Journal of Advances in Biology & Biotechnology

Volume 27, Issue 4, Page 198-205, 2024; Article no.JABB.114433
ISSN: 2394-1081

Analysis of Genetic Variability and Heritability in Brinjal (*Solanum melongena* L.) Genotypes

Saima Tabasum [a], Gazala Nazir [a*], Khursheed Hussain [a], Gowhar Ali [a], Nageena Nazir [a], Faheema Mushtaq [a], Z. Hussain [a] and Arizoo [a]

[a] Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Shalimar, Srinagar, Kashmir- 190025, India.

Authors' contributions

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

Article Information

DOI: 10.9734/JABB/2024/v27i4754

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/114433

Original Research Article

Received: 15/01/2024
Accepted: 19/03/2024
Published: 23/03/2024

ABSTRACT

Analysis on "Study of genetic variability and heritability in brinjal (*Solanum melongena* L.) genotypes" was carried out at the experimental field of Division of Vegetable Science, FOH, SKUAST, Kashmir Shalimar during kharif season 2021 in Randomised Complete Block Design with three replications. The experimental material comprised of forty genotypes. Analysis of variance revealed that mean sum of squares due to genotypes for all the characters were highly significant, revealing significant variation among all the genotypes for all the traits under study. The phenotypic coefficients of variation were found to be higher than the corresponding genotypic coefficients of variation. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) in present experienment were high for the traits; average fruit weight (43.69% and 43.69%), total anthocyanin content (39.10 % and 39.10%), ascorbic acid (31.73 % and 31.73) and dry matter

**Corresponding author: E-mail: gazalanazir6@gmail.com;*

(42.31% and 42.29). Heritability in broad sense was found to be high for all traits under study (greater than 70 per cent). Highest genetic advance as percentage of mean was recorded in average fruit weight (90) followed by dry matter (87.11) and total anthocyanin content (80.55).

Keywords: Genetic variability; heritability; GCV; PCV; brinjal.

1. INTRODUCTION

A frequently cross-pollinated crop, Brinjal (*Solanum melongena* L.), is a member of the angiospermic family "Solanaceae," with cross pollination rates as high as 48% observed [1]. Brinjal come in a wide variety of sizes, shapes, and colours, indicating that the Indian subcontinent is a significant hub for variation and perhaps origin. It is one of the most well-liked and adaptable vegetable crops in India, suitable for a variety of agro-climatic zones, and may be produced all year long from sea level to snow line. India is the second largest producer of Brinjal in the world next to China The annual global production of Brinjal is around 55.2 million metric tonnes, making it an important crop both economically and horticulturally. In India, the total area planted with Brinjal is 730,000 hectares, producing 12801,000 MT annually with an average productivity of 16.8 MT/hectare [2]. While in Jammu and Kashmir, it covers 2.51 thousand hectares and produces 45.62 thousand metric tonnes annually [2].

Brinjal is an important vegetable crop in our nation, and human society has had a social and economic link with it since ancient times. Despite their low yields and susceptibility to diverse pests and diseases, many indigenous cultivars are well-liked in many different places because of their desirable qualities. In terms of fruit size, shape, colour, growth behaviour, canopy bearing habit, yield, disease & insect-pest resistance, as well as quality and adaptation for different regions and for different growing seasons, there is significant genetic variety in Brinjal across the country.

The complete diversity existence in a germplasm must be studied and divided into genetic, phenotypic, and environmental variability in order for selection and development programmes to be effective. A crucial prerequisite for genetic improvement in a crop is the availability of genetic diversity. This makes it possible for the breeder to implement an effective breeding plan. Therefore, unpredictability plays a crucial role in determining the quantity of advancement anticipated from selection. A crop's potential for improvement would be greater the more genetic diversity it possessed and keeping the land limitation in mind it is important to improve the yield of brinjal by developing high yielding varieties [3].

2. MATERIALS AND METHODS

The experimental field of Division of Vegetable Science is located at the main campus, Shalimar, Srinagar 15 km away from Srinagar city on the foot hills of Mahadev. The altitude of the location is 1685 meter above mean sea level and situated 34^{o} N of latitude and 74.89^{o} E of longitude. The void temperature is temperate characterized by mild summers. Forty genotypes of Brinjal were evaluated with a spacing of 60x45cm in kharif season 2021 with design of experiement as Randomised Complete Block Design with three replications.

