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Genetic Diversity Assessment of Brinjal Germplasm for Varietal Improvement

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Abstract

Forty-one (41) brinjal (*Solanum melongena* L.) germplasm of were evaluated at the field of Plant Genetic Resources Centre, BARI, Gazipur to identify the salient features and to assess genetic divergence of germplasm in the time of rabi season 2021-22. Distinct variation was observed in qualitative characters among the germplasm except two characters i.e. fruit cross section and fruit position. For the characters length breath ratio and calyx prickles of fruit, the topmost variation was found. In case of quantitative characters, variation was noticed maximum in the length of fruit (CV-43.79%), afterwards individual weight of fruit (CV-32.91%) and yield plant^{-1} (CV-30.12%). The highest number of germplasm was dispersed into cluster I. Among the clusters, cluster II and cluster III were occupied by ten germplasm, respectively. Cluster mean value was noted maximum in cluster II for the characters days required for 50% flowering (67.90%), plant height (97.97 cm), individual fruit weight (107.35 g), and yield plant^{-1} (2.51%). Among the principal components, 27.28% of the total variation interpreted by the first PC and the second PC clarified 22.36% of the variation. In the biplot, germplasm NF-15, NF-20, NF-13, NF-7, NF-4, NF-25, NF-16, and NF-2 etc. were independently far away from the studied germplasm by keeping a distance from the centroid. These results displayed distinctiveness and divergence of germplasm as regards of the studied traits. Populations with high values for the first eigen vectors are individual fruit weight (0.642), yield plant^{-1} (0.564), and width of fruit (0.313), these characters were the utmost significant contributors towards the diversity of germplasm in PC1. The germplasm NF-4 (3.45 kg), NF-30 (3.38 kg), and NF-25 (3.08 kg) were higher yielders among the tested germplasm and may be used for future varietal improvement of brinjal.

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Introduction

Brinjal (*Solanum melongena* L., 2n = 24), is the most important year-round vegetable crop, and is regarded as one of the members of Solanaceae family. Brinjal is being cultivated from the subtropics to the Mediterranean region. By covering 87% growing area more than 90% of global brinjal is produced in Asia (Bhagirath and Kadambini 2009). In Bangladesh brinjal got the second position after potatoes considering production. It is also noted poor man's vegetables for its high production capacity and availability (Kumar *et al.*, 2014). In 2019, brinjal is a significant fruit vegetable that exceed world production by about 55.20 million tones (FAO, 2020). Brinjal's total production in Bangladesh was 585,000 tons during 2019-20 (BBS, 2020). Huge indigenous biodiversity persists in brinjal with plant type, leaf size, midrib colour, stem colour, leaf tip; size, shape, colour of fruit and yield; fruit and cooking quality, and pests and diseases tolerance (Ullah *et al*., 2014).

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During the development of variety by a hybridization program, germplasm characterization is surely substantial to figure out genetic information. In plant breeding programs, characterization of germplasm is an essential task to deliver required information (Lin, 1991). Collected germplasm's characterization is necessitated to determine lines suitable for development of new varieties (Adeniji and Aloyce, 2012). Plant breeders are focused on study of genetic divergence on the basis of qualitative and quantitative characters since these traits could be scored shortly and simply through low-cost methods (Uddin *et al*., 2021). Forty-one germplasm of brinjal were collected under a project entitled "Collection and Characterization of Brinjal Genotypes for Varietal Improvement" from special research allocation funded by Science and Technology Ministry. Hence, this research was executed to characterize the germplasm of brinjal morphologically and to estimate genetic divergence for future crop improvement.

