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Morphological characterization of Bitter gourd (*Momordica charantia L.*) Genotypes and their Hybrids

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ABSTRACT

Bitter gourd (*Momordica charantia* L.) is a highly valued cucurbit crop known for its nutritional and medicinal properties. A breeding programme leveraging genetic diversity is essential for cultivar development. This study evaluated morphological variation among 13 parental lines and 30 F1 hybrids using DUS (Distinctiveness, Uniformity, and Stability) testing guidelines. Key traits, including fruit colour, shape, tuberculation, ridges, peduncle length, and leaf characteristics, were assessed. All genotypes exhibited monoecious flowering with fertile pollen and an indeterminate growth habit. The findings confirm substantial phenotypic diversity, providing a robust framework for varietal identification and registration under the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act 2001. The study highlights the significance of systematic characterization for genetic improvement and conservation efforts in bitter gourd breeding.

INTRODUCTION

Bitter Gourd (*Momordica charantia* L.), also known as karela or bitter melon, is a diploid species (2n = 22) with an estimated genome size of 339 Mb (Urasaki *et al*. 2017). It is a valuable member of the Cucurbitaceae family cultivated extensively across tropical and subtropical regions of Asia, South America, East Africa, and the Caribbean. Bitter Gourd is renowned for its dual significance as a vegetable and medicinal plant (Cui *et al*. 2020).

A successful breeding program depends on the strategic use of existing genetic diversity. Breeders require access to diverse plant genetic resources, supported by detailed and reliable information, to advance their work. Distinctiveness, Uniformity and Stability (DUS) testing, as mandated by the Protection of Plant Varieties and Farmers' Rights (PPVFR) Act 2001, plays a crucial role in modern plant breeding through several key functions. Firstly, DUS testing serves as the foundation for protecting intellectual property rights through Plant Variety Protection (PVP) systems, safeguarding the interests of breeders and encouraging innovation. DUS testing determines whether a newly developed cultivar is distinct from existing ones within the same species and prevents redundancy among gene bank accessions (Mahapatra *et al*. 2022; Verma *et al*. 2025).

In India, the great variability exists in bitter gourd genotypes and the true character expression in the example varieties assume a greater significance under PPV&FR Act, 2001 for their protection on a set of relevant characteristics prescribed in the 'Minimal Descriptors of Vegetable crops' for bitter gourd by Srivastava *et al*. (2001) and International Union for the Protection of New Varieties of Plants (UPOV), 2007.

Moreover, information on the available genetic variability for different quantitative traits is invaluable for devising effective breeding strategies for genetic enhancement. Continuous efforts in this direction will be crucial for developing cultivars with improved productivity and consumer

preference. Their morphological characteristics may also differ; hence, there is a need for a detailed study of genetic variation in cultivated bottle gourd genotypes to generate data. This data will be essential to validate suggested comparative advantages and may provide new options for crop improvement.

Materials and Methods

Thirty hybrids (F_1) along with nine parents were evaluated under a randomized block design with three replications at the Main Experimental Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, during the *zaid* seasons 2023-24 and 2024-25. Geographically, the experimental site falls under a humid subtropical climate and is located respectively between 24.47º and 26.56ºN latitude and 82.12º and
83.58ºE longitude, at an altitude of 113 m above mean sea level. The soil type at the experimental site was sandy-loam with an average fertility level and a pH range varying from 6.5 to 8.5. Based on their diversity and elite status for different economically important traits, ten lines and three testers The research materials comprised genetically pure seed of 15 parents and their hybrids of bitter gourd, *viz*. Sel-1 (L_1), V-21-14 (L_2), V-65-1 (L_3), V-193 (L_4), V-198 (L_5), V-158 (L_6), V-26 (L_7), V-169 (L_8),
NDBG-8 (L_9), NDBG-9 (L_{10}), Kashi Mayuri (T_1), Arka Harit (T_2), DARAL-43 (T_3) and their hybrids were selected for using the crossing programme. Crosses were made using a line × tester mating design. A total of thirty hybrids, along with their respective parents (obtained by selfing), were harvested separately and raised in a randomized block design with three replications. Good agricultural practices were followed.

