**Evaluation of Guava (*Psidium Guajava* L.) Cultivars Based on Morphological Traits and Yield performance in *Tarai* Region of Uttarakhand.**

**Abstract**

Guava (*Psidium guajava* L.), is a major tropical and sub-tropical fruit crop, valued for its high nutritional value, economic importance and industrial purposes. Despite its prevalent cultivation in India and global tropical and sub-tropical regions, morphological characterization of guava cultivars is still limited, especially for local and wild types. Such characterization is indispensable for effective germplasm identification, conservation and targeted breeding programme to improve yield, quality of fruits and adaptability. The present study aimed to evaluated 14 guava cultivars, planted at the Horticulture Research Centre, G. B. pant University of Agriculture and Technology, Pantnagar, Uttarakhand, during 2022 and 2023. The experiment was laid out in randomized block design with three replications. Morphological traits evaluated comprised tree growth, foliage, flower, fruit and seed parameters, following the ‘Guava Descriptor’ (2011) guidelines. Significant genetic variability was examined among cultivars for all morphological traits. Tree height varied from 2.75 m (VNR Bihi) to 5.18 m (Barafkhana), and tree spread ranged from 8.15 m² (Allahabad Safeda) to 53.52 m² (L-49). Foliage traits like leaf length (9.22–12.84 cm) and leaf area (46.03–76.62 cm²) also differed noticeably. Flowering time, flower size and petal characteristics exposed significant variation, with flowering initiation from April 12 (Sangareddy) to April 24 (Hisar Surkha). VNR Bihi recorded higher fruit weight (347.03 g), fruit length (92.50 mm) and fruit width (90.07 mm). The hardness of the seeds ranged from a low of 7.35 kg/cm² in Allahabad Safeda to a high of 16.81 kg/cm² in Black Guava.

**Keywords**: Guava, germplasm, qualitative, quantitative, Diversity

**1. Introduction**

Guava (Psidium guajava L.) is an important tropical fruit crop recognized for its nutritional, economic and industrial relevance. It belongs to the family *Myrtaceae* and is originally native to Central America. It is extensively cultivated across India and throughout tropical and subtropical regions of the world, owing to its good adaptability, high productivity and multiple uses in the fresh fruit consumption and processing industries such as jams, jellies, juices and purees. Guava is the richest source of vitamin-c (250-295 mg. 100-1) after Barbados cherry and Aonla (Patra et al., 2004; Mishra et al., 2005 and Singh et al., 2016). Guava is one of the major fruit crop in India, both in terms of area and production. As per the latest available data, the total fruit production of guava in India in 2024 was approximately 112.62 million metric tonnes from an area of 7.04 million hectares, whereas guava alone contributed about 5.0 million metric tonnes production from 0.32 million hectares area, with an average productivity of 15.6 tonnes per hectare (**MoA & FW, 1st advance estimate 2024**).

Morphological characterization is essential for the identification, conservation and exploitation of guava germplasm. It offers the basis for effective selection of germplasm utilized in breeding programs for the crop improvement of targeted traits and adaptation to various agro-climatic conditions (Shiva *et al*., 2017). The evaluation of morphological characteristics includes a wide range of plant traits such as tree growth, foliage characteristics, floral characteristics, fruit characteristics and seed parameter, all of which contribute to the crop overall performance and commercial value (Navjot and Amardeep, 2019). In fruit production, morphological characterization helps in recognizing cultivars that are best suited for specific regions and market demands, ensuring optimal productivity and fruit quality (Golam *et al*., 2021). The wide variability observed among guava cultivars in traits such as flowering percentage, fruit set, and physical fruit attributes allows for targeted selection and recommendation of elite genotypes for commercial cultivation (Shiva *et al*., 2017 and Sanjuana *et al*., 2007). Studies focus on characterization of wild species and local cultivars is still lacking in Indian breeding programme which plays a significant role for further crop improvement. The present study was carried out to characterize 14 guava cultivars on the basis of tree, foliage, flower, fruit and seed characters.

**2. Materials and Methods**

The present investigation was conducted during 2022 and 2023 at Horticulture Research Centre, Patharchatta, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The experiment was established on 9-10 year old plants of 14 distinct guava (*Psidium guajava* L.) cultivars, namely: Pant Prabhat, Allahabad Safeda, L-49, VNR Bihi, Hisar Safeda, Baruipur, Barafkhana, Kayamganji, Sangareddy, Red Flesh, Lalit, Arka Kiran, Hisar Surkha and Black Guava. The plants were spaced at 5 m x 5 m intervals. The data were systematically recorded for different morphological traits such including tree growth characteristics, foliage traits, flower traits, fruit traits and seed parameters. The analytical pooled data (2022-2023) of the investigation is presented in different tables. The experimental site is located at the foothills of the Himalayas between 29.5o North latitude and 79.3o East longitude, with an elevation of 243.84 m above mean sea level. All experimental plants were maintained under uniform cultural practices during the entire period of investigation.

**2.1 Morphological characteristics**

The morphological characteristics of guava cultivars were documented in accordance with the guidelines outlined in the 'Guava Descriptor’ (2011), published by the All India Coordinated Research Project on Subtropical Fruits (AICRP-STF) at CISH, Lucknow. The observations included various plant traits, including tree height, tree spread, twig diameter and internodal length of twigs. Foliage characteristics recorded comprised shape of mature leaf, leaf length, leaf width, leaf length : leaf width, petiole length, leaf area, shape of leaf apex, shape of leaf base, colour of young twig, young leaf anthocyanin colouration and internodal length. Flower traits assessed included flower size, stamen length, petal length and petal width. Fruit characteristics evaluated were fruit length, fruit diameter, fruit volume, fruit weight and seed cavity size of mature fruits, fruit skin colour, fruit shape and fruit pulp colour. Seed parameters such as seed size, seed hardiness, number of seeds per fruit, 100 seeds weight and yield were also recorded in accordance with the ‘Guava descriptor’ published in 2011. The seed hardiness of the mature fruits was estimated with the help of a grain seed hardness tester and expressed in Kg/cm2. The chlorophyll content in the leaves was measure non-destructively using Apogee-Mc-100 Chlorophyll Meter SPAD and expressed in SPAD unit.

