randomly selected plants per treatment from each replication for 19 plants growth and fruit traits *viz*., days to 50% germination, days to first male flower emergence (days after sowing), days to first female flower emergence (days after sowing), node number of first male flower, node number of first female flower, intermodal length (cm), number of leaves per plant, leaf area cm^2), number of branches, male/female ratio, days to first picking (days after sowing**)**, fruit length (cm), fruit diameter (cm), specific gravity of fruits (g/cm^3), total soluble solids (^{0}Brix), dry matter content (%), fruit weight (g), number of fruits per plant and fruit yield per plant (kg). Analysis of variance was done by method suggested by Panse and Sukhatme [3]. The genotypic and phenotypic coefficients of variation were calculated using the formulae of Burton [4] and Johnson et al. [5]. The heritability and genetic advance were calculated according to Allard [6] and genetic advance as per cent of mean was estimated using the method of Johnson et al [5].

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance

Analysis of variance indicated that the genotypes differed significantly for all the traits studied during both the seasons as mean sum of square due to genotypes in ANOVA (Table 1) were significant for these traits. These differences indicated the presence of variability in the available germplasm and offers opportunity for improvement in yield and quality traits of sponge gourd. The standard error of mean and critical difference were used to compare the relative performance of the genotypes for various traits. Coefficient of variation (CV) is an indicator of reliability of a particular environmental condition in which the experiment was carried out.

Table 1. Analysis of variance (ANOVA) for Spring-summer and rainy seasons 2019

S.N.	**Traits**	**Mean Sum of Square**						
		Source of Variation	**Replications**		**Genotypes**		**Error**	
		Degree of Freedom	**Spring-summer**	**Rainy**	**Spring-summer**	**Rainy**	**Spring-summer**	**Rainy**
			02	**02**	**15**	**15**	**30**	**30**
1	Days to 50% germination		0.65	0.77	2.99**	3.2**	0.32	0.45
2	Days to first male flower emergence (DAS)		0.26	0.07	12.77**	16.39**	1.47	1.63
3	Days to first female flower emergence (DAS)		0.57	0.64	28.74**	37.64**	2.84	3.40
4	Node number of first male flower		0.11	0.08	15.92**	16.54**	1.42	1.83
5	Node number of first female flower		0.08	0.97	21.59**	27.07**	1.78	2.13
6	Inter nodal length (cm)		0.00	0.01	24.04**	26.32**	1.39	1.80
7	Number of leaves per plant		1.57	2.38	54.01**	69.24**	4.40	4.91
8	Leaf area (cm^2)		18.51	0.84	3575.86**	3870.86**	209.72	254.50
9	Number of branches		1.23	0.31	31.55**	53.9**	1.13	1.62
10	Male/female ratio		0.16	0.00	4.27**	6.3**	0.26	0.40
11	Days to first picking (DAS)		0.29	0.11	24.89**	36.34**	1.92	2.41
12	Fruit length (cm)		0.34	0.03	82.45**	94.72**	9.23	12.20
13	Fruit diameter (cm)		0.00	0.01	4.1**	13.2**	0.10	0.20
14	Specific gravity of fruits (g/cm^3)		0.00	0.00	0.2**	3.7**	0.01	0.02
15	Total soluble solids (^{0}Brix)		0.04	0.00	2.45**	3.5**	0.25	0.36
16	Dry matter content (%)		0.00	0.00	3.21**	2.6**	0.34	0.52
17	Fruit weight (g)		1.19	3.37	287.14**	341.7**	21.45	24.71
18	Number of fruits per plant		1.95	6.85	226.76**	254.05**	16.50	18.30
19	Fruit yield per plant (kg)		0.01	0.04	2.77**	3.26**	0.10	0.15

Table 2. Genetic variability parameters in sponge gourd (*Luffa cylindrica* (L.) Roem.) for different traits during spring summer season, 2019

