

# Growth response of guava (*Psidium guajava* L.) varieties in containerized system for urban horticulture

## Abstract

Guava (*Psidium guajava* L.), prized for its nutritional and economic value, thrives in tropical and subtropical regions, making it a suitable candidate for urban container farming. This study, conducted at the Department of Fruit Science, College of Agriculture, Vellayani, evaluated the growth response of five guava varieties under 80-liter air-pot cultivation. Among the varieties, Arka Mridula excelled in vegetative parameters, including plant height (72.33 cm) and biochemical traits like total chlorophyll (0.98 mg/100g) and reducing sugars (1.84%). Arka Rashmi showed the best reproductive performance, with early flowering (101 days after pruning), maximum flowers (12.33), and optimal canopy spread. These findings highlight the potential of Arka Rashmi for container cultivation, offering a sustainable solution for urban horticulture and food security challenges.

**Key words:** Guava, *Psidium guajava*, varietal evaluation, container growing, urban horticulture

## Introduction

Guava (*Psidium guajava* L.), belonging to the Myrtaceae family is a well-known fruit tree cultivated across tropical and subtropical regions, Guava is highly valued in the market due to its appealing taste, aroma, sweet flavour, and a well-balanced combination of acidity, sugar, and pectin (Mitra *et al.*, 2007). The fruit is particularly rich in vitamin C and also contains significant amounts of vitamins A and B (Rai *et al.*, 2010). Additionally, guava is a good source of pectin, calcium, and phosphorus. The pink color in the flesh of pink guava varieties is due to the carotenoid lycopene (Mercadante *et al.*, 1999).

The guava tree is highly adaptable and can thrive in a wide range of climatic conditions, making it suitable for cultivation in many tropical and subtropical regions. It is also a low-maintenance crop with high productivity, offering considerable economic returns (Kadam *et al.*, 2012). In regions where winter temperatures drop to 7°C, guava growth halts, leaves turn purple, and commercial production can become challenging.

India is the leading producer of guava with around 4,107 metric tonnes of annual production, covering an area of 2,70,000 hectares, with an average yield of 15.61 metric tonnes per hectare (National Horticulture Board, 2019). Uttar Pradesh, Madhya Pradesh, Bihar, Andhra Pradesh and Haryana are the major states cultivating guava.

Kerala, a state with geographical and spatial limitations has enormous potential to address the urban food supply chain, through urban home gardening, particularly on roof tops and balconies and container growing is one of its key components. Container farming is a micro-scale farming model where individual households can grow fruits and vegetables in containers.

As the global urban population is projected to double in the next 30 years, particularly in developing countries, cities would be facing increased challenges in food security, environmental degradation, poverty, and malnutrition. By 2050, over 60 per cent of the world's population will be residing in urban areas, intensifying competition for the small percentage of land (only 18%) that is cultivable. This land is further threatened by urban expansion, industrial development, and environmental disasters. Urban horticulture offers a viable solution by utilizing small urban spaces to grow food and greenery, thus improving food production, generating employment, and reducing environmental pollution (Solankey *et al.*, 2020). Fruit crops like guava, citrus, ber, and pomegranate can be successfully cultivated in urban and semi urban areas in containers (Srivastava *et al.*, 2019).

Cultivation of guava in Kerala is limited to homesteads mostly occupied by local varieties. Guava responds well to canopy modification by pruning and training and is one of the most suitable crops for high density planting, as it bears fruits on current season's growth (Singh, 2007). A large number of guava varieties have been released for commercial cultivation by various institutions, such as CCS Haryana Agricultural University (Hisar Safeda, Hisar Surkha), CISH, Lucknow (Lalit, Shweta), IHR, Bengaluru (Arka Amulya, Arka Kiran, Arka Mridula, Arka Rashmi), GBPUA&T (Pant Parbhat), and AAI, Allahabad (Allahabad Surkha). However, their adaptability to urban horticulture through container growing has not been thoroughly studied. The existing germplasm and varieties show significant heterozygosity, resulting in considerable variation in vegetative and floral parameters. (Praveen, 2019)