**3. Statistical analysis**

The field experiment was laid out as Randomized Block Design with three replications in each treatment. The quantitative morphological data were analyzed to test the significance of differences between the means for various parameters through Analysis of Variance (ANOVA). Significant differences among groups were determined using Duncan's multiple range tests at p < 0.05. All computation and statistical analyses were done using IBM SPSS Statistics 19 statistical software (**IBM, NY, USA**) and R Studio Software (**v4.1.2; R Core Team 2024**).

**4. Results and Discussion**

**4.1 Tree growth characters**

All guava cultivars showed considerable variability for tree characters, indicating considerable genetic variation in morphology and physiology of tree traits. The data associated with tree growth characteristics of different guava cultivars summarized in table (1). Tree height among different cultivars differed significantly and it ranged from 2.75 m (VNR Bihi) to 5.18 m (Barafkhana). Other cultivar such as L-49 was having 4.93 m tree height and non-significant variation was observed between Hisar Safeda (4.38 m) and Red Flesh (4.5 m); Hisar Surkha (4.08 m) and Black Guava (4.13 m), and Lalit and Arka Kiran (3.83 m). Tree height is an important character which directly influence the light penetration, canopy architecture and cultural practices; affecting the photosynthetic activity and production. The significant variation was observed for tree spread character, where, maximum tree spread was recorded in cultivar L-49 (53.52 m2) and minimum in Allahabad Safeda (8.15 m2). Barafkhana (36.75 m2), Red Flesh (25.04 m2) and Hisar Safeda (23.01 m2) also varied significantly. The spread of individual trees affects their canopy coverage and light interception capacity, directly influencing fruit yield and quality. With a wider canopy spread, the trees generate more photosynthetic surface area resulting in more fruit per tree. However, too much spread can reduce planting density and cause difficulties in cultural management practices. Twig diameter evaluation showed that Pant Prabhat was significantly superior to all other cultivars with the maximum diameter (6.30 mm) and Baruipur with the minimum diameter (4.08 mm). Several

**Table 1: Tree characters (quantitative traits) of different guava cultivars assessed during 2022 and 2023.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Cultivars** | **Tree height (m)** | **Tree spread (m2)** | **Twig diameter (mm)** | **Internodal length of twigs (cm)** |
| 1 | Pant Prabhat | 3.9e | 11.09i | 6.30ᵃ | 3.71ᵇ |
| 2 | Allahabad Safeda | 3.25g | 8.15j | 5.43ᵇ | 3.21ᶜᵈ |
| 3 | L-49 | 4.93b | 53.52a | 5.01ᶜᵈᵉ | 3.22ᶜᵈ |
| 4 | VNR Bihi | 2.75h | 8.78j | 5.46ᵇ | 4.41ᵃ |
| 5 | Hisar Safeda | 4.38c | 23.01d | 4.51ᵍʰ | 2.39ᵉ |
| 6 | Baruipur | 3.53f | 20.33e | 4.08ⁱ | 3.12ᵈ |
| 7 | Barafkhana | 5.18a | 36.75b | 4.53ᵍʰ | 3.07ᵈ |
| 8 | Kayamganji | 3.23g | 18.5f | 4.79ᵉᶠᵍ | 3.21ᶜᵈ |
| 9 | Sangareddy | 3.33g | 11.28i | 5.28ᵇᶜ | 3.43ᶜ |
| 10 | Red Flesh | 4.5c | 25.04c | 5.18ᵇᶜᵈ | 3.79ᵇ |
| 11 | Lalit | 3.83e | 17.56g | 4.93ᵈᵉᶠ | 3.27ᶜᵈ |
| 12 | Arka Kiran | 3.83e | 14.07h | 4.37ʰ | 3.08ᵈ |
| 13 | Hisar Surkha | 4.08d | 25.74c | 4.86ᵉᶠ | 3.42ᶜ |
| 14 | Black Guava | 4.13d | 10.82i | 4.68ᶠᵍ | 3.14ᵈ |
|  | SEm± | 0.046 | 0.257 | 0.097 | 0.069 |
|  | CD at 5% | 0.136 | 0.751 | 0.200 | 0.143 |

\*Means with same letter within a column shows non-significant differences (at p≤0.05) as per Duncan’s multiple-range test

cultivars including VNR Bihi, Allahabad Safeda, Sangareddy and Red Flesh were at par with diameters varying from 5.18 to 5.46 mm. Twig diameter is an important morphological structural trait that affects the mechanical strength and fruit-bearing capacity of branches. VNR Bihi was significantly found superior among all other cultivar with maximum internodal length (4.41 cm), whereas the minimum was observed in Hisar Safeda (2.39 cm). Red Flesh and Pant Prabhat were statistically at par, revealing internodal lengths of 3.79 cm and 3.71 cm, respectively. Several cultivars, including Sangareddy, Hisar Surkha and Lalit, exhibited non-significant differences, with values ranging from 3.27 to 3.43 cm. It is a key plant architectural trait that determine shoot elongation pattern and leaf arrangement; and it also affect flowering pattern, fruit set and yield potential in fruit trees. Pandey et al. (2016) noticed 2.05 m to 6.00 m tree height in different cultivar of guava. Sanjana and Kavino (2024) recorded tree height ranged from 2.10 m to 3.00 m in Arka Kiran, tree spread 1.31 m to 3.29 m and internodal length of twig 2.30 to 4.12 cm. Similar finding for twig diameter is also observed by Sahoo et al. (2024).