The uniform, healthy seedlings were transplanted on ridges maintaining inter and intra row spacing of 60cm x 45cm, respectively. All the recommended package of practices for raising a healthy crop were followed. Observations were recorded on five randomly selected plants of each genotype in each replication for various traits viz; Days to first flowering, Days to first fruit set, Days to first fruit picking, Number of branches per plant, Plant height(cm), Plant spread(cm), Fruit length (cm), Fruit diameter (cm), Number of fruits per plant, Average fruit weight (g), Fruit yield per plant (kg), Fruit yield per plot (kg), Fruit yield per hectare (q), Total soluble solids (°Brix), Total Anthocyanin content (mg/100g), Vitamin C (mg/100g), Phenols (mg/100g), Total sugars (%) and Dry matter (%).

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance

The analysis of variance indicated highly significant differences among the genotypes due to genotypes for all traits *viz*; Days to first flowering, Days to first fruit set, Days to first fruit picking, Number of branches per plant, Plant height(cm), Plant spread(cm), Fruit length (cm), Fruit diameter (cm), Number of fruits per plant,

Average fruit weight (g), Fruit yield per plant (kg), Fruit yield per plot (kg), Fruit yield per hectare (q), Total soluble solids (°Brix), Total Anthocyanin content (mg/100g), Vitamin C (mg/100g), Phenols (mg/100g), Total sugars (%) and Dry matter (%). Same results were found by Hassan et al. [4], Madhavi et al. [1], Milli et al. [5], Praveen et al. [6] and Dhaka and Soni [7], Kumar et al. [8], Singh et al. [9], Ansari et al. [10], Gazala et al. [11]. Analysis of variance indicated that sufficient variability existed for all these characters and which provide the potential for selection of suitable genotypes having desirable traits for further crop improvement as depicted in Tables 1a, 1b and 1c. However, analysis of variance by itself is not enough and conclusive to explain all the inherent genotypic variance in the genotype.

3.2 Genetic Parameters of Variability

The degree of variability present in crop plants, which is one of the most crucial selection criteria in the breeding programme, heavily influences the breeding program's success. A number of metrics, including GCV, PCV, h^2, genetic progress and GA%, were used to estimate variance. Environment played a critical effect in how a characteristic appeared phenotypically. The genotypic (heritable) and environmental (non-heritable) components of phenotypic variability are combined. In current study various genetical parameters like GCV, PCV heritability in broad sense and GA has been explained and is depicted in Table 2. The results of the finding have been discussed as below.

For both quantitative and qualitative qualities, the phenotypic coefficient of variation (PCV) was higher than the genotypic counterpart (GCV), indicating that the influence of environment is also a factor in the apparent variance in addition to genotype. According to Ukkund et al. [12], the magnitude of the coefficients of variability varies from character to character, being either low, moderate, or high. In our situation, the levels of variability across all variables were low (15%), moderate (15–30%) and high (> 30%), indicating a higher degree of diversity in the sample employed in the study. High phenotypic coefficient of variation (PCV) indicates the existence of greater scope for selection of the trait under consideration, which is dependent on the amount of variability present, while high genetic coefficient of variation (GCV) indicates the presence of high genetic variability for the traits which may facilitate selection. As can be perused from Table 2, the phenotypic coefficient of variation (PCV) in our present investigation were high for the traits; average fruit weight

List 1. List of Brinjal (*Solanum melongena* L.) genotypes used in the present study