Data Observation

Observations on 10 botany-based morphometric characters were recorded as per the DUS guidelines of bitter gourd (PPV & FRA, 2009). Data were recorded from each replication, avoiding the border rows, at specified stages of the crop growth period when the characters had their full expression. All observations on the stem, leaves and flowers were recorded from the first inflorescence to the first harvesting, whereas observations on fruits were recorded at the commercial and physiological maturity stages. The data were observed for all the ten morphometric traits from the following fruit colour, fruit shape, fruit tubercles, fruit ridge, peduncle length (cm), flower colour, leaf blade length, leaf blade width, leaf blade no. of lobes, petiole length, within four assessing groups *viz*., MG (measurement by a single observation on a group of plants or parts of plants), MS (measurement on a number of individual plants or parts of plants), VG (visual assessment by a single observation on a group of plants or parts of plants), VS (visual assessment by observations on individual plants or parts of plants)-as discussed in the DUS guidelines of bottle gourd.

Results and discussion

Among the ten lines, three tester and their hybrids, significant variation was observed for all the important characters. The states of expression of a particular trait along with example varieties of bitter gourd are presented in Table 1. Among the morphological traits, identified 10 traits as grouping traits, *viz*. Fruit colour, fruit shape, fruit tubercules, fruit ridge, peduncle length, flower colour, leaf blade length, leaf blade width, Leaf blade number of lobes and petiole length at commercial maturity (marketable stage). In the present study, All the varieties monoecious sex expression with fertile pollens. The male sterility and parthenocarpy was found absent in all the varieties. On the basis of growth habit, bitter gourd varieties have been grouped in three categories *viz*. Determinate, Intermediate and Indeterminate, all the varieties expressed indeterminate growth habit.

In the present study, morphological variation was assessed among thirteen parental lines and thirty F_1 hybrids, including a bitter gourd check. Fruit colour segregated into thirteen whitish-green, fourteen light-green and sixteen dark-green genotypes. Fruit shape varied, with ten cylindrical, fifteen oblong and nineteen spindle-shaped fruits. Fruit tuberculation exhibited four patterns: two genotypes lacked tubercules, while fifteen had moderate density, fourteen were dense and thirteen displayed sparse tubercules. Fruit ridges were either continuous (nineteen genotypes) and discontinuous (twenty-five genotypes). Peduncle length varied, with eleven large, twenty-six medium and seven short types. All genotypes exhibited yellow flower colour. For leaf traits, blade length was categorized as short (fourteen), medium (eighteen) and long (eleven), while blade width was either long (six) and medium (thirty-seven). The number of leaf lobes included five–seven (fourteen genotypes), six–eight (ten genotypes) and nine–six (eight genotypes). Petiole length showed variation, with seventeen short, eighteen medium and eight long types. These findings highlight the phenotypic diversity among bitter gourd genotypes, providing valuable insights for breeding programs. The studies of Rahman *et al*. (2021), Islam *et al*. (2014) and Rathod *et al*. (2008) also described the variability in bitter gourd in respect of morphological, yield and yield contributing traits. It is also suggested that a periodical review of all varieties be undertaken at all the DUS test centres to validate the set of varieties. Bitter gourd being highly cross-pollinated crop a strict maintenance breeding of the reference varieties, including the example varieties and use of alternate example varieties for conduct of DUS testing in bitter gourd, if needed, are also suggested. The varieties characterized for DUS were grouped into different categories for each character which could be used as reference varieties. These varieties can be used in the varietal improvement programme of muskmelon for desirable traits. Genetic improvement of desirable varieties can also be done through gene combinations from unadopted sources having resistance against biotic and abiotic stresses. These test guidelines apply to all varieties, hybrids and parental lines of bitter gourd. It is concluded that the developed DUS descriptors can be effectively used for identification and grouping of varieties and comparing candidate varieties for registration under PPV&FR Act to protect the right of farmers and plant breeders.

CONCLUSION

The study revealed significant morphological diversity among 13 parental lines and 30 F_1 hybrids of bitter gourd. Key variations were observed in fruit traits (colour, shape, tuberculation, ridges), peduncle length, and leaf characteristics. All genotypes exhibited monoecious flowering with fertile pollen and indeterminate growth habit. The developed DUS descriptors effectively distinguished varietal traits, providing a reliable framework for varietal identification and registration under the PPV&FR Act 2009. These findings establish essential baseline data for future bitter gourd breeding and conservation programs.