**4.2 Foliage characters**

Significant variability was documented among guava cultivars for all foliage traits recorded, suggesting considerable genetic variability in morphology and physiology of leaf traits and data is presented in table 2. Leaf length ranged from 9.22 cm (Hisar Surkha) to a maximum of 12.84 cm (Baruipur). Other cultivars such as Arka Kiran (12.53 cm), Black Guava (12.52 cm), and Allahabad Safeda (12.36 cm), have long leaves and implies better photosynthetic surface area compared to other cultivars. Hisar Surkha showed shorter length (9.22 cm) leaves compared with VNR Bihi (10.21 cm) at (p ≤ 0.05). Leaf width was maximum in Pant Prabhat (6.25 cm) of regional landrace, which has statistical importance to majorly other cultivars, followed by Hisar Safeda (6.08 cm). Similarly, the narrowest leaves were in Sangareddy (4.19 cm) and Kayamganji (4.60 cm), which suggest those are a type of lanciniate. The highest leaf length to width ratio was in Kayamganji (2.65) and Sangareddy (2.58), which was significantly bigger than cultivars like VNR Bihi (1.85) and Hisar Surkha (1.82), suggesting distinctly elongated leaf shape. Leaf area, varied among different cultivars. The maximum leaf area was exhibited by Pant Prabhat (76.62 cm²), and the values of Hisar Safeda (72.52 cm²) and Baruipur (70.08 cm²) were also significantly higher. Sangareddy (46.03 cm²) and Hisar Surkha (46.79 cm²) had significantly lower leaf area so they may have potentially affected their ability to photosynthesize and prevented transpiration ability. For leaf blade measurements, both Baruipur (11.68 cm) and Arka Kiran (11.44 cm) had the longest leaf blades and both Hisar Surkha (8.37 cm) and VNR Bihi (9.21 cm) had the shortest. For leaf blade width, Pant Prabhat (5.79 cm) and Hisar Safeda (5.66 cm) had the widest blades, while Sangareddy (3.77 cm) and Kayamganji (4.30 cm) had significantly narrower widths. The blade length divided blade width showed also a similar trend with the maximum in Sangareddy (2.62) and Kayamganji (2.59) while Hisar Surkha (1.73) and VNR Bihi (1.87) showed the most compact ratios. Leaf petiole length was another morphological variable that influenced the orientation of the blade and highest whilst L-49 had the lengthiest (8.79 mm) and Pant Prabhat a little shorter (8.17 mm) both these cultivars may have elevated leaf position. In contrast, Hisar Surkha (4.28 mm) and Kayamganji (5.47 mm) had the smallest petioles, resulting in leaves being located closer to the shoot axis. The leaf chlorophyll index, reported in SPAD units, had substantial variations between cultivars, reflecting differences in pigment concentrations in the leaves and perhaps *via* photosynthetic activity. The highest SPAD values were for VNR Bihi (469.50) followed by Lalit (444.17) and Arka Kiran (374.17), indicating higher chlorophyll content. The lowest SPAD indices were obtained in Black Guava (269.00) and Hisar Safeda (273.67), indicating lower photosynthetic potential. Dubey *et al*. (2016) observed similar type of variation for quantitative traits of foliage characteristics like leaf length (10.75-13.96 cm), leaf width (4.38-7.08 cm), length : width ratio (1.87-2.73) and petiole length (0.75-0.83 cm) in different cultivars of guava. Similar types of finding were also observed by Pandey et al. (2017) and Shiva *et al*. (2017).

All the plants that were evaluated will have been stable for few leaves qualitative traits like margin type and overall colour. There were differences in leaf shape (obovate in most, Pant Prabhat, Allahabad Safeda, L-49 etc., lanceolate Barafkhana, Snagareddy, Red Flesh, etc. and oblong Baruipur, Kayamganji) which shows variation that was conceptualized in genotype and classifications as well. The colour of the leaves was all indicative of a green leaf colour, except for the aforementioned Black Guava that was definitely purple in coloration. All cultivars were mostly round; except Hisar Safeda and Red Flesh which were cordate and Barafkhana and Sangareddy that were obtuse. The leaf tips were mostly obtuse or apiculate often, while Pant Prabhat and Arka Kiran had rounded tips; interestingly all cultivars had an entire leaf margin. The colour of midribs varied from cream to yellow coloured in all cultivars except Black Guava having a red midrib was a rare mark across the germplasm. The anthocyanin expression on young leaves was expressed in Pant Prabhat, Allahabad Safeda, L-49, and Sangareddy, while some cultivars like Hisar Safeda, Barafkhana, and Lalit did not exhibit this trait (table 3). Ran *et al.* (2017) recorded pale green to dark green colour of leaves, obovate, oblong and elliptical shape of leaves in different cultivars of guava in rainy season. Dubey *et al*. (2016) observed similar type of variation for qualitative traits of foliage characteristics such as leaf colour green to dark; leaf shape oblong to lanceolate; leaf apex-acute, obtuse and rounded and leaf base rounded to obtuse in different guava cultivars. Similar types of finding was also observed by Pandey et al. (2017) and Shiva *et al*. (2017).

**4.3 Flower characters**

The data related to flowers characters (quantitative traits) of different guava cultivars was summarized in table (4). Flowering dates among different cultivars differed significantly, the first flowering cultivar was Sangareddy, which flowered on April 12, Pant Prabhat and 'L-49' flowered a day later (13 April) and the last flowering recorded in Hisar Surkha (24 April) and Arka Kiran (22 April). Variation observed in duration of flowering, which ranged from 31.00 days (Black Guava) to 42.83 days (Allahabad Safeda). Lalit (40.00 days) also showed a long duration of flowering statistically similar to Barafkhana. Flower size also differed among the cultivars from the smallest 28.99 mm (Arka Kiran) to the largest 43.39 mm (Hisar Surkha). The comparison for the largest flower with Baruipur (43.07 mm), Kayamganji (43.07 mm), and Barafkhana (38.61 mm). The flower with higher number of petals recorded in Barafkhana (6.17), followed by Hisar Surkha (6.00), which were significantly higher than other cultivars including L-49, VNR Bihi and