Materials and Methods

The experiment was executed at Plant Genetic Resources Centre's research field of Bangladesh Agricultural Research Institute (BARI), Gazipur, at rabi season 2021-22. Forty-one (41) brinjal germplasm were used that were collected from different upazilas of Narsingdi, Bogura district and PGRC, BARI, Gazipur. Seeding was done in seed beds on 1st December 2021 and thirty days aged seedlings were transplanted. The size of plot was 3 X 1.4 m^2. Each germplasm were planted in two rows plots having four pits. Distance between row to row and plant to plant was maintained in 70 cm X 70 cm. Fertilizer doses were 10 ton/ha Cow dung, 300 kg/ha Urea, 250 kg/ha TSP, 200 kg/ha MP, 100 kg/ha gypsum, and 10 kg/ha Boric acid (Azad *et al*., 2019). The entire amounts of cowdung, TSP, gypsum and boron were applied at the time of land preparation prior to one week of transplanting. Urea and MP were put on in application in the three equivalent splits at 15 after transplanting, before flowering and before fruiting. Weeding and mulching were executed according to need. Bagging was done in individual fruit to avoid cross-pollination. The data were recorded according to the descriptor developed by IBPGR, 1990. Qualitative data was illustrated in the method of frequency distribution. Quantitative data were analyzed over simple descriptive statistics incorporating mean, variance, standard deviation, and coefficient of variation. Cluster analysis and Principle component analysis were carried out by computerized software Statistical Tool for Agricultural Research (STAR 2.0.1, 2014).

Results and Discussion

Forty-one (41) germplasm of brinjal were studied for characterization and divergence. These germplasms were characterized by twenty-six (26) different characters including 18 qualitative and 8 quantitative characters.

Qualitative characters

A total of 18 qualitative characters were assessed to find out the variation of germplasm (Table 01 and 02). The studied characters displayed well defined variation except cross section and position of fruit. The topmost variation was noticed in overall length breath ratio and calyx prickles of fruit.

Variability in growth and foliage

Entirely the studied traits appertaining to plant growth habits and foliage displayed distinct variations among the germplasm (Table 01). Plant growth habits were observed in three types i.e. upright (34.14%), intermediate (60.98%), and prostrate (4.88%). (Shekar *et al*., 2013) grouped the brinjal germplasm into upright and intermediate. (Islam *et al*., 2018) clustered 48% intermediate, 45% upright, and 7% prostrate growth habit amongst the 40 germplasm at the vegetative stage. They advocated that the recording of plant growth habit is needed for the identification of brinjal varieties. In case of leaf blade lobing 12 germplasm had weak type (29.27%), 12 germplasm had intermediate type (88%), 13 germplasm had strong type (31.71%) and very strong type leaf blade lobing was found in only 4 germplasm (9.76%). (Sunseri *et al*., 2010) stated 60% weak type, 37% intermediate, and 3% strong type lobbing of leaf blade in brinjal. Very acute (2.44%), acute (51.22%), intermediate (31.71%), and obtuse (14.63%) categories of leaf blade tip angle were observed among the studied germplasm. (Dash *et al*., 2019) noted acute type leaf blade tip angle in

many brinjal genotypes. In case of leaf blade length, variation was exhibited in three types i.e. 14.63% germplasm of short leaf length and 58.54% germplasm had an intermediate leaf length which was the maximum, and 26.83% germplasm had longer leaf length. For the character leaf prickles, variation was exhibited in three types i.e. 95.12% germplasm had no leaf prickles and the rest had very few (2.44%) and intermediate (2.44%). Considerable variation was observed in leaf prickle by (Uddin *et al*., 2021) where maximum genotypes (72 genotypes) had intermediate leaf prickle.

Table 1. Variability in growth and foliage characters in brinjal germplasm

Name of descriptor	Descriptor state	No. of germplasm	% of germplasm
Plant growth habit	Upright	14	34.14
	Intermediate	15	60.98
	Prostrate	2	4.88
Leaf blade lobing	Weak	12	29.27
	Intermediate	12	29.27
	Strong	13	31.71
	Very strong	04	9.76
Leaf blade tip angle	Very acute	01	2.44
	Acute	21	51.22
	Intermediate	13	31.71
	Obtuse	06	14.63
Leaf blade length	Short	06	14.63
	Intermediate	24	58.54
	Long	11	26.83
Leaf blade width	Short	11	26.83
	Intermediate	16	39.02
	Wide	14	34.15
Leaf prickles	None	39	95.12
	Very few	01	2.44
	Intermediate	01	2.44
Leaf hairs	Very few	20	48.78
	Few	18	43.90
	Intermediate	02	4.88
	Many	01	2.44
Corolla colour	Pale violet	03	7.32
	Light violet	18	43.90
	Bluish violet	20	48.78
Stigma position	Included	3	7.32
	Same level	19	46.34
	Exerted	19	46.34