Traits	General Mean	Range		Variance		Coefficient of variation (%)		Heritability (h^2)	Genetic Advance	Genetic Gain (%)
		Min.	Max.	Genotypic	Phenotypic	GCV	PCV			
Days to 50% germination	7.27	5.0	9.0	0.89	1.21	12.98	15.13	73.55	1.67	22.92
Days to first male flower emergence (DAS)	34.55	31.77	37.00	3.77	5.24	5.62	6.62	71.93	3.39	9.81
Days to first female flower emergence (DAS)	40.64	37.44	43.33	8.63	11.47	7.23	8.34	75.25	5.25	12.93
Node number of first male flower	9.82	7.66	12.33	4.83	6.25	22.38	25.46	77.29	3.98	40.53
Node number of first female flower	18.23	14.32	21.11	6.60	8.38	14.10	15.88	78.77	4.70	25.77
Inter nodal length (cm)	12.47	10.61	14.30	7.55	8.94	22.04	23.98	84.45	5.20	41.73
Number of leaves per plant	32.28	26.77	36.77	16.54	20.94	12.60	14.17	78.98	7.44	23.06
Leaf area (cm^2)	180.46	139.80	212.79	1122.05	1331.77	18.56	20.22	84.25	63.34	35.10
Number of branches	7.06	6.22	8.44	10.14	11.27	45.13	47.58	89.97	6.22	88.19
Male/female ratio	5.60	4.48	6.01	1.34	1.60	20.65	22.57	83.72	2.18	38.92
Days to first picking (DAS)	51.84	48.44	54.55	7.66	9.58	5.34	5.97	79.95	5.10	9.83
Fruit length (cm)	20.49	14.56	27.40	24.41	33.64	24.11	28.30	72.56	8.67	42.30
Fruit diameter (cm)	2.58	2.19	2.86	1.33	1.43	44.82	46.47	93.02	2.29	89.05
Specific gravity of fruits (g/cm^3)	0.81	0.66	0.91	0.06	0.07	31.04	33.40	86.36	0.48	59.42
Total soluble solids (%)	5.28	4.55	5.94	0.73	0.98	16.21	18.78	74.58	1.52	28.85
Dry matter content (%)	7.38	6.89	7.83	0.96	1.30	13.25	15.43	73.78	1.73	23.44
Fruit weight (g)	87.94	82.01	96.13	88.56	110.01	10.74	11.97	80.50	17.39	19.85
Number of fruits per plant	27.55	19.78	35	70.09	86.59	30.39	33.78	80.94	15.52	56.32
Fruit yield per plant (kg)	2.51	1.75	3.44	0.89	0.99	37.62	39.68	89.90	1.84	73.48

Table 3. Genetic variability parameters in sponge gourd (*Luffa cylindrica* (L.) Roem.) for different traits during Rainy season, 2019

Traits	General Mean	Range		Variance		Coefficient of variation (%)		Heritability (h^2)	Genetic Advance	Genetic Gain (%)
		Min.	Max.	Genotypic	Phenotypic	GCV	PCV			
Days to 50% germination	5.48	4.33	6.67	0.92	1.37	17.47	21.34	67.07	1.62	29.48
Days to first male flower emergence (DAS)	29.95	26.09	39.44	4.92	6.55	7.41	8.55	75.11	3.96	13.22
Days to first female flower emergence (DAS)	34.67	29.11	37.33	11.41	14.81	9.74	11.10	77.05	6.11	17.62
Node number of first male flower	8.32	6.33	10.33	4.90	6.73	26.63	31.20	72.82	3.89	46.81

Traits	**General Mean**	**Range**		**Variance**		**Coefficient of variation (%)**		**Heritability (h^2)**	**Genetic Advance**	**Genetic Gain (%)**
Node number of first female flower	11.57	9.33	14.66	8.31	10.44	24.91	27.92	79.60	5.30	45.79
Inter nodal length (cm)	14.71	11.96	16.44	8.17	9.97	20.26	22.38	81.95	5.33	37.78
Number of leaves per plant	47.21	42.00	52.66	21.44	26.35	9.81	10.87	81.37	8.60	18.23
Leaf area (cm^2)	191.18	146.69	229.23	1205.45	1459.95	18.16	19.99	82.57	64.99	33.99
Number of branches	8.10	7.33	10.00	17.43	19.05	51.56	53.90	91.49	8.23	101.60
Male/female ratio	3.75	3.34	4.26	1.97	2.37	37.38	41.01	83.10	2.63	70.20
Days to first picking (DAS)	43.83	40.11	45.55	11.31	13.72	7.67	8.45	82.43	6.29	14.35
Fruit length (cm)	23.37	17.56	29.26	27.51	39.71	22.44	26.96	69.27	8.99	38.47
Fruit diameter (cm)	2.88	2.52	3.39	4.33	4.53	72.40	74.05	95.59	4.19	145.82
Specific gravity of fruits (g/cm^3)	0.81	0.68	0.91	1.23	1.25	136.25	137.36	98.40	2.26	278.42
Total soluble solids (%)	3.72	3.00	4.39	1.05	1.41	27.47	31.85	74.41	1.82	48.82
Dry matter content (%)	6.39	6.02	6.77	0.69	1.21	13.03	17.23	57.14	1.30	20.29
Fruit weight (g)	90.69	82.94	102.87	105.66	130.37	11.33	12.59	81.05	19.06	21.02
Number of fruits per plant	29.31	19.78	38.11	78.58	96.88	30.04	33.35	81.11	16.45	55.73
Fruit yield per plant (kg)	2.79	1.86	3.73	1.04	1.19	36.50	39.05	87.36	1.96	70.28