**Table 2: Foliage characters (quantitative traits) of different guava cultivars assessed during 2022 and 2023.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Cultivars** | **Leaf length (cm)** | **Leaf width (cm)** | **Leaf length : Leaf width** | **Leaf area (cm2)** | **Leaf blade length (cm)** | **Leaf blade width (cm)** | **Leaf blade length : leaf blade width** | **Petiole length (mm)** | **Leaf chlorophyll index**  **(SPAD units)** |
| **1** | Pant Prabhat | 12.23ᵃᵇᶜ | 6.25ᵃ | 1.98ᶜᵈ | 76.62ᵃ | 11.43ᵃ | 5.79ᵃ | 1.98ᶜᵈᵉ | 8.17ᵃᵇ | 283.67ᵏ |
| **2** | Allahabad Safeda | 12.36ᵃᵇ | 5.20ᶜᵈᵉᶠ | 2.41ᵃᵇ | 65.23ᵃᵇᶜᵈᵉ | 11.13ᵃᵇ | 4.74ᵈᵉᶠ | 2.38ᵃᵇ | 7.71ᵇᶜ | 299.50ʲ |
| **3** | L-49 | 11.44ᵃᵇᶜᵈ | 5.13ᶜᵈᵉᶠᵍ | 2.26ᵇᶜ | 59.51ᶜᵈᵉᶠ | 11.04ᵃᵇ | 4.77ᵈᵉᶠ | 2.33ᵃᵇᶜ | 8.79ᵃ | 340.17ᶠ |
| **4** | VNR Bihi | 10.21ᵈᵉ | 5.65ᵇᶜ | 1.85ᵈ | 58.61ᶜᵈᵉᶠ | 9.21ᵈ | 4.94ᶜᵈᵉ | 1.87ᵉ | 7.51ᵇᶜ | 469.50ᵃ |
| **5** | Hisar Safeda | 11.84ᵃᵇᶜ | 6.08ᵃᵇ | 1.96ᵈ | 72.52ᵃᵇ | 10.99ᵃᵇ | 5.66ᵃᵇ | 1.93ᵈᵉ | 5.78ᵈ | 273.67ˡ |
| **6** | Baruipur | 12.84ᵃ | 5.41ᶜᵈᵉ | 2.39ᵃᵇ | 70.08ᵃᵇᶜ | 11.68ᵃ | 5.20ᵇᶜᵈ | 2.26ᵃᵇᶜᵈ | 5.63ᵈ | 345.00ᵉ |
| **7** | Barafkhana | 11.34ᵇᶜᵈ | 4.77ᶠᵍ | 2.38ᵃᵇ | 54.17ᵉᶠᵍ | 10.41ᵇᶜ | 4.62ᵉᶠ | 2.26ᵃᵇᶜᵈ | 7.34ᶜ | 326.00ʰ |
| **8** | Kayamganji | 12.14ᵃᵇᶜ | 4.60ᵍʰ | 2.65ᵃ | 56.45ᵉᶠᵍ | 11.16ᵃᵇ | 4.30ᶠ | 2.59ᵃ | 5.47ᵈ | 274.67ˡ |
| **9** | Sangareddy | 10.82ᶜᵈ | 4.19ʰ | 2.58ᵃᵇ | 46.03ᵍ | 9.87ᶜᵈ | 3.77ᵍ | 2.62ᵃ | 6.20ᵈ | 317.83ⁱ |
| **10** | Red Flesh | 11.79ᵃᵇᶜ | 4.84ᵉᶠᵍ | 2.44ᵃᵇ | 57.41ᵈᵉᶠᵍ | 11.04ᵃᵇ | 4.54ᵉᶠ | 2.43ᵃ | 7.52ᵇᶜ | 358.33ᵈ |
| **11** | Lalit | 10.81ᶜᵈ | 4.78ᶠᵍ | 2.25ᵇᶜ | 52.27ᶠᵍ | 10.45ᵇᶜ | 4.62ᵉᶠ | 2.28ᵃᵇᶜᵈ | 5.83ᵈ | 444.17ᵇ |
| **12** | Arka Kiran | 12.53ᵃᵇ | 4.93ᵈᵉᶠᵍ | 2.54ᵃᵇ | 62.35ᵇᶜᵈᵉᶠ | 11.44ᵃ | 4.59ᵉᶠ | 2.51ᵃ | 7.35ᶜ | 374.17ᶜ |
| **13** | Hisar Surkha | 9.22ᵉ | 5.04ᵈᵉᶠᵍ | 1.82ᵈ | 46.79ᵍ | 8.37ᵉ | 4.88ᶜᵈᵉ | 1.73ᵉ | 4.28ᵉ | 331.00ᵍ |
| **14** | Black Guava | 12.52ᵃᵇ | 5.46ᶜᵈ | 2.31ᵇ | 68.62ᵃᵇᶜᵈ | 11.06ᵃᵇ | 5.41ᵃᵇᶜ | 2.05ᵇᶜᵈᵉ | 7.70ᵇᶜ | 269.00ᵐ |
|  | SE(m) | 0.42 | 0.17 | 0.096 | 3.57 | 0.25 | 0.16 | 0.11 | 0.23 | 1.40 |
|  | CD at 5% | 0.88 | 0.36 | 0.197 | 7.34 | 0.51 | 0.34 | 0.23 | 0.47 | 2.88 |

\*Means with same letter within a column shows non-significant differences (at p≤0.05) as per Duncan’s multiple-range test