Variability in characters of fruit

Characters pertaining to the brinjal fruit displayed prominent variation among the germplasm excluding cross section and position of fruit (Table 02). In the case of fruit length/breadth ratio, 12.21% germplasm had ‘broader than long’ type. 7.32% and 9.76% germplasm had ‘as long as broad as ’and ‘slightly longer than broad’ type, respectively. ‘Twice as long as broad’ type was observed in 7.32% germplasm and ‘three times as long as broad’ in 29.74%. The rest (17.85%) had ‘several times as long as broad’ type fruit. No fruits were found curved in 90.20% of the germplasm. 7.32% germplasm showed slightly curved and 2.44% showed curved. (Parida *et al*., 2020) noticed that 68 genotypes had no curvature on fruit; 37 genotypes showed slightly curved fruit and 25 genotypes had curved fruit. Fruit apex was exhibited as three categories such as, protruded (17.07%), rounded (39.03%) and depressed (43.90%). (Sunseri *et al*., 2010) reported that 38, 34, and 28% of eggplant genotypes had depressed, rounded, and protruded types of fruit apex shape, respectively. Four categories of fruit color at ripening such as green

(75.61%) which was maximum and lilac grey (9.76%), purple (7.32%), and black purple (7.32%) were observed (Fig. 03). Fruit color distribution was exhibited as uniform (14.63%), mottled (21.95%), netted (36.59%) and striped (26.83%). Relative fruit calyx length was very short (48.78%), short (48.78%), and intermediate (2.44%) type. Similar kinds of fruit calyx prickle distribution were also reported by (Parida *et al*., 2020).

Table 2. Variability in fruit characters in brinjal germplasm

Name of descriptor	Descriptor state	No. of germplasm	% of germplasm
Fruit length/ breadth ratio	Broader than long	4	12.21
	As long as broad	22	7.32
	Slightly longer than broad	5	9.76
	Twice as long as broad	3	7.32
	Three times as long as broad	4	29.74
	Several times as long as broad	3	17.85
Fruit curvature	None (fruit straight)	37	90.24
	Slightly curved	3	7.32
	Curved	1	2.44
Fruit apex shape	Protruded	7	17.07
	Rounded	16	39.03
	Depressed	18	43.90
Fruit colour at commercial ripeness	Green	31	75.61
	Lilac grey	4	9.76
	Purple	3	7.32
	Black purple	3	7.32
Fruit colour distribution	Uniform	6	14.63
	Mottled	9	21.95
	Netted	15	36.59
	Striped	11	26.83
Relative fruit calyx length	Very short	20	48.78
	Short	20	48.78
	Intermediate	1	2.44
Fruit calyx prickles	None	26	63.41
	Very few	3	7.32
	Few	4	9.76
	Intermediate	4	9.76
	Many	3	7.32
	Very many	1	2.44
Fruit cross section	Circular (no groovs)	41	100.00
Fruit position	Pendant	41	100.00

Quantitative Characters

Range, mean, standard deviation, and CV% of the quantitative data of brinjal are presented in Table 03. The maximum quantitative variation was observed in fruit length (CV-43.79%) which was followed by individual fruit weight (CV-32.91%) and yield plant^{-1} (CV-30.12%). Germplasm required 63-91 days to fifty percent flowering with an average of 66.59 days. Quantitative trait descriptors of forty-one brinjal germplasm are presented in Table 04. The taller plant exhibited in the germplasm of NF-17 (122.20 cm), NF-6 (121.6 cm), and NF-16 (116.5 cm) (Table 04). The longer fruit was observed in NF-17 (19.00 cm) followed by NF-14 (14.60 cm) and NF-20 (13.80 cm). Germplasm NF-16 and NF-28 had maximum fruit diameter (7.4 cm) that was followed by NF-25 (7.15 cm) and NF-39 (6.75 cm). The heavier fruit was found in NF-16 (175.60 g) and the lightest fruit was found in NF-15 (44.50 g). NF-16 produced the maximum fruit per plant (35) that was followed by NF-20 (32) and NF-11(27). The highest yield per plant was found in NF-16 (3.51 kg). The germplasm NF-4 (3.45 kg), NF-30 (3.38 kg), and NF-25 (3.08 kg) were higher yielder among the tested germplasm.