3.2 Variance and Coefficients of Variation

The phenotypic variance and coefficients of variation were higher in magnitude than its genotypic counterpart indicating considerable environmental effect on expression of genes. During spring summer season (Table 2), high genotypic and phenotypic variances were observed for leaf area (1122.05 and 1331.77), fruit weight (88.56 and 110.01), number of fruits per plant (70.09 and 86.59), fruit length (24.41 and 33.64), number of leaves per plant (16.54 and 20.94) and number of branches (10.14 and 11.27). Similarly, during rainy season (Table 3) also higher genotypic and phenotypic variances were observed for leaf area (1205.45 and 1459.95), fruit weight (105.66 and 130.37), number of fruits per plant (78.58 and 96.88), number of leaves per plant (21.44 and 26.35) and days to first female flower emergence (11.41 and 14.81). The genotypic and phenotypic coefficients of variation were high to medium for the traits like number of branches (45.13% and 47.58%), fruit diameters (44.82% and 46.47%), fruit yield per plant (37.62% and 39.68%), specific gravity of fruits (31.04% and 33.40%), numbers of fruits per plant (30.39% and 33.78%), fruit length (24.11% and 28.30%) and node number of first male flower (22.38% and 25.46%) during spring summer season (Table-2). During rainy season (Table 3), high genotypic and phenotypic coefficients of variation were noted for specific gravity of fruits (136.25% and 136.36%), fruit diameters (72.40% and 74.05%) and number of branches (59.56% and 53.90%) whereas the coefficients were medium for male/female ratio (37.38% and 41.01%), fruit yield per plant (36.50% and 39.05%), number of fruits per plant (30.04% and 33.35%), total soluble solids (27.47% and 31.85%), node number of first male flower (26.63% and 31.20%), node numbers of first female flower (24.91% and 27.92%) and fruit length (22.44% and 26.96%). For the rest of traits, the genotypic and phenotypic coefficients of variation were low.

The phenotypic coefficient of variation (PCV) values was higher in magnitude than their corresponding genotypic coefficient of variation (GCV) values for all the traits. High to medium high magnitude of PCV and GCV were recorded for specific gravity of fruits, number of branches, fruit diameter, fruit length, number of fruits per plant, node number of first male flower and fruit yield per plant across the spring summer and rainy seasons. These values indicated a scope for improvement of these traits by straight selection. The higher magnitude of GCV and PCV was also reported in sponge gourd by Kumar et al. [7] for number of branches, Male/female ratio, number of fruit per plant and yield per plant; Singh *et al.* [8] for node number of male and female flower, number of fruits per plant and fruit yield per plant; Sharma et al. [9] for node number at which first appearance of pistillate flower and number of leaves per vine at 15 DAS and Kumar et al. [10] for total yield per vine, average weight of fruit and total soluble solids; Pandey et al. [11] for average fruit length, number of fruits per plant, average fruit weight and fruit diameter; Khule et al.. [12] for days to first male flower appearance, days to first female flower appearance, node number of first female flower, number of fruits per plant, fruit weight, fruit length and fruit diameter; Sanandia [13] for fruit yield per plant and number of fruits per plant and Singh et al. [14] for fruit weight, yield per plant, fruit length, node number of first female flower and number of fruits per plant.

3.3 Heritability

Heritability in broad sense was found high for fruit diameters (93.02%), numbers of branches (89.97%), fruit yield per plant (89.90%), specific gravity of fruits (86.36%), internodal length (84.45%), leaf area (84.25%), male/female ratio (83.72%), Number of fruits per plant (80.94%) and fruit weight (80.50%) whereas it was medium for rest of the traits during spring summer season (Table 2). During rainy season (Table 3), high heritability was noted for specific gravity of fruits (98.40%), fruit diameters (95.59%), numbers of branches (91.49%), fruit yield per plant (87.36%), male/female ratio (83.10%), leaf area (82.57%), days to first picking (82.43%), inter nodal length (81.95%), number of leaves per plant (81.37%), numbers of fruits per plant (81.11%) and fruit weight (81.05%). For the rest of the traits heritability was observed to be medium from 57.14% for dry matter content to 79.60% for node numbers of first female flower. In present investigation, high heritability (>80%) was found for fruit diameter, number of branches, fruit yield per plant, inter nodal length, number of fruits per plant, fruit weight and male/female ratio over the seasons. High heritability for these traits indicated that large proportion of phenotypic variance has been attributed to genotypic variance and therefore, reliable selection could be made for these traits on the basis of phenotypic expression. Corresponding to the results of present investigation, high heritability has also been reported in sponge gourd by

