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Diversity analysis in eggplant germplasm in india using DIVA-GIS approach

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ABSTRACT

Eggplant (*Solanum melongena* L.) is an important solanaceous vegetable crop of Indian origin having immense variability in morphological descriptors evolved in different agro-ecological zones of the country. Among the 2,500 accessions conserved in the National Gene Bank at National Bureau of Plant Genetic Resources, New Delhi, 20% were randomly selected for morphological diversity analysis. Wide range of variation was recorded for 21 descriptors studied. Shannon Diversity Index (H) for traits ranged from for fruit position (0.01), fruit curvature (0.20), plant growth habit (0.46), fruit apex shape (0.52), leaf blade tip angle (0.64), plant height (0.71), petiole color (0.76), leaf blade colour (0.77), leaf prickles on upper surface (0.84), fruit peduncle prickles (0.87), calyx spininess (0.95), calyx colour (0.99), plant spread(1.01), corolla colour (1.02), fruit seediness (1.03), fruit density (1.03), fruit colour distribution (1.10), leaf blade lobbing (1.15), fruit shape (1.30), fruit length breadth ratio (1.40) to a maximum of 1.51 for fruit colour. Morphological diversity and accessions' collection site data are integrated using DIVA-GIS software for diversity analysis, and finding gaps relating to germplasm collection and conservation of eggplant germplasm. Grid maps generated for the diversity analysis of several fruit descriptors indicated the occurrence of diverse accessions for plant height from the states of Karnataka, Odisha, Rajasthan and Uttar Pradesh, for fruit colour from Andhra Pradesh, Orissa, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal and for fruit shape from eastern states. The study would help in better management and utilization of eggplant genetic resources in the country.

Key words: Brinjal, morphological variability, DIVA-GIS, germplasm, diversity analysis.

INTRODUCTION

Eggplant or brinjal (S*olanum melongena* L., 2n=24) belongs to family Solanaceae and is an important popular vegetable crop grown throughout the year all over India. Being primary centre of origin, wide range of variability exists, and a large number of traditionally grown cultivars (landraces) have evolved in different agro-ecological zones in India. Genetic variability present in different traits offers great scope for improvement in the crop. The knowledge of morphological variability, its nature and magnitude are essential for selecting desirable genotypes from the germplasm for successful utilization in breeding programme. The value of germplasm depends not only on the number of accessions but also on the genetic variability present among them.

DIVA-GIS, a Geographic Information System (GIS), is a recent tool that supports the analysis of exploration, evaluation, gene bank and herbarium databases to elucidate genetic, ecological and geographic patterns of the distribution of crops and wild species. It is designed to assist the plant genetic resources curators and biodiversity managers to map the range of distribution in the species (Hijmans and Spooner, 4). GIS has been successfully used by researchers in identifying areas of diversity in various crops. For the first time in India, DIVA-GIS have been used to study the diversity in eggplant germplasm. Keeping this in view, the present paper reports the results of a study on the variability of morphological traits in eggplant germplasm as integrated with DIVA-GIS analysis.

MATERIALS AND METHODS

Amongst the 500 accessions of indigenous brinjal germplasm representing different geographical regions and agro-ecological zones of the country (Table 1), characterization data was recorded on 492 accessions (eight accessions did not germinate). The accessions were grown in 25 blocks at NBPGR Experimental Station, Issapur, New Delhi. Twenty four blocks had 20 accessions each and the last block comprised of remaining 12 accessions. Each accession was grown in 6 m row plots, with 60 cm plant to plant spacing and 75 cm row to row spacing. Six improved cultivars, namely, Pusa Kranti, Pusa ssUpkar, Pusa Ankur, Arka Shirish, Arka Neelkanth and Arka Keshav were included as checks (controls) and spaced randomly once in each block. Recommended agronomic practices for crop

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Table 1. Region/State-wise number of accessions included in the study.

Region/ State	No. of accessions	Region/ State	No. of accessions
North Eastern		Eastern	
Assam	62	Bihar	18
Meghalaya	19	Chhattisgarh	01
Tripura	02	Jharkhand	12
Central		Odisha	96
Madhya Pradesh	17	West Bengal	77
Southern		Northern	
Andhra Pradesh	37	Delhi	08
Karnataka	11	Haryana	01
Kerala	26	Himachal Pradesh	11
Tamil Nadu	39	Jammu and Kashmir	02
Western		Punjab	06
Gujarat	07	Uttar Pradesh	10
Maharashtra	18	Uttarakhand	04
Rajasthan	08		
Total			492

growth were followed. Data were recorded on eight randomly chosen competitive plants for 21 descriptors (Table 2) following the minimal descriptors list defined by NBPGR (Srivastava *et al*., 10).