Table 3. Quantitative variation of different characters in brinjal

Characters	Min	Max	Mean	SD	CV (%)
Days to 50% flowering	63	91	66.59	5.39	8.10
Plant height (cm)	66.8	122.2	96.29	12.12	12.58
Fruit length (cm)	3.83	19.00	8.36	3.66	43.79
Fruit width (cm)	1.85	7.40	5.22	1.18	22.61
Individual fruit weight (g)	44.5	175.6	95.91	31.56	32.91
Number of fruits per plant	17	35	22.83	3.53	15.48
100 seed wt.	0.20	0.41	0.30	0.05	17.61
Yield per plant (g)	1.1	3.51	2.15	0.65	30.12

Table 4. Listing of quantitative traits descriptors of forty-one brinjal germplasm

Collector's number	Days to 50% flowering	Plant height (cm)	Fruit length (cm)	Fruit width (cm)	Individual fruit weight (g)	No. of fruits per plant	100 seed wt. (g)	Yield per plant (kg)
NF-01	83	99.6	6.20	5.2	70.0	23	0.29	1.61
NF-02	73	88.0	6.85	6.23	85.2	17	0.37	1.45
NF-03	64	85.6	9.00	5.00	118.5	18	0.41	2.13
NF-04	91	90.2	10.30	5.80	150.2	23	0.25	3.45
NF-05	63	76.4	4.00	4.75	72.5	20	0.29	1.45
NF-06	64	121.6	6.20	5.10	70.32	25	0.26	1.76
NF-07	63	102.5	13.75	4.25	164.0	20	0.32	3.28
NF-08	64	104.4	7.50	6.24	89.5	23	0.27	2.06
NF-09	65	85.9	7.50	5.70	100.8	24	0.31	2.42
NF-10	67	87.4	6	5	84.6	21	0.29	1.78
NF-11	64	100.4	12.5	7	101.8	27	0.34	2.75
NF-12	63	75.5	11.8	5.5	105	20	0.28	2.10
NF-13	64	96.6	13.5	4.5	89.3	26	0.21	2.32
NF-14	63	72.2	14.6	4.2	119.7	23	0.3	2.75
NF-15	65	85.8	18	1.85	44.5	35	0.2	1.56
NF-16	63	116.5	9.6	7.4	175.6	20	0.29	3.51
NF-17	64	122.2	19	3.6	105.33	19	0.34	2.00
NF-18	64	111.4	5.75	6	98.5	17	0.25	1.67
NF-19	63	87.4	8.5	6	109.5	26	0.27	2.85
NF-20	70	97.4	13.8	4.16	78.6	32	0.29	2.52
NF-21	64	99.2	8.1	3.8	89.7	24	0.22	2.15
NF-22	65	109.5	6.5	5.9	75.6	22	0.38	1.66
NF-23	69	92.6	6	5	60	24	0.3	1.44
NF-24	64	91.4	5.8	6.8	62.5	21	0.26	1.31
NF-25	70	98.8	7.5	7.15	139.8	22	0.39	3.08
NF-26	64	98.2	7.8	4.5	51.2	26	0.41	1.33
NF-27	67	107.2	9.1	4.52	131.6	22	0.27	2.90
NF-28	66	105.4	8	7.4	100.2	23	0.3	2.30
NF-29	64	90.6	9.6	6	66.5	23	0.31	1.53
NF-30	66	94.2	3.83	4.5	135.5	25	0.32	3.39
NF-31	64	92.2	5.2	4.8	70.5	26	0.21	1.83
NF-32	65	66.8	5.3	4.9	77.2	20	0.3	1.54
NF-33	65	90.6	5.5	4.2	100.9	22	0.27	2.22
NF-34	73	91.4	6.5	4.5	163	17	0.32	2.77
NF-35	68	98	9.1	6.9	112.5	23	0.23	2.59
NF-36	68	106.2	5	4.5	55	22	0.33	1.05
NF-37	67	98.2	8.9	3.6	88	24	0.36	2.11
NF-38	67	106.2	4.78	4.94	70.6	23	0.37	1.62
NF-39	64	93.6	6.2	6.75	77.9	21	0.26	1.64
NF-40	65	104.8	4.5	4.8	80.3	23	0.29	1.85
NF-41	65	105.8	5	5.23	90.5	24	0.34	2.17