S. No.	Genotypes	Source	S. No.	Genotypes	Source
1.	IC-074207	SKUAST-K	23.	SKAU-B-234	SKUAST-K
2.	IC-074244-1	SKUAST-K	24.	SKAU-B-236	SKUAST-K
3.	IC-089818	SKUAST-K	25.	SKAU-B-239	SKUAST-K
4.	IC-089888	SKUAST-K	26.	SKAU-B-241	SKUAST-K
5.	IC-090062	SKUAST-K	27.	SKAU-B-245	SKUAST-K
6.	IC-090063	SKUAST-K	28.	SKAU-B-247	SKUAST-K
7.	IC-099712	SKUAST-K	29.	SKAU-B-249	SKUAST-K
8.	IC-111010	SKUAST-K	30.	SKAU-B-251	SKUAST-K
9.	IC-261801	SKUAST-K	31.	SKAU-B-255	SKUAST-K
10.	IC-354867	SKUAST-K	32.	SKAU-B-257	SKUAST-K
11.	SKAU-B-193	SKUAST-K	33.	SKAU-B-259	SKUAST-K
12.	SKAU-B-197	SKUAST-K	34.	SKAU-B-263	SKUAST-K
13.	SKAU-B-205	SKUAST-K	35.	SKAU-B-266	SKUAST-K
14.	SKAU-B-209	SKUAST-K	36.	SKAU-B-268	SKUAST-K
15.	SKAU-B-211	SKUAST-K	37.	SKAU-B-270	SKUAST-K
16.	SKAU-B-215	SKUAST-K	38.	SKAU-B-274	SKUAST-K
17.	SKAU-B-219	SKUAST-K	39.	SKAU-B-276	SKUAST-K
18.	SKAU-B-222	SKUAST-K	40.	SKAU-B-279	SKUAST-K
19.	SKAU-B-224	SKUAST-K			
20.	SKAU-B-226	SKUAST-K			
21.	SKAU-B-229	SKUAST-K			
22.	SKAU-B-231	SKUAST-K			

Table 1a. Analysis of variance with respect to MSS for growth, maturity, yield attributing and quality

			Mean Sum of Squares						
S. No.	**Source of variation**	**Degrees of freedom**	**Days to first flowering**	**Days to first fruit set**	**Days to first fruit picking**	**Number branches per plant**	**Plant height(cm)**	**Plant spread(cm)**	**Fruit length(cm)**
1	Replication	2	12.47	15.98	20.00	3.47	42.21	36.69	6.27
2	Genotypes	39	25.69**	30.48**	33.20**	7.93**	549.58**	186.93**	41.47**
3	Error	78	0.73	0.72	1.66	0.91	0.09	0.03	0.23

**Significant at 5% probability level*
***Significant at 1% probability level*

Table 1b. Analysis of variance with respect to MSS for growth characters in brinjal (*Solanum melongena* L.)

			Mean Sum of Squares					
S. No.	**Source of variation**	**Degrees of freedom**	**Fruit diameter (cm)**	**Number of fruits per plant**	**Average fruit weight(g)**	**Fruit yield per plant (kg)**	**Fruit yield per plot (kg)**	**Fruit yield per hectare (q)**
1	Replication	2	0.05	17.53	50.99	0.002	15.24	263.01
2	Genotypes	39	0.69**	25.21**	14104.98**	0.10**	630.30**	14752.67**
3	Error	78	0.004	0.08	0.11	0.0001	1.13	17.64

**Significant at 5% probability level*
***Significant at 1% probability level*

Table 1c. Analysis of variance with respect to MSS for quality traits in brinjal (*Solanum melongena* L.)

			Mean Sum of Squares					
S. No.	**Source of variation**	**Degrees of freedom**	**Total soluble solids(°Brix)**	**Total anthocyanin (mg/100g)**	**Ascorbic acid(mg/100g)**	**Phenols(mg/100g)**	**Total sugars(%)**	**Dry matter(%)**
1	Replication	2	0.50	0.42	0.42	0.34	0.12	0.22
2	Genotypes	39	1.06**	9.95**	16.89**	485.34**	0.59**	16.86**
3	Error	78	0.008	0.0002	0.002	0.001	0.009	0.003

**Significant at 5% probability level*
***Significant at 1% probability level*

Table 2. Estimates of mean, range, phenotypic variance, genotypic variance, phenotypic and genotypic coefficients of variation, heritability (bs) and genetic advance (as % of mean) for growth, maturity, yield attributing and quality characters in brinjal (*Solanum melongena* L