Shannon Diversity index and frequencies were calculated for all the descriptors. Shannon's index accounts for both abundance and evenness of the trait states present (Negassa, 7). The proportion of descriptors states *i* relative to the total number of states (p_i) is calculated, and then multiplied by the natural logarithm of this proportion ($\ln p_i$). The resulting product is summed across the states and multiplied by -1:

$$H = -\sum_{j1}^{s} p_j \, 1n \, p_j$$

In order to assess the extent of variation and understand the spatial distribution, DIVA-GIS version 7.1.6, software available at www.diva-gis.org was used. Geographical coordinates of the collection sites of eggplant germplasm from different parts of India were obtained using Global Positioning System (GPS, Garmin-12). India shape file was used for plotting the geo-referenced points using the layer menu on the software. Point-to-grid option using 'simple' method on the "Analysis Menu" and the output variables 'Diversity' was selected for getting the output files. Under diversity, Shannon Diversity Index was selected. Grid maps on the diversity analysis for descriptors, *viz*., plant height, plant spread, fruit colour, fruit curvature, fruit shape and fruit length/ breadth ratio were generated to study the diversity distribution in India. These descriptors were selected for analysis because of their importance in contributing to yield (plant height, plant spread) and also for their preferences (fruit traits) among different ethnic groups as required for their different culinary preparations.

RESULTS AND DISCUSSION

A wide range of variability was observed for 21 morphological descriptors among the 492 accessions (Table 2). As evidenced by the Shannon Diversity Index (H) for the different traits which ranged from a minimum of 0.01 for fruit position to a maximum of 1.51 for fruit colour. Plant height (H = 0.71) varied from short (6.3% accessions) to tall (18.9% Accessions) with 74.8% of the accessions belonging to medium height (50-100 cm). Plant growth habit (H = 0.46) ranged from upright (7.5%) to prostrate (4.9%) with 87.6% of the accessions falling under the intermediate category. Plant spread (H = 1.01) ranged from very narrow (<30 cm - 1.4%) to very broad (>90 cm - 21.1%) with maximum number of accessions (59.3%) in the broad category (60-90 cm). Leaf colour (H = 0.77) was found to be green in maximum number of accessions (64%), whereas, petiole colour (H = 0.76) was mainly green (51.6%) and greenish violet (47.2%). Calyx colour (H = 0.99) was green for large number of accessions (56.3%) along with light purple (21.5%) and dark purple (22.2%) distributed more or less evenly among the rest of the accessions. Prickles on the upper

Table 2. Shannon Diversity Index (H) and frequencies of the various descriptor states.

Descriptor	No. of Acc. (%)	Descriptor	No. of Acc. (%)
Plant height (H = 0.71)		Corolla colour (H = 1.02)	
Small (<50 cm)	31 (6.3)	White	4 (0.8)
Medium (50-100 cm)	368 (74.8)	Greenish white	14 (2.8)
Tall (>100 cm)	93 (18.9)	Pale violet	260 (52.9)
Plant spread (H = 1.01)		Light violet	30 (6.1)
Very narrow (< 30 cm)	7 (1.4)	Bluish white	184 (37.4)
Intermediate (> 30-60 cm)	89 (18.10)	Calyx colour (H = 0.99)	
Broad (>60-90 cm)	292 (59.3)	Green	277 (56.3)
Very broad (>90 cm)	104 (21.2)	Light purple	106 (21.5)
Plant growth habit (H = 0.46)		Dark purple	109 (22.2)
Upright	37 (7.5)	Calyx spininess (H = 0.95)	
Intermediate	431 (87.6)	No spine	280 (56.9)
Prostrate	24 (4.9)	Medium spiny	145 (29.5)
Petiole colour (H = 0.76)		Highly spiny	67 (13.6)
Green	254 (51.6)	Fruit peduncle prickles (H = 0.87)	
Greenish violet	232 (47.2)	None	336 (68.3)
Violet	4 (0.8)	Few (1-5)	84 (17.1)
Dark brown	2 (0.4)	Intermediate (5-10)	69 (14.0)
Leaf blade lobing (H = 1.15)		Many (>10)	3 (0.6)
Very weak	21 (4.3)	Fruit length/breadth ratio (H = 1.40)	
Weak	153 (31.1)	Broader than long	13 (2.6)
Intermediate	237 (48.1)	As long as broad	95 (19.3)
Strong	81 (16.5)	Slightly longer than broad	206 (41.9)
Leaf blade tip angle (H = 0.64)		Twice as long as broad	2 (0.4)
Very acute	112 (22.8)	Thrice as long as broad	63 (12.8)
Acute	369 (75.0)	Several times as long as broad	113 (23.0)
Intermediate	11 (2.2)	Fruit curvature (H = 0.20)	
Leaf blade colour (H = 0.77)		None	474 (96.4)
Light green	19 (3.9)	Slightly curved	11 (2.2)
Green	316 (64.2)	Curved	2 (0.4)
Dark green	157 (31.9)	Snake shaped	3 (0.6)
Leaf prickles on upper surface (H = 0.84)		Sickle shaped	2 (0.4)
None	336 (68.3)	Fruit shape (H = 1.30)	
Few (1-5)	89 (18.1)	Long	127 (25.8)
Many (>5)	67 (13.6)	Round	86 (17.5)
		Oblong	205 (41.7)
		Oval	74 (15.0)
Fruit apex shape (H = 0.52)		Fruit flesh density (H = 1.03)	
Prostrate	408 (82.9)	Very loose (Spongy)	1 (0.2)