**Table 3: Foliage characters (qualitative traits) of different guava cultivars assessed during 2022 and 2023.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sr. No. | **Cultivars** | **Leaf shape** | **Leaf colour** | **Leaf shape at base** | **Leaf shape at tip** | **Leaf blade margin** | **Colour of midribs** | **Anthocyanin colour of young leaf** |
| **1** | Pant Prabhat | Obovate | Green | Round | Round | Entire | Cream | Present |
| **2** | Allahabad Safeda | Obovate | Green | Round | Obtuse | Entire | Cream | Present |
| **3** | L-49 | Obovate | Green | Round | Obtuse | Entire | Yellow | Present |
| **4** | VNR Bihi | Obovate | Green | Round | Round | Entire | Yellow | Present |
| **5** | Hisar Safeda | Obovate | Green | Cordate | Apiculate | Entire | Yellow | Absent |
| **6** | Baruipur | Oblong | Green | Round | Obtuse | Entire | Cream | Absent |
| **7** | Barafkhana | Lanceolate | Green | Obtuse | Acute | Entire | Cream | Absent |
| **8** | Kayamganji | Oblong | Green | Round | Obtuse | Entire | Cream | Absent |
| **9** | Sangareddy | Lanceolate | Green | Obtuse | Acute | Entire | Cream | Present |
| **10** | Red Flesh | Lanceolate | Green | Cordate | Apiculate | Entire | Cream | Present |
| **11** | Lalit | Lanceolate | Green | Round | Obtuse | Entire | Cream | Absent |
| **12** | Arka Kiran | Obovate | Green | Round | Round | Entire | Cream | Absent |
| **13** | Hisar Surkha | Obovate | Green | Round | Apiculate | Entire | Cream | Absent |
| **14** | Black Guava | Lanceolate | Purple | Round | Obtuse | Entire | Red | Absent |

**Table 4: Flowers characters (quantitative traits) of different guava cultivars assessed during 2022 and 2023.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. no.** | **Cultivars** | **Date of 1st flower open** | **Duration of flowering (days)** | **Flower size (mm)** | **No. of petals/flower** | **Petal length (mm)** | **Petal width (mm)** | **Stamen length (mm)** |
| 1 | Pant Prabhat | 13th April | 36.83ᵉᶠᵍ | 37.89ᶜ | 5.50ᵃᵇᶜ | 16.49ᵉᶠ | 13.00ᵃ | 13.84ᵉ |
| 2 | Allahabad Safeda | 19th April | 42.83ᵃ | 32.90ᵈ | 5.67ᵃᵇᶜ | 17.62ᵉᶠ | 12.49ᵃ | 14.56ᵈᵉ |
| 3 | L-49 | 13th April | 37.67ᵈᵉᶠᵍ | 42.36ᵃᵇᶜ | 5.17ᶜ | 17.05ᵉᶠ | 14.08ᵃ | 16.61ᵇᶜ |
| 4 | VNR Bihi | 14th April | 33.67ʰ | 39.04ᵃᵇᶜ | 5.17ᶜ | 18.44ᶜᵈᵉ | 12.74ᵃ | 14.36ᵈᵉ |
| 5 | Hisar Safeda | 14th April | 39.83ᵇᶜᵈ | 41.63ᵃᵇᶜ | 5.50ᵃᵇᶜ | 20.94ᵃᵇ | 13.00ᵃ | 17.52ᵃᵇᶜ |
| 6 | Baruipur | 20th April | 34.17ʰ | 43.07ᵃᵇ | 5.67ᵃᵇᶜ | 20.37ᵃᵇᶜ | 14.29ᵃ | 16.91ᵇᶜ |
| 7 | Barafkhana | 21th April | 40.67ᵃᵇᶜ | 38.61ᵇᶜ | 6.17ᵃ | 22.05ᵃ | 12.81ᵃ | 18.24ᵃᵇ |
| 8 | Kayamganji | 19th April | 35.17ᵍʰ | 43.07ᵃᵇ | 5.17ᶜ | 20.73ᵃᵇ | 13.10ᵃ | 17.15ᵇᶜ |
| 9 | Sangareddy | 12th April | 39.17ᶜᵈᵉ | 40.65ᵃᵇᶜ | 5.17ᶜ | 18.04ᵈᵉ | 13.23ᵃ | 18.69ᵃᵇ |
| 10 | Red Flesh | 20th April | 36.17ᶠᵍʰ | 42.18ᵃᵇᶜ | 5.50ᵃᵇᶜ | 17.73ᵉ | 13.87ᵃ | 19.28ᵃ |
| 11 | Lalit | 21th April | 40.00ᵇᶜᵈ | 43.28ᵃ | 5.67ᵃᵇ | 20.08ᵃᵇᶜ | 14.10ᵃ | 15.96ᶜᵈ |
| 12 | Arka Kiran | 22th April | 38.67ᶜᵈᵉᶠ | 28.99ᵉ | 5.17ᶜ | 15.67ᶠ | 9.72ᵇ | 13.97ᵈᵉ |
| 13 | Hisar Surkha | 24th April | 42.00ᵃᵇ | 43.39ᵃ | 6.00ᵃᵇ | 19.92ᵇᶜ | 13.21ᵃ | 16.99ᵇᶜ |
| 14 | Black Guava | 19th April | 31.00ⁱ | 40.59ᵃᵇᶜ | 5.33ᵇᶜ | 18.51ᶜᵈᵉ | 12.19ᵃ | 16.78ᵇᶜ |
|  | SEm± |  | 0.79 | 1.34 | 0.22 | 0.63 | 0.68 | 0.64 |
|  | CD at 5% |  | 1.63 | 2.75 | 0.46 | 1.29 | 1.40 | 1.32 |

\*Means with same letter within a column shows non-significant differences (at p≤0.05) as per Duncan’s multiple-range test

Kayamganji, with lower number of petals (5.17). Petal lengths also varied among cultivars and were as short as 15.67 mm (Arka Kiran) and as long as 22.05 mm (Barafkhana), which was statistically superior to other cultivars. The most petal width was found in Baruipur (14.29 mm) and Lalit (14.10 mm), and minimum petal width was found in Arka Kiran had 9.72 mm. Stamen length again seemed to be a clear differentiator as Red Flesh (19.28 mm) and Sangareddy (18.69 mm) exhibited the longest stamens while these were statistically *at par* with Barafkhana (18.24 mm) and Hisar Safeda (17.52 mm). The minimum stamen length was recorded in Pant Prabhat (13.84 mm) and Arka Kiran (13.97 mm). Similar type of variation were also observed by Singh *et al*. (2016); Singh *et al*. (2017) and Pravin *et al*. (2023) for the flowers characteristics. Pravin *et al*. (2023) noticed flower initiation firstly in variety Allahabad Safeda on 20 April and highest duration of flowering in cultivar Pant Prabhat (35 days) in rainy season under semi-arid condition of Haryana.