Kumar et al*.* [7] for number of primary branches, days to first female flower appearance, Male/female ratio, node number of first female flower, fruit diameter, fruit length, number of fruits per plant and fruit yield per plant; Singh et al. [15] for fruit diameter, fruit length, number of fruits and fruit yield; Kumar et al. [10] for average weight of fruit; Pandey et al. [16] for average fruit yield per plant and Sanandia [13] for fruit yield per plant and number of fruits per plant.

3.4 Genetic Advance as Percentage of Mean (Genetic Gain)

During spring summer season (Table 2), high genetic advance as percentage of mean (genetic gain) was recorded for most of the traits ranging from 89.05% for fruit diameter to 35.10% for leaf area. Other traits with high genetic advance as percentage of mean were number of branches (88.19%), fruit yield per plant (73.48%), specific gravity of fruits (59.42%), number of fruits per plant (56.32%), fruit length (42.30%), intermodal length (41.73%), node number of first male flower (40.53%) and male/female ratio (38.92%). Medium value of this parameter was recorded for total soluble solids (28.85%), node number of first female flower (25.77%), dry matter content (23.44%), number of leaves per plant (23.06%), days to 50% germination (22.92%) and fruit weight (19.85%). For the rest of traits genetic advance as percentage of mean was found to be low. During rainy season (Table-3), genetic advance as percentage of mean was high or medium for the most of the traits studied in this investigation expect days to first male flower emergence and days to first picking where this parameter was low (<15%).The highest value of genetic advance as percentage of mean was registered by specific gravity of fruits (278.42%) followed by fruit diameter (145.82%), number of branches (101.60%), fruit yield per plant (70.28%), male/female ratio (70.20%), numbers of fruits per plant (55.73%), total soluble solids (48.82%), node number of first male flower(46.81%), node number of first female flower (45.79%), fruit length (38.47%), internodal length (37.78%) and leaf area (33.99%).Medium value for this parameter was observed for days to 50% emergence (29.48%, fruits weight (21.02%), dry matter content (20.29%), number of leaves per plant (18.23%) and days to first female flower emergence (17.62%). The study of genotypic coefficient of variation helps to measure the range of genetic variation existing at specific experimental site for a particular character and to compare the variability existing in various characters. However, it cannot measure the heritable variation; the phenotypic coefficient of variation together with heritability estimates would give reliable indication of the expected amount of improvement through selection [17]. High magnitude of phenotypic coefficient of variation coupled with high heritability expressed in terms of high genetic advance as percentage of mean (>50%) was recorded for fruit diameter, number of branches, fruit yield per plant, specific gravity of fruits, male/female ratio and numbers of fruits per plant, over spring summer and rainy seasons. It indicated that these traits could be improved through direct selection with appreciable response of selection. Similar findings on high genetic advance as percentage of mean has also been reported in sponge gourd by Kumar et al*.* [7] for number of primary branches, sex ratio, fruit diameter, fruit length, number of fruits per plant and fruit yield per plant; Singh *et al.* [8] for fruit length, fruit diameter, number of fruits per plant, and fruit yield per plant; Kumar *et al.* [7]for specific gravity; Pandey *et al.* (2013) for number of fruits per plant, fruit diameter and fruit yield per plant; Khule *et al.* (2011) for fruit yield per plant and number of fruits per plant and Sanandia [13] for fruit yield per plant.

4. CONCLUSIONS

Based on two seasons (spring-summer and rainy) Analysis of variance highlighted significant differences among all genotypes for various traits. Phenotypic variance and coefficients of variation were notably higher than genotypic variance and coefficients, indicating a substantial environmental influence on gene expression. Traits such as number of branches, fruit diameter, number of fruits per plant, and fruit yield per plant displayed high phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability, and genetic advance as a percentage of mean. This suggests the potential for these traits to be improved through straightforward direct selection methods.

CONFERENCE DISCLAIMER

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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