Guava cultivation in many regions is largely limited to homesteads, where local varieties are predominant. While crop improvement efforts in India have led to the development of promising selections and hybrids suited to different agro-climatic conditions (Dinesh and Vasugi, 2010), there is limited information on their performance in container growing. In Kerala Agricultural University studies were conducted to evaluate the effects of various container types, sizes, and planting materials on performance of guava in containers (Tharene, 2024). In this study two types (plastic container and air-pots) and three sizes

(40L,60L and 80L) of containers and three planting materials (rooted cuttings, air layers and grafts) were evaluated for container growing of guava and the best results for the growth and yield response was obtained for air layers grown in 80L air-pots. However, efforts for a comprehensive varietal evaluation in container systems remain insufficient.

In this context, this study was proposed to explore the growth response of different varieties (*Psidium guajava* L.) of guava in containerized system. This study explores the growth response of guava varieties in containers, providing valuable insights into sustainable urban horticulture for space-limited environments. By demonstrating practical approaches to enhance productivity in small spaces with minimal resources, it addresses the challenges of urbanization, environmental pollution, and limited green spaces. The findings contribute to the promotion of urban greenery and align with Sustainable Development Goals (SDGs) 11 (Sustainable Cities and Communities), 13 (Climate Action), and 15 (Life on Land). This study underscores the importance of urban horticulture as a necessity for sustainable urban development, fostering resilient communities and advancing equitable access to green solutions.

## Materials and methods

**Planting materials and experimental site:** The experiment was carried out from November 2023 – October 2024 at the Department of Fruit Science, College of Agriculture, Vellayani. The area is situated at 8° 43' North Latitude and 76° 54' East Longitude at an altitude of 29 m above mean sea level. The experiment involved a comparison of performance among different varieties of guava (three months old air layers). Healthy air layers of variety Arka Kiran and Lucknow 49 were purchased from Agricultural Research Station (ARS), Mannuthy, Thrissur, Kerala Agricultural University, while varieties like Arka Mridula, Arka Rashmi and Allahabad Safeda were purchased from College of Agriculture, Vellanikkara, Thrissur. The potting mixture was composed of soil, FYM, and sand in 1:1:1 ratio. One fifth of the recommended dose of fertilizers as per the KAU Package of Practices (KAU, 2016) was applied to the plants in pots.

**Design of experiment and treatment details:** The experiment was laid out in a completely randomized design (CRD) with five treatments and three replications. Treatments include five varieties (T<sub>1</sub>- Allahabad Safeda, T<sub>2</sub>- Lucknow 49, T<sub>3</sub> – Arka Kiran, T<sub>4</sub>- Arka Rashmi, T<sub>5</sub>- Arka Mridula) of guava.

**Measurement of growth parameters:** Growth characters viz., plant height, plant spread, stem girth, primary branch girth and secondary branch girth were recorded from the observational plants at trimonthly intervals from each treatment and the mean values were worked out. Pruning of the layers was carried out at a height of 20 cm above the ground level six months after planting. **Plant height** The height of the plant was measured from the base of the stem at soil level to the growing tip in the vertical position and expressed in centimeters (cm). **Plant spread** The spread of the plant was recorded by measuring the maximum spread in North-South and East-West directions with the help of measuring scale and expressed in centimeters. **Stem girth** Stem girth was measured as the circumference of the main stem at 10 to 15 cm from the base of the stem using a twin and measured with a scale and expressed in centimeters (cm). **Primary branch girth** Circumference of the primary branch was observed and expressed in centimeters (cm). **Secondary branch girth** Circumference of the secondary branch was observed and expressed in centimeters (cm).

**Measurement of floral parameters: Days to flowering** The number of days taken from the last pruning to the first blooming was measured and recorded in days. **Number of flowers** The number of flowers in each plant observed during the experimental period was counted from the last pruning.)