**4.4 Fruit characters**

The extensive analysis of 16 guava cultivars showed major genotypic variability among many quantitative fruit traits presented in table 5. VNR Bihi as clearly the best with respect to key size parameters and recorded with higher fruit weight (347.03 g), fruit length (92.50 mm) and fruit width (90.07 mm). Sangareddy and Barafkhana were also large but with distinctly lower values than VNR Bihi. The length to width ratio ranged from 0.93 (Baruipur) to 1.05 (Hisar Safeda), suggesting varying degrees of circularity among fruit. Perhaps distinguishing cultivars like Pant Prabhat, Allahabad Safeda and Sangareddy, showed the length to width ratios close to one, which suggests near-spherical fruit and are considered more commercially marketable. With regards to how far the fruit stalk length was, Sangareddy had the longest fruit stalk length at 26.58 mm, VNR Bihi, the second longest (25.11 mm) with Arka Kiran showing the shortest fruit stalk length (14.01 mm), both aspects can affect harvestability and could correspondingly affect stem-end rot. Calyx cavity diameter, which is associated with visual fruit attractiveness and postharvest quality, was greatest in Arka Kiran (13.69 mm) and VNR Bihi (12.63 mm), indicating the presence of deeper calyx cavities. Conversely, Red Flesh (9.87 mm) and L-49 (10.27 mm) had smaller cavity diameters, which may limit contaminant entry. For flesh core diameter and seed core diameter, VNR Bihi had the largest diameter (15.67 mm and 45.41 mm, respectively), which is not surprising considering it had the largest fruit size. By comparison, Red Flesh was found to have the smallest flesh core diameter (8.45 mm) and had a relatively medium sized seed core diameter (37.89 mm), resulting in the largest pulp/seed ratio, which may have a value for processing uses. Notably, Black Guava, had the smallest seed core diameter at (27.38 mm), which may contribute to breeding program goals of reduced seed yield in new varieties. The statistical analyses using Duncan’s multiple range test for several of traits measured for each genotype demonstrated significant differences (p ≤ 0.05) and clearly show distinct levels of performances that may demonstrate exploitable genetic potential.

**Table 5: Fruit characters (quantitative traits) of different guava cultivars assessed during 2022 and 2023.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Cultivars** | **Fruit weight (g)** | **Fruit length (mm)** | **Fruit width (mm)** | **Fruit length : fruit width** | **Fruit stalk length (mm)** | **Calyx cavity diameter (mm)** | **Flesh core diameter (mm)** | **Seed core diameter (mm)** |
| **1** | Pant Prabhat | 106.57ᵈᵉ | 64.20ᶠᵍ | 61.85ᵈᵉᶠ | 1.03ᵃᵇ | 21.05ᶜ | 12.24ᵇ | 12.77ᵇᶜ | 36.51ᶜᵈ |
| **2** | Allahabad Safeda | 84.30ᶠᵍ | 72.28ᶜᵈ | 69.38ᶜ | 1.04ᵃᵇ | 20.07ᵉᶠ | 12.50ᵇ | 12.82ᵇᶜ | 37.71ᶜ |
| **3** | L-49 | 108.87ᶜᵈᵉ | 59.57ᵍʰ | 60.32ᵉᶠ | 0.98ᵇᶜᵈᵉ | 20.88ᶜᵈ | 10.27ᵈ | 13.70ᵇ | 42.49ᵇ |
| **4** | VNR Bihi | 347.03ᵃ | 92.50ᵃ | 90.07ᵃ | 1.02ᵃᵇᶜ | 25.11ᵇ | 12.63ᵇ | 15.67ᵃ | 45.41ᵃ |
| **5** | Hisar Safeda | 126.40ᵇᶜ | 60.39ᵍʰ | 57.46ᶠᵍ | 1.05ᵃ | 20.36ᵈᵉ | 11.79ᵇ | 11.97ᶜᵈ | 36.47ᶜᵈ |
| **6** | Baruipur | 83.12ᶠᵍ | 66.76ᵉᶠ | 71.06ᶜ | 0.93ᵉ | 16.96ʰ | 10.43ᶜᵈ | 12.58ᵇᶜ | 38.38ᶜ |
| **7** | Barafkhana | 143.07ᵇ | 73.52ᶜ | 76.65ᵇ | 0.96ᵈᵉ | 16.43ʰ | 11.46ᵇᶜ | 12.46ᵇᶜ | 34.47ᵈᵉ |
| **8** | Kayamganji | 118.38ᶜᵈ | 81.54ᵇ | 81.30ᵇ | 1.00ᵃᵇᶜᵈ | 18.06ᵍ | 12.09ᵇ | 12.57ᵇᶜ | 37.56ᶜ |
| **9** | Sangareddy | 143.83ᵇ | 69.63ᶜᵈᵉ | 66.92ᶜᵈ | 1.04ᵃᵇ | 26.58ᵃ | 12.03ᵇ | 12.50ᵇᶜ | 44.83ᵃ |
| **10** | Red Flesh | 74.01ᵍ | 64.19ᶠᵍ | 63.26ᵈᵉ | 1.01ᵃᵇᶜᵈ | 19.62ᶠ | 9.87ᵈ | 8.45ᶠ | 37.89ᶜ |
| **11** | Lalit | 114.71ᶜᵈᵉ | 68.13ᵈᵉᶠ | 65.93ᶜᵈ | 1.03ᵃᵇ | 18.07ᵍ | 10.06ᵈ | 11.56ᶜᵈᵉ | 37.56ᶜ |
| **12** | Arka Kiran | 82.87ᶠᵍ | 57.82ʰᶦ | 57.89ᶠᵍ | 1.00ᵃᵇᶜᵈ | 14.01ⁱ | 13.69ᵃ | 10.12ᵉ | 31.57ᶠ |
| **13** | Hisar Surkha | 97.31ᵉᶠ | 57.27ʰᶦ | 59.12ᵉᶠᵍ | 0.97ᶜᵈᵉ | 20.90ᶜᵈ | 11.76ᵇ | 10.41ᵈᵉ | 33.11ᵉᶠ |
| **14** | Black Guava | 74.67ᵍ | 53.32ᶦ | 54.18ᵍ | 0.98ᵇᶜᵈᵉ | 18.22ᵍ | 12.39ᵇ | 10.53ᵈᵉ | 27.38ᵍ |
|  | SE(m) | 5.84 | 1.67 | 1.63 | 0.017 | 0.19 | 0.36 | 0.51 | 0.68 |
|  | CD at 5% | 12.01 | 3.44 | 3.36 | 0.035 | 0.41 | 0.73 | 1.05 | 1.40 |