Table-1 Characterization of bottle gourd genotypes

Genotypes	Fruit: colour	Fruit: Shape	Fruit: tubercles	Fruit: ridge	Peduncle length (cm)	Flower colour	Leaf blade: length	Leaf blade: width	Leaf blade: no. of lobes	Petiole: length
Sel-1(L1)	Whitish green	Spindle-shaped (fusiform)	Absent	Discontinuous	5-7 (Medium)	Yellow	4-8 (Short)	7-10 (Medium)	5-7	5-7 (Short)
V-21-14(L2)	Light green	Cylindrical	Moderate	Continuous	6-8 (Medium)	Yellow	6-9 (Medium)	8-11 (Medium)	6-8	6-8 (Medium)
V-65-1(L3)	Dark green	Oblong	Dense	Discontinuous	5-9 (Medium)	Yellow	5-9 (Medium)	7-11 (Medium)	5-7	5-7 (Short)
V-193(L4)	Light green	Spindle-shaped	Sparse	Continuous	6-9 (Medium)	Yellow	7-10 (Medium)	8-12 (Medium)	6-8	6-8 (Medium)
V-198(L5)	Dark green	Cylindrical	Moderate	Discontinuous	5-8 (Medium)	Yellow	6-9 (Medium)	7-10 (Medium)	5-7	5-7 (Short)
V-158(L6)	Whitish green	Spindle-shaped	Sparse	Continuous	5-9 (Medium)	Yellow	5-8 (Short)	7-11 (Medium)	5-7	5-7 (Short)
V-26(L7)	Light green	Oblong	Dense	Discontinuous	6-8 (Medium)	Yellow	6-9 (Medium)	8-12 (Medium)	6-8	6-8 (Medium)
V-169(L8)	Dark green	Cylindrical	Moderate	Continuous	5-7 (Medium)	Yellow	7-10 (Medium)	8-12 (Medium)	6-8	6-8 (Medium)
NDBG8 (L9)	Dark green	Spindle-shaped	Dense	Discontinuous	5-9 (Medium)	Yellow	5-8 (Short)	7-11 (Medium)	5-7	5-7 (Short)
NDBG-9 (L10)	Whitish green	Cylindrical	Sparse	Continuous	6-8 (Medium)	Yellow	6-9 (Medium)	8-12 (Medium)	6-8	6-8 (Medium)
Kashi Mayuri(T_1)	Light green	Spindle-shaped (fusiform)	Moderate	Continuous	5-10 (Medium)	Yellow	7-10 (Medium)	8-12 (Medium)	6-8	7-9 (Medium)
Arka Harit(T_2)	Light green	Spindle-shaped	Absent	Continuous	6-8 (Medium)	Yellow	7-10 (Medium)	8-12 (Medium)	6-8	6-8 (Medium)
Daral-43(T_3)	Dark green	Cylindrical	Moderate	Discontinuous	5-9 (Medium)	Yellow	6-9 (Medium)	8-12 (Medium)	6-8	6-8 (Medium)
L_1xT_1	Dark green	Oblong	Dense	Discontinuous	5-9 (Medium)	Yellow	7-13 (Long)	8-12 (Medium)	5-7	7-11 (Long)
L_1xT_2	Light green	Spindle-shaped	Sparse	Discontinuous	8-12 (Long)	Yellow	5-8 (Short)	8-12 (Medium)	5-6	5-7 (Short)
L1xT3	Light green	Oblong	Moderate	Discontinuous	5-9 (Medium)	Yellow	6-11 (Medium)	9-14 (Long)	5-7	5-7 (Short)
L2xT1	Whitish green	Cylindrical	Sparse	Discontinuous	4-6 (Short)	Yellow	6-11 (Medium)	8-12 (Medium)	6-9	6-9 (Medium)
L2xT2	Whitish green	Spindle-shaped	Moderate	Continuous	4-6 (Short)	Yellow	7-13 (Long)	6-9 (Medium)	6-9	6-9 (Medium)
L2xT3	Light green	Oblong	Sparse	Discontinuous	5-9 (Medium)	Yellow	7-13 (Long)	8-12 (Medium)	5-6	7-11 (Long)
L3xT1	Whitish green	Spindle-shaped	Dense	Continuous	4-6 (Short)	Yellow	7-13 (Long)	6-9 (Medium)	5-7	5-7 (Short)
L3xT2	Light green	Cylindrical	Sparse	Discontinuous	5-9 (Medium)	Yellow	6-11 (Medium)	8-12 (Medium)	5-6	6-9 (Medium)
L3xT3	Whitish green	Spindle-shaped	Sparse	Continuous	5-9 (Medium)	Yellow	6-11 (Medium)	9-14 (Long)	5-7	4-6 (Short)
L4xT1	Whitish green	Spindle-shaped	Moderate	Discontinuous	8-12 (Long)	Yellow	5-8 (Short)	7-12 (Medium)	6-9	4-6 (Short)