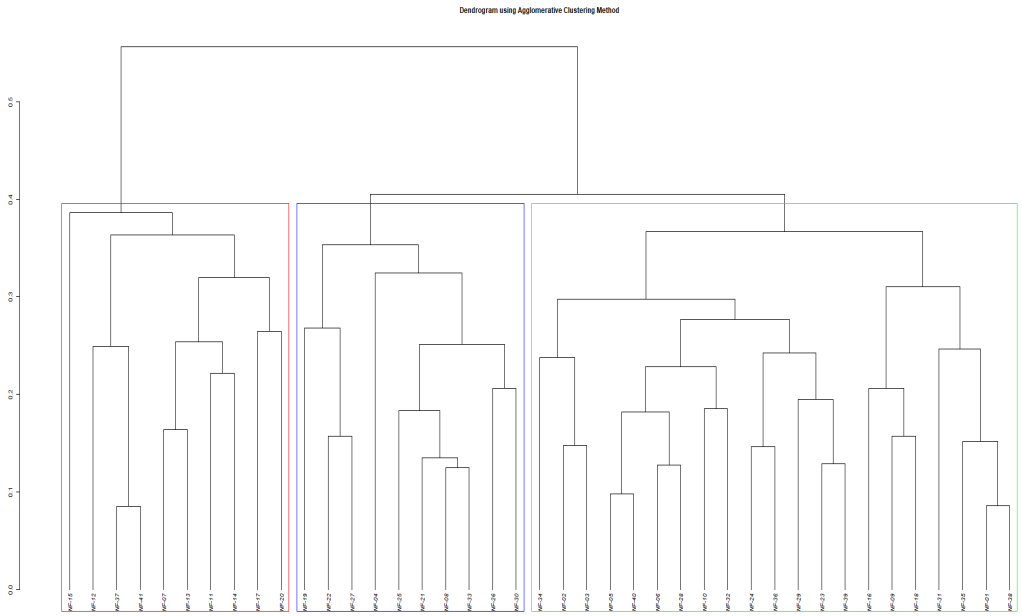

Fig. 1. Cluster tree of forty-one germplasm of brinjal based on quantitative characters

Germplasm Distribution and Dendrogram

Forty-one brinjal germplasm were grouped into three clusters based on 8 quantitative traits. The dendrogram showed that the cluster I included 21 germplasm. Cluster II and Cluster III included ten germplasm, respectively (Table 05 and Figure 01). These results were confirmed by the findings of (Quamruzzaman *et al.*, 2009). They observed nineteen genotypes were grouped into 5 clusters based on cluster analysis in brinjal genotypes.

Table 5. Distribution of forty-one germplasm in three different clusters

Cluster	Number of germplasm	Germplasm included in different clusters
I	21	NF-01, NF-02, NF-03, NF-05, NF-06, NF-09, NF-10, NF-16, NF-18, NF-23, NF-24, NF-28, NF-29, NF-31, NF-32, NF-34, NF-35, NF-36, NF-38, NF-39, NF-40
II	10	NF-04, NF-08, NF-19, NF-21, NF-22, NF-25, NF-26, NF-27, NF-30, NF-33
III	10	NF-07, NF-11, NF-12, NF-13, NF-14, NF-15, NF-17, NF-20, NF-37, NF-41

Cluster means

Characterizations of individual germplasm were made with respect of their mean value for different characters to get an idea of whether the germplasm has similar characteristics that could be disseminated. In cluster means the genetic differences between clusters were reflected. Enormous variations were observed in cluster mean for all characters (Table 06). The maximum cluster mean value was observed in Cluster II for the characters days to 50% flowering (67.90%), plant height (97.97 cm), Individual fruit weight (107.35 g), and yield per plant (2.51%). Larger fruit length and fruit width were observed in cluster III and cluster I, respectively. Grouping of the germplasm to different clusters allows selecting germplasm to develop high-yielding and good-quality varieties.