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Descriptor	No. of Acc. (%)	Descriptor	No. of Acc. (%)
Rounded	11 (2.3)	Loose (Crumbly)	92 (18.7)
Depressed	73 (14.8)	Medium compact	304 (61.8)
Fruit colour (H = 1.51)		Compact	78 (15.8)
Milky white	8 (1.6)	Very compact	17 (3.5)
Green	140 (28.5)	Fruit position (H = 0.01)	
Deep yellow	2 (0.4)	Pendent	491 (99.8)
Scarlet red	4 (0.8)	Semi-pendent	1 (0.2)
Lilac red	9 (1.8)	Seediness (H = 1.03)	
Purple	95 (19.4)	Low	96 (19.5)
Purple black	39 (7.9)	Medium	239 (48.6)
Black	8 (1.6)	High	157 (31.9)
Light purple	187 (38.0)		
Fruit colour distribution (H = 1.10)			
Uniform	231 (47.0)		
Mottled	4 (0.8)		
Irregular striped	127 (25.8)		
Regular striped	130 (26.4)		

surface of the leaf varied from none (68.3% acc.) to many (13.6%). A large number of the accessions had smooth calyx (56.9%), while 13.6% of the accessions had highly spiny calyx. A range of corolla colour was observed as white (0.8%), greenish white (2.8%), pale violet (52.9%), light violet (6.1%) and bluish white (37.4%). Wide variation was also observed for fruit colour, which ranged from milky white (1.6%), green (28.5%), deep yellow (0.4%), scarlet red (0.8%), lilac red (1.8%), purple (19.4%), purple black (7.9%), black (1.6%) and light purple (38.0%). Fruit shape was oblong in 41.7% of the accessions, while long, round and oval fruit shape were found in 25.8, 17.5 and 15% of the accessions, respectively indicating wide variation for fruit shape. Uniform fruit colour was observed in 47% of the accessions, whereas, irregularly and regularly striped fruits were observed in 25.8 and 26.4% of the accessions, respectively, while 0.8% of the accessions had mottled fruit colour distribution. Majority of accessions (96.4%) had straight fruit with no curvature. A large number of the accessions had medium compact fruits (61.8%), while, loose, compact and very compact fruit flesh density accounted for 18.7, 15.8 and 3.5% of the accessions respectively. Most of the accessions (68.3%) had no prickles on the peduncle. Most of the accessions with peduncle prickles also had leaf prickles on the upper surface also.

The present study revealed a wide range of variation for the above mentioned important morphological traits. Wide variations in morphological traits in eggplant were also reported by Nainar *et al.* (6), Daunay *et al.* (2), and Kumar *et al.* (3). However, these studies were restricted to fewer number of germplasm accessions representing limited geographical areas. The eggplant accessions from the states of Karnataka, Odisha, Rajasthan and Uttar Pradesh recorded high Shannon Diversity Index for plant height indicating that future germplasm collections for diverse accessions for plant height may be targeted in these states. High diversity index for plant spread (H = 1.01) was found in accessions from the states of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Uttar Pradesh and West Bengal indicating that desired plant type may be found in the accessions from these states.