S. No.	Parameters	Mean	Range	Phenotypic variance (PV)	Genotypic variance (GV)	Phenotypic coefficient of variation (PCV)	Genotypic coefficient of variation (GCV)	Heritability (bs)	Genetic advance (as % of mean)
1	Days to first flowering	46.81	40.53-50.52	9.05	8.31	6.42	6.16	0.91	12.16
2	Days to first fruit set	55.24	47.36-59.2	10.64	9.92	5.90	5.70	0.93	11.34
3	Days to first fruit picking	64.30	55.33-68.46	12.18	10.51	5.42	5.03	0.86	9.64
4	No. of branches per plant	12.43	8.81-14.86	3.25	2.33	14.50	12.29	0.71	21.47
5	Plant height (cm)	77.78	44.3-103.54	183.25	183.16	17.40	17.39	0.99	35.83
6	Plant spread (cm)	57.20	38.45-74.52	62.33	62.29	13.80	13.79	0.99	28.41
7	Fruit length(cm)	14.13	7.27-18.96	13.98	13.74	26.45	26.23	0.98	53.58
8	Fruit diameter (cm)	4.05	3.15-4.66	0.23	0.23	11.97	11.85	0.98	24.19
9	No. of fruits per plant	10.27	7.26-19.83	8.45	8.37	28.29	28.15	0.99	57.71
10	Average fruit weight (g)	156.93	49.44-307.36	4701.73	4701.62	43.69	43.69	0.98	90.00
11	Fruit yield per plant (kg)	0.90	0.38-1.14	0.036	0.035	21.00	20.94	0.99	43.07
12	Fruit yield per plot (kg)	69.06	29.01-87.01	210.85	209.72	21.02	20.96	0.99	43.07
13	Fruit yield ha^{-1}(q)	334.54	140.7-422.76	4929.32	4911.67	20.98	20.94	0.99	43.07
14	TSS content (˚Brix)	3.93	2.6-5.96	0.35	0.35	15.23	15.04	0.97	30.63
15	Total anthocyanin content (mg/100g)	4.65	0.21-7.8	3.32	3.31	39.10	39.10	0.99	80.55
16	Ascorbic acid (mg/100g)	7.46	2.30-10.33	5.63	5.63	31.73	31.73	0.99	65.35
17	Phenols (mg/100g)	95.24	77.1-114.1	161.78	161.78	13.53	13.35	0.98	27.50
18	Total sugars (%)	2.65	2.08-3.62	0.20	0.19	17.06	16.67	0.95	33.56
19	Dry matter (%)	5.60	1.4-10.3	5.62	5.61	42.31	42.29	0.99	87.11

(43.69%), total anthocyanin content (39.10 %), ascorbic acid (31.73 %) and dry matter (42.31%). Moderate phenotypic coefficient of variation (PCV) was recorded for plant height (17.40 %), fruit length (26.45 %), number of fruits per plant (28.29%), fruit yield per plant (21%), fruit yield per plot (21.02%), fruit yield per hectare (20.98%), total soluble solids (15.23 %) and total sugars (17.06 %) whereas, it was low for days to first flowering (6.42 %), days to first fruit set (5.90 %). days to first fruit picking (5.42 %), number of branches per plant (14.50%), plant spread (13.80%), fruit diameter (11.97%) and phenols (13.53%).

Similarly, the genotypic coefficient of variation (GCV) was high for average fruit weight (43.69%), total anthocyanin content (39.10 %), ascorbic acid (31.73 %) and dry matter (42.29%), moderate for plant height (17.39 %), fruit length (26.23 %), number of fruits per plant (28.15%), fruit yield per plant (20.94%), fruit yield per plot (21.96%), fruit yield per hectare (20.94%), total soluble solids (15.04 %) and total sugars (16.67 %) and low in case of days to first flowering (6.16 %), days to first fruit set (5.70%). days to first fruit picking (5.03%), number of branches per plant (12.29%), plant spread (13.79%), fruit diameter (11.85%) and phenols (13.35%)

The presence of high GCV for the traits as above indicates that there is considerable genetic variation present in these traits to warrant selection for better eggplant genotypes. In the earlier studies also, the high estimates of phenotypic (PCV) and genotypic (GCV) coefficients of variation have been observed for different characters by Sujjin et al. [13], Arti and Sharma [14], Balas et al. [15], Bende et al. [16], Dasmohapatra et al. [17] and Jirankali et al. [18] while moderate PCV and GCV were observed by Akpan et al. [19], Sujin et al. [13], Patel et al. [20], Ravali et al. [21] and Tirkey et al. [22] Low PCV and GCV obtained for different characters were supported by the findings of Vidya and Kumar [23], Mangi et al. [24], Verma et al. [25], Jirankali et al. [18] and Bende et al. [16].