L4xT2	Dark green	Spindle-shaped	Dense	Discontinuous	5-9 (Medium)	Yellow	7-13 (Long)	6-9 (Medium)	6-9	6-9 (Medium)
L4xT3	Whitish green	Oblong	Dense	Discontinuous	5-9 (Medium)	Yellow	7-13 (Long)	8-12 (Medium)	5-7	7-11 (Long)
L5xT1	Whitish green	Oblong	Sparse	Continuous	7-11 (Long)	Yellow	5-8 (Short)	8-12 (Medium)	5-7	4-6 (Short)
L5xT2	Dark green	Spindle-shaped	Moderate	Continuous	5-9 (Medium)	Yellow	5-8 (Short)	6-9 (Medium)	5-6	6-9 (Medium)
L5xT3	Dark green	Spindle-shaped	Moderate	Continuous	8-12 (Long)	Yellow	7-13 (Long)	7-12 (Medium)	5-7	5-7 (Short)
L6xT1	Dark green	Cylindrical	Sparse	Continuous	5-9 (Medium)	Yellow	7-13 (Long)	8-12 (Medium)	5-8	7-11 (Long)
L6xT2	Light green	Oblong	Dense	Discontinuous	5-9 (Medium)	Yellow	6-11 (Medium)	9-14 (Long)	5-7	5-7 (Short)
L6xT3	Dark green	Oblong	Moderate	Continuous	5-9 (Medium)	Yellow	5-8 (Short)	9-14 (Long)	6-9	6-9 (Medium)
L7xT1	Light green	Oblong	Dense	Continuous	7-11 (Long)	Yellow	5-8 (Short)	6-9 (Medium)	5-8	7-11 (Long)
L7xT2	Light green	Spindle-shaped	Moderate	Continuous	8-12 (Long)	Yellow	7-13 (Long)	8-12 (Medium)	6-9	7-11 (Long)
L7xT3	Whitish green	Spindle-shaped	Moderate	Continuous	7-11 (Long)	Yellow	5-8 (Short)	9-14 (Long)	6-8	5-7 (Short)
L8xT1	Dark green	Oblong	Dense	Discontinuous	8-12 (Long)	Yellow	5-8 (Short)	8-12 (Medium)	5-6	5-7 (Short)
L8xT2	Dark green	Oblong	Sparse	Discontinuous	5-9 (Medium)	Yellow	6-11 (Medium)	8-12 (Medium)	5-7	7-11 (Long)
L8xT3	Whitish green	Oblong	Sparse	Discontinuous	4-6 (Short)	Yellow	5-8 (Short)	6-9 (Medium)	5-6	4-6 (Short)
L9xT1	Dark green	Cylindrical	Sparse	Discontinuous	7-11 (Long)	Yellow	7-13 (Long)	7-12 (Medium)	5-7	5-7 (Short)
L9xT2	Light green	Spindle-shaped	Dense	Discontinuous	4-6 (Short)	Yellow	5-8 (Short)	8-12 (Medium)	6-9	6-9 (Medium)
L9xT3	Dark green	Oblong	Dense	Discontinuous	4-6 (Short)	Yellow	5-8 (Short)	8-12 (Medium)	6-9	6-9 (Medium)
L10xT1	Dark green	Spindle-shaped	Moderate	Continuous	5-9 (Medium)	Yellow	6-11 (Medium)	6-9 (Medium)	5-6	6-9 (Medium)
L10xT2	Whitish green	Cylindrical	Dense	Discontinuous	4-6 (Short)	Yellow	7-13 (Long)	9-14 (Long)	5-7	7-11 (Long)
L10xT3	Light green	Spindle-shaped	Dense	Discontinuous	8-12 (Long)	Yellow	6-11 (Medium)	7-12 (Medium)	6-8	6-9 (Medium)
VNR (check variety)	Whitish green	Oblong	Moderate	Discontinuous	4-6 (Long)	Yellow	5-8 (Long)	6-9 (Short)	5-7	4-6 (Short)

Fig. 1: leaf: number of lobes

Fig. Fruit ridges: discontinuous

Fig. Fruit ridges: continuous

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Conflict of interest

Authors declare no conflict of interest.

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