The high Shannon Diversity Index for fruit colour was found in accessions belonging to Andhra Pradesh, Odisha, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal highlighting the preferences of different fruit colour varying from white to green to purple for varied recipes in these states. High Shannon Diversity Index for fruit shape was recorded in germplasm sourced from eastern states of India.

This variability may be attributed to the large number of accessions studied from this area (204) and due to drastic differences in soil types, climate and local preferences within the region. Eggplant accessions from Andhra Pradesh, Assam, Bihar, Odisha, Uttar Pradesh and West Bengal possessed high Diversity Index for fruit length/ breadth ratio. It indicates different recipes specific demand for round, long and oblong fruit shapes. Kumar *et al*. (3) suggested that the higher diversity in landrace populations may be due to the high environmental heterogeneity of different collection sites ranging from moisture deficit rainfed uplands to moist low lying areas in the region. Regional diversity in brinjal landraces could also be attributed to strong cultural variations, diverse food preferences and recipes evolved over time. These region specific diverse preferences by different ethnic groups' specifically local tribes have also helped in *in situ*/ on farm conservation of these landraces.

GIS mapping may be effectively used for documentation, diversity analysis, identifying gaps in collection, assessment of loss of diversity, developing new strategies for conservation, and sustainable utilization, particularly in the wake of recent international developments related to food and nutritional security. GIS mapping has been successfully used in identifying areas of high diversity in *Phaseolus* bean (Jones *et al*., 5), wild potatoes (Hijmans *et al*., 4), piper (Parthasarathy *et al*., 8), *Jatropha curcas* (Sunil *et al*., 11), black gram (Abraham *et al*., 1), and *Canavalia* (Sivaraj *et al*., 9).

DIVA-GIS grid maps were generated for the descriptors namely, plant height, plant spread, fruit colour, fruit curvature, fruit shape and fruit length/ breadth ratio. The grid maps revealed high Shannon Diversity Index (0.86-2.0) in accessions from the states of Karnataka, Odisha, Rajasthan and Uttar Pradesh for plant height. High diversity index for plant spread was found in accessions from the states of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Uttar Pradesh and West Bengal. The high Shannon Diversity Index for fruit colour ranged from 1.3-2.0 for the accessions sourced from Andhra Pradesh, Odisha, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal (Fig. 1), whereas, Andhra Pradesh, Assam, Bihar and Gujarat recorded high diversity index (0.5-1.0) for fruit curvature (Fig. 2). High Shannon Diversity Index (1.1-2.0) for fruit shape (Fig. 3) was recorded in germplasm assembled from eastern states of India. Eggplant accessions from Andhra Pradesh, Assam, Bihar, Odisha, Uttar Pradesh and West Bengal possessed high Diversity Index for fruit length/breadth ratio (Fig. 4).

Among the eggplant germplasm sourced from several Indian states, based on morphological evaluation and its integration with geographic extrapolation using DIVA-GIS analysis it can be concluded that rich diversity for plant height and plant spread occurred in the states of Odisha, Karnataka and Uttar Pradesh. Bihar, Andhra Pradesh, Odisha

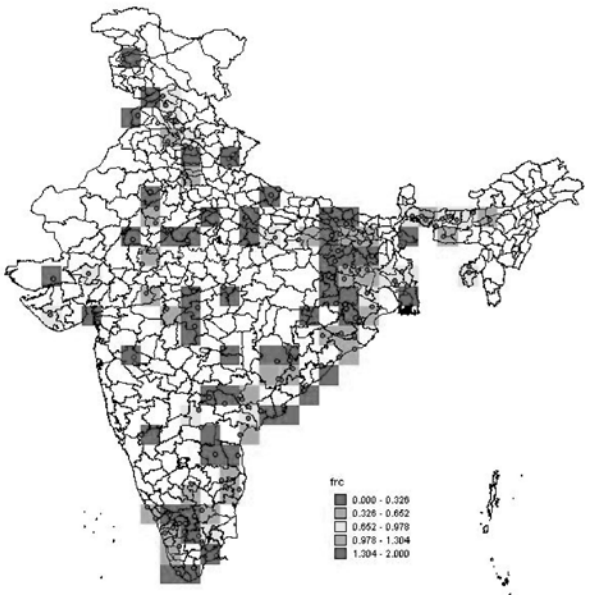

Fig. 1. DIVA-GIS grid map showing diversity analysis for fruit colour.