\*Means with same letter within a column shows non-significant differences (at p≤0.05) as per Duncan’s multiple-range test

**Table 6: Fruit characters (qualitative traits) of different guava cultivars assessed during 2022 and 2023.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Cultivars** | **Fruit shape** | **Fruit shape at stalk end** | **Fruit shape at apex end** | **Fruit skin colour** | **Fruit longitudinal ridges** | **Fruit longitudinal grooves** | **Fruit flesh colour** |
| 1 | **Pant Prabhat** | Round | Broadly rounded | Flattened | Pale yellow greenish | Absent | Absent | Creamy white |
| 2 | **Allahabad Safeda** | Round | Round | Broadly Round | Pale yellow | Absent | Absent | Creamy white |
| 3 | **L-49** | Round | Broadly Round | Broadly Round | Pale yellow greenish | Absent | Absent | Creamy white |
| 4 | **VNR Bihi** | Round | Broadly rounded | Broadly rounded | Pale yellow greenish | Present | Absent | White |
| 5 | **Hisar Safeda** | Round | Round | Broadly rounded | Pale yellow greenish | Absent | Absent | Creamy white |
| 6 | **Baruipur** | Round | Truncate | Broadly rounded | Pale yellow greenish | Absent | Absent | White |
| 7 | **Barafkhana** | Oblong | Broadly rounded | Broadly rounded | Pale yellow greenish | Present | Absent | White |
| 8 | **Kayamganji** | Oblong | Broadly rounded | Broadly rounded | Pale yellow greenish | Absent | Absent | Creamy white |
| 9 | **Sangareddy** | Oblong | Broadly rounded | Broadly rounded | Pale yellow | Present | Present | Pink red |
| 10 | **Red Flesh** | Round | Broadly rounded | Broadly rounded | Pale yellow greenish | Absent | Absent | Red |
| 11 | **Lalit** | Sub globose | Broadly rounded | Flattened | Pale yellow greenish | Absent | Absent | Pinkish red |
| 12 | **Arka Kiran** | Round | Broadly rounded | Broadly rounded | Pale yellow greenish | Absent | Absent | Pink red |
| 13 | **Hisar Surkha** | Round | Broadly rounded | Broadly rounded | Pale yellow greenish | Absent | Absent | Pink |
| 14 | **Black Guava** | Oblong | Round | Broadly rounded | Purple | Absent | Absent | Purple |

Qualitative descriptors further underscored the distinction in genotypes among guava cultivars is summarized in table 6. The shape of the fruit in most of the cultivars was round with an exception of cultivars of Barafkhana, Sangareddy, Kayamganji and Black Guava which were oblong and the cultivar Lalit was sub-globose. The shape of the apex and stalk end of the fruit were primarily broadly rounded while the cites like Baruipur had truncate and cultivars of Pant Prabhat and Lalit were flattened inherited traits that influence fruit symmetry and consumer preference. The skin fruit colour of most cultivars was pale yellow greenish, typical of commercially marketed guavas. The fruit skin colour of Black Guava was the only outlier with its purple skin which would be classified as a rare phenotype possibly ornamental or nutraceutical compared to similar cultivated species. Three cultivars, VNR Bihi, Barafkhana and Sangareddy expressed longitudinal ridges with Sangareddy also having longitudinal grooves which was a rare yet interesting visual combination. The flesh colour, the most important fruit quality attribute for both table-type and processing type keeping quality, varied significantly. Most cultivars flesh colour were either creamy white or white. Three cultivars of Sangareddy, Arka Kiran and Lalit ranged from pink to pinkish red pulp attributes. Two cultivars, Red Flesh and Black Guava were intensely red and purple flesh which may reflect possible increase lycopene and anthocyanin level. Similar type of findings for the fruit characters were also observed by Sharma *et al*. (2010); Kumari and Thakur (2016); Shalu *et al*. (2017); Sahoo *et al*. (2017) and Pravin *et al*. (2023). Highest fruit weight (362.00 g), fruit length (10.05 cm) and fruit width (8.16 cm) noticed by Pravin *et al*. (2023) in Kg Guava under semi-arid condition of Haryana.