Table 6. Cluster means for eight characters of forty-one brinjal germplasm

Characters	I	II	III
Days to 50% flowering	66.81	67.90	64.80
Plant height (cm)	95.79	97.97	95.66
Fruit length (cm)	6.53	7.46	13.09
Fruit width (cm)	5.60	5.26	4.39
Individual fruit weight (g)	89.15	107.35	31.81
Number of fruits per plant	21.48	23.50	25.00
100 seed wt.	0.30	0.30	0.30
Yield per plant (kg)	1.87	2.51	2.36

Principal Component Analysis (PCA)

Principal component analysis was carried out by calculating the first two principal components that are accounted for 49.64 % of the total divergence (Figure 02). The first PC displayed 27.28% of the total variability and the second PC explained 22.36% of the variation among 41 brinjal germplasm. Thus, the present study revealed that the first PC was more important than the second PC for explaining the variability among the germplasm based on studied traits. Begum *et al*. (2013) observed that the first axes totally accounted for 20.07% variation among the genotype. The brinjal germplasm NF-15, NF-20, NF-13, NF-7, NF-4, NF-25, NF-16, and NF-2 were independently far away from the others and they were at a distance from the centroid. These results displayed their distinctiveness and divergence of the germplasm.

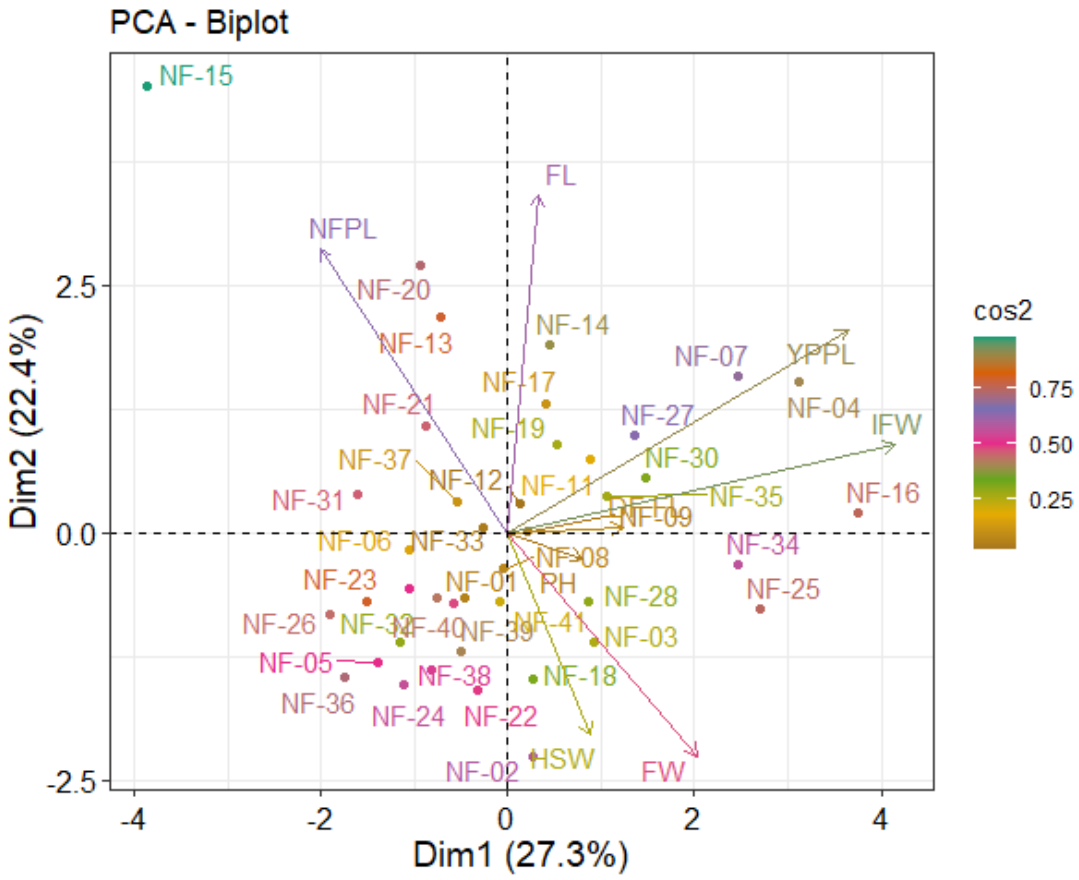

Fig. 2. The plot of the first two PC1 and PC2 for forty-one brinjal germplasm showing relationship between germplasm and characters