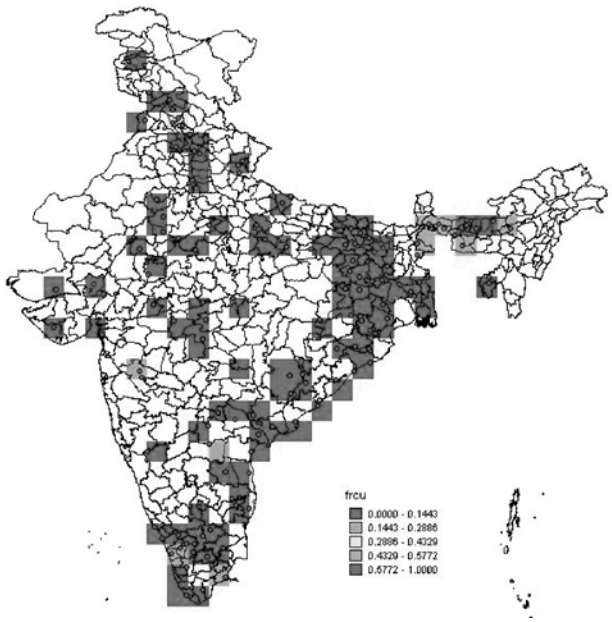

Fig. 2. DIVA-GIS grid map showing diversity analysis for fruit curvature.

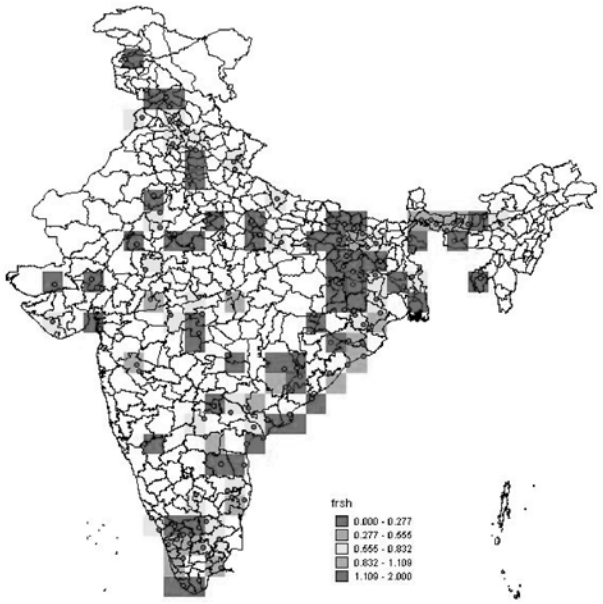

Fig. 3. DIVA-GIS grid map showing diversity analysis for fruit shape.

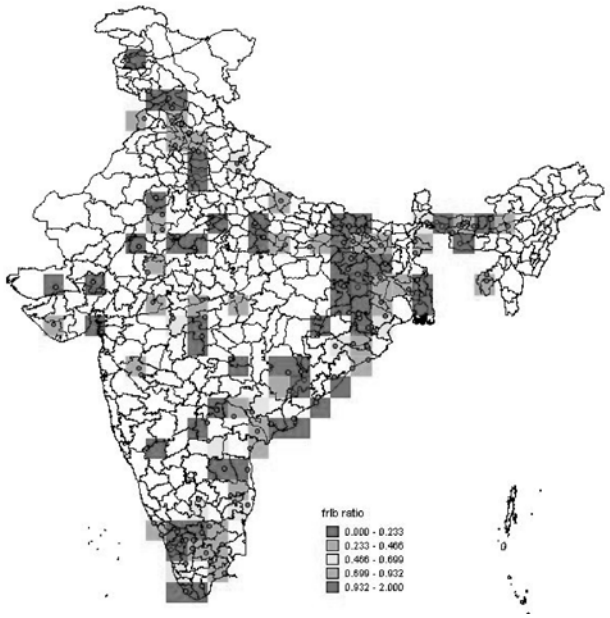

Fig. 4. DIVA-GIS grid map showing diversity analysis for fruit length/ breadth ratio.

and West Bengal are diversity rich pockets for eggplant germplasm for fruit descriptors. Future germplasm collections planned, if any, can be targeted from these diversity pockets of the country. Further, identification of trait specific germplasm may be targeted from genebank accessions collected from diversity rich areas for the particular descriptor. This may increase the probability of identifying the ideal genotypes thus economizing the resources and time required in the evaluation of large number of germplasm accessions thus facilitating faster utilization of germplasm in breeding programme.

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