**4.5 Seed characters**

The data related to seed characters and yield performance (quantitative traits) of different guava cultivars is presented in table (7). Seed size was categorized into large, medium and small. L-49, Baruipur, Barafkhana, Black Guava, and VNR Bihi were in the large seed size category while Allahabad Safeda, Kayamganji and Hisar Surkha were medium seed size cultivars. Hisar Safeda, Red Flesh and Arka Kiran had small seed size. The number of seeds per fruit varied widely between 128.67 in VNR Bihi and 312.50 in Lalit. Baruipur and Barafkhana also had, significantly higher number of seeds per fruit (309.67 and 295.00) than all others. Black Guava and Pant Prabhat had the minimum seeds per fruit and hence might have potential advantage for edible pulp. Seed weight per fruit ranged from 1.46 g in Pant Prabhat to 3.04 g from Lalit. However, Baruipur (3.02 g) and Barafkhana (2.93 g) also had highest seed weight, suggesting there may be some correlation between seeds per fruit and seed weight. The weight of 100 seeds ranged from a low of 0.66 g in Hisar Safeda to a high of 1.06 g in Baruipur. Black Guava also recorded with 100-seed weight of 1.03 g. It indicates there were different density and hardness of seeds. The hardness of the seeds ranged from a low of 7.35 kg/cm² in Allahabad Safeda to a high of 16.81 kg/cm² in Black Guava, when measured in kg/cm². Recorded seed hardness from other cultivars, Barafkhana, VNR Bihi and Kayamganji, were also in the upper range (>14.5 kg/cm²) while Pant Prabhat and Hisar Surkha were in the soft range (<9.0 kg/cm²). The differences in seed hardness may greatly affect consumer acceptability, eating quality and suitability for processing. Within cultivars, yield per tree was

**Table 7: Seed characters and yield performance (quantitative traits) of different guava cultivars assessed during 2022 & 2023.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. no.** | **Cultivars** | **Seed size** | **No. of seeds/fruit** | **Seed weight/fruit (g)** | **100 seeds weight (g)** | **Seed hardiness (kg/cm2)** | **Fruit yield (kg/tree)** |
| 1 | Pant Prabhat | Large | 151.00ᶠᵍ | 1.46ᵍ | 1.01ᵃᵇᶜ | 8.05ᵏ | 32.20ʲ |
| 2 | Allahabad Safeda | Medium | 171.33ᵉᶠ | 1.77ᵉᶠ | 0.90ᵇᶜᵈᵉ | 7.35ˡ | 42.97ʰ |
| 3 | L-49 | Large | 221.00ᶜᵈ | 2.36ᵇᶜ | 0.99ᵃᵇᶜ | 9.32ⁱ | 60.74ᶜ |
| 4 | VNR Bihi | Large | 128.67ᵍ | 1.47ᵍ | 0.88ᶜᵈᵉᶠ | 14.82ᵇ | 42.59ʰ |
| 5 | Hisar Safeda | Small | 225.17ᶜᵈ | 2.15ᶜᵈ | 0.66ᵍ | 10.93ᵍ | 65.54ᵃ |
| 6 | Baruipur | Large | 309.67ᵃ | 3.02ᵃ | 1.06ᵃ | 14.32ᶜ | 57.53ᵈᵉ |
| 7 | Barafkhana | Large | 295.00ᵃ | 2.93ᵃ | 0.93ᵃᵇᶜᵈ | 14.73ᵇ | 58.78ᵈ |
| 8 | Kayamganji | Medium | 261.50ᵇ | 2.54ᵇ | 0.95ᵃᵇᶜᵈ | 14.55ᵇᶜ | 50.98ᶠ |
| 9 | Sangareddy | Medium | 210.50ᵈ | 2.58ᵇ | 0.84ᵈᵉᶠ | 12.57ᵉ | 34.56ⁱ |
| 10 | Red Flesh | Small | 241.83ᵇᶜ | 2.06ᵈ | 0.75ᶠᵍ | 13.19ᵈ | 56.30ᵉ |
| 11 | Lalit | Medium | 312.50ᵃ | 3.04ᵃ | 0.84ᵈᵉᶠ | 11.67ᶠ | 63.14ᵇ |
| 12 | Arka Kiran | Small | 217.33ᵈ | 1.96ᵈᵉ | 0.76ᶠᵍ | 9.92ʰ | 34.38ⁱ |
| 13 | Hisar Surkha | Medium | 188.50ᵉ | 1.64ᶠᵍ | 0.77ᵉᶠᵍ | 8.69ʲ | 48.54ᵍ |
| 14 | Black Guava | Large | 129.83ᵍ | 1.67ᶠᵍ | 1.03ᵃᵇ | 16.81ᵃ | 22.59ᵏ |
|  | SEm± |  | 7.32 | 0.077 | 0.043 | 0.12 | 0.65 |
|  | CD at 5% |  | 15.04 | 0.159 | 0.088 | 0.26 | 1.34 |

\*Means with same letter within a column shows non-significant differences (at p≤0.05) as per Duncan’s multiple-range test

statistically significantly different. Hisar Safeda had the highest yield (65.54 kg/tree), with Lalit (63.14 kg/tree) and L-49 (60.74 kg/tree) yielding nearly as much and indicating even higher productivity. On the other hand, Black Guava had the lowest (22.59 kg/tree), although it had the largest seeds and highest seed hardness. Moderately fruitful cultivars were Kayamganji (50.98 kg/tree) and Barafkhana (58.78 kg/tree); Sangareddy and Red Flesh were in the middle range with fruit yields between 34.56-56.30 kg/tree. Kumari *et al.* (2023) observed similar types of results for seed characters such as seed size, number of seeds/fruits, seed weight/fruit and 100 seeds weight. Rai *et al*. (2021) reported similar finding for seed hardiness and Singh *et al*. (2010) for fruit yield. Kumar and Singh (2021) reported highest yield in L-49 (142.75 kg/tree).

**5. Conclusion**

Morphological characterization of fourteen guava cultivars revealed significant genetic variability across tree growth characteristics, foliage traits, floral traits, fruit traits and seed parameters. This diversity underscores the potential of certain genotypes such as VNR Bihi, Pant Prabhat, Black Guava, Kayamganji, Sangareddy, Barafkhana, Arka Kiran and Lalit for targeted improvement. Morphological characterization is crucial for identifying elite genotypes suited for specific agro-climatic conditions and market preferences. Such evaluations offer an initial framework for guava breeding programs by enabling selection for desirable traits including yield potential, fruit quality attributes and consumer acceptability. Besides, the identification of unique traits in wild types and local germplasm enhances genetic resource conservation and utilization in crop improvement initiatives.

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