3.3 Heritability

Heritability, which is important in evaluating the expression of phenotype connected to the genetic contribution of the trait, has a major impact on how effective a given breeding strategy is for different traits. According to Johansan et al. [26], the genetic advance and heritability values helped predict the anticipated advancement through selection. The estimates of heritability (broad sense) were found to be high for all the characters studied *viz*. Days to first flowering (91%), Days to first fruit set(93%), Days to first fruit picking(86%), Number of branches per plant(71%), Plant height(99%), Plant spread(99%), Fruit length (98%), Fruit diameter (98%), Number of fruits per plant(99%), Average fruit weight (98%), Fruit yield per plant (99%), Fruit yield per plot (99%), Fruit yield per hectare (99%), Total soluble solids (97%), Total Anthocyanin content (99%), Vitamin C (99%), Phenols (98%), Total sugars (95%) and Dry matter (99%). High heritability for different traits indicated that large proportion of phenotypic variance was attributed to genotypic variance and therefore, reliable selection could be made for these traits on the basis of phenotypic expression. Corroborating with the result of present investigation, Mohanty [27] estimated heritability in broad sense and it ranged from 56.8 per cent for plant height to 92.9 per cent for number of fruits per plant and illustrated that due to such a high values of heritability these traits were least influenced by environmental modification. Similarly, Shekar et al. [28] also reported “high heritability in fruit length (99.00 %), fruit diameter (97.00 %), day to first flowering (97.00 %), days to first picking (97.00 %), number of fruits per plant (89.00 %), fruit yield per plant (83.00 %), fruit yield per plot (83.00 %), fruit yield per hectare (83.00 %) and number of branches per plant (81.00 %)”. Akpan et al. [19] reported “high broad sense heritability estimates for fruit circumference (98.37 %), fruit diameter (97.44 %), number of fruits per plant (83.27 %) in brinjal grown in early season, while the late season planting experiment showed that fruit yield per hectare (98.08 %), number of fruits per plant (99.48 %), fruit circumference (99.16 %) and fruit diameter (98.50 %) were among traits with high broad sense heritability”.

3.4 Genetic Advance and Genetic Gain

An inquisition of data in Table 2 revealed that genetic gain (expressed as per cent of population mean) was low to high in nature and ranged from 9.64 to 90 per cent for different characters under study. It was found high for the traits *viz*. Number of branches per plant(21.47%), Plant height(35.83%), Plant spread(28.41%), Fruit length (53.58%), Fruit diameter (24.19%), Number of fruits per plant(57.71%), Average fruit weight (90%), Fruit yield per plant (43.07%), Fruit yield per plot (43.07%), Fruit yield per hectare (43.07%), Total soluble solids (30.63%), Total

Anthocyanin content (80.55%), Vitamin C (65.35%), Phenols (27.50%), Total sugars (33.56%) and Dry matter (87.11%). Moderate genetic gain was observed for days to first flowering (12.16 %) and days to first fruit set (11.34 %) while, low genetic gain was observed for days to first fruit picking (9.64 %).

A reliable selection could be made for these qualities based on phenotypic expression since high heritabilities for various traits suggested that a significant amount of phenotypic variation was related to genotypic variance. High heritability (> 60 %) coupled with high genetic advance as per cent over mean (> 20 %) were observed for Number of branches per plant, Plant height, Plant spread, Fruit length, Fruit diameter, Number of fruits per plant, Average fruit weight, Fruit yield per plant, Fruit yield per plot, Fruit yield per hectare, Total soluble solids, Total Anthocyanin content, Vitamin C, Phenols, Total sugars and Dry matter and the results were in accordance with Verma et al. [25], Dasmohapatra et al. [17], Balas et al. [15], Jirankali et al. [18] and Bende et al. [16]. This indicates the predominance of additive gene component. Thus, there is scope for improving these characters with direct selection.

4. CONCLUSION

Based on the findings of the present investigation it could be concluded that sufficient amount of genetic variation existed in the present set of material and the genotypes could be used in future breeding programmes for bringing about improvement in the crop. Analysis of variance indicated that mean sum of squares due to genotypes were significant for all the characters indicating the presence of sufficient amount of variability in the genotypes.The phenotypic coefficient of variation was in general higher than the genotypic coefficient of variation for all the characters, indicating that the influence of environment is also a factor in the apparent variance in addition to genotype. High heritability coupled with high genetic gain was observed for almost all traits under study indicating that these features are controlled by additive gene action and that direct selection for these traits could result in a significant improvement in the ability to recognise superior genotypes of brinjal.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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