Eigenvalues and Eigen vectors

The eigenvalues and vectors of eight characters for a PCA of important traits for the first fifth principal components in 41 brinjal germplasm are shown in Table 07. Populations with high scores for the first eigenvectors are individual fruit weight (0.642), yield per plant (0.5643), and fruit width (0.3138), these traits were the most important contributors to the diversity of the germplasm in PC1. The second eigenvector was mostly connected with scores of fruit length (0.5837) and number of fruits per plant (0.4893), these traits were the second most important contributors among the eight characters for 41 germplasm. Quamruzzaman *et al*., 2009 found three characters for contribution towards divergence.

Table 7. Principal Components for eight traits of brinjal germplasm

Characters	PC1	PC2	PC3	PC4
Days to 50% flowering	0.1914	0.0088	0.6065	0.3193
Plant height (cm)	0.1253	-0.0449	-0.6873	0.5843
Fruit length (cm)	0.0504	0.5837	-0.2433	-0.2279
Fruit width (cm)	0.3138	-0.3864	0.0050	0.3817
Individual fruit weight (g)	0.6423	0.1520	0.0082	-0.1410
Number of fruits per plant	-0.3116	0.4893	-0.0223	0.2964
100 seed wt.	0.1363	-0.3492	-0.3155	-0.5010
Yield per plant (g)	0.5643	0.3513	0.0204	0.0153
Eigenvalue	2.182	1.788	1.0772	0.9573
Variability (%)	27.28	22.36	13.46	11.97
Cumulative (%)	27.28	49.64	63.11	75.07

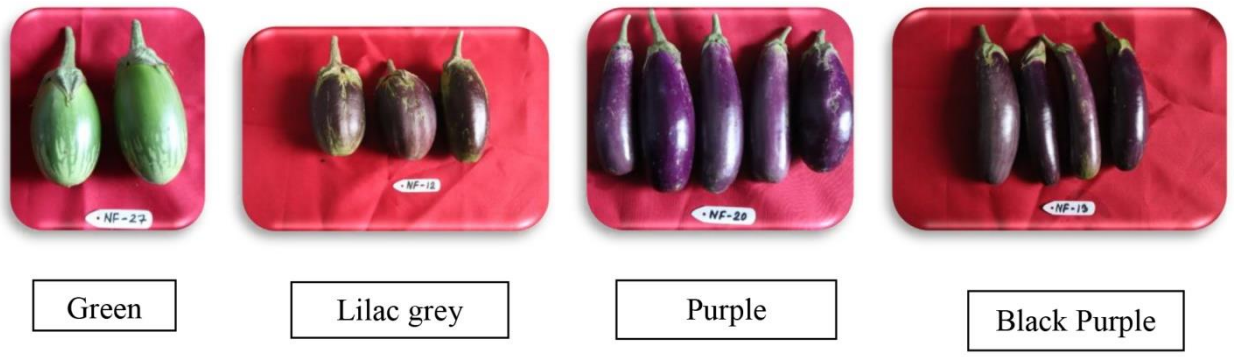

Fig. 3. Variation in fruit colour where green was 75.61%, lilac grey (9.76%), Purple (7.32%), and black purple (7.32%) in collected germplasm

Conclusions

The genetic variability of forty-one germplasm of brinjal was estimated through morphological characterization and the assessment of genetic divergence through biometrical approaches assisted in choosing genetically diverged parents for a fruitful hybridization program. The study indicated that the brinjal germplasm NF-20, NF-13, NF0-7, NF-4, NF-25, NF-16, and NF-2, etc. were separately isolated from the others in respect of different characters. Therefore, the promising germplasm identified in the present study might be used in future breeding programs for crop improvement.

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Conflict of Interests

The authors claim that they have no interests that conflict with one another.

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