### **Physiological parameters**

The total chlorophyll content in the leaves was measured using the method outlined by Hiscox and Israelstam (1980). The total reducing sugars in the leaves were quantified using the Dinitrosalicylic acid (DNS) method as described by Somogyi (1952). The total soluble protein in the leaves was determined using Lowry's method (1951). The total carotenoid content in the leaves was estimated according to the procedure described by Sadasivam and Manikam (1976).

**Statistical analysis:** The observations were subjected to statistical analysis adopting standard procedures (ANOVA) by using KAU GRAPES Software (Gopinath *et al.*, 2021).

## **Results and Discussion**

### **Vegetative parameters**

#### **Plant height**

Table 1. Variation in plant height (cm) among different varieties of guava

Treatment	3 MAP	6 MAP	9 MAP
T <sub>1</sub>	28.00 <sup>c</sup>	57.67 <sup>b</sup>	71.33 <sup>a</sup>
T <sub>2</sub>	39.00 <sup>a</sup>	63.67 <sup>a</sup>	63.33 <sup>b</sup>
T <sub>3</sub>	27.83 <sup>c</sup>	53.33 <sup>d</sup>	61.33 <sup>c</sup>
T <sub>4</sub>	32.00 <sup>b</sup>	54.67 <sup>c</sup>	56.67 <sup>d</sup>
T <sub>5</sub>	28.67 <sup>c</sup>	57.67 <sup>b</sup>	72.33 <sup>a</sup>
SEm±	0.68	0.33	0.49
CD(0.05)	2.14	1.05	1.56

The different guava varieties varied significantly from each other in plant height (Table 1). Plant height was assessed at three-month intervals from 3 months after planting (MAP) to 9MAP. At 3 MAP, T<sub>2</sub> (39.00 cm) was the tallest, followed by T<sub>4</sub> (32.00 cm), while the shortest was T<sub>3</sub> (27.83 cm) and it was on par with T<sub>1</sub> (28.00 cm) and T<sub>5</sub> (28.67 cm). At 6 MAP, T<sub>2</sub> maintained the greatest height (63.67 cm), followed by T<sub>1</sub> and T<sub>5</sub>; T<sub>3</sub> had the lowest height (53.33 cm). By 9 MAP, which was 3 months after pruning of main stem, T<sub>5</sub> exhibited the highest plant height (72.33 cm), which was on par with T<sub>1</sub> (71.33 cm), while T<sub>4</sub> had the lowest recorded height (56.67 cm). The present study revealed that at 9MAP the guava variety Arka Mridula exhibited the maximum height (72.33 cm) in container growing, which was on par with Allahabad Safeda (71.33 cm). This finding aligns with Sahoo (2017), in which Allahabad Safeda demonstrated superior height over other guava varieties, indicating its inherent potential for robust vertical growth.

### Girth of main stem (stem girth)

Table 2. Variation in girth of the main stem (cm) among different varieties of guava

Treatment	3 MAP	6 MAP	9 MAP
T <sub>1</sub>	3.17 <sup>b</sup>	4.71 <sup>d</sup>	5.43 <sup>d</sup>
T <sub>2</sub>	3.83 <sup>a</sup>	5.31 <sup>a</sup>	6.08 <sup>a</sup>
T <sub>3</sub>	3.30 <sup>b</sup>	4.28 <sup>e</sup>	5.08 <sup>e</sup>
T <sub>4</sub>	2.80 <sup>c</sup>	4.85 <sup>c</sup>	5.61 <sup>c</sup>
T <sub>5</sub>	2.80 <sup>c</sup>	4.90 <sup>b</sup>	5.67 <sup>b</sup>
SEm±	0.06	0.01	0.02
CD(0.05)	0.19	0.01	0.05

Girth of main stem showed significant difference throughout the observation period among different varieties of guava (Table 2). Stem girth was assessed at three-months interval from 3 MAP to 9 MAP. At 3 MAP, T<sub>2</sub> exhibited the largest stem girth (3.83 cm), followed by T<sub>3</sub> (3.30 cm), which was on par with T<sub>1</sub> (3.17 cm). The smallest stem girth was observed in T<sub>4</sub> and T<sub>5</sub>

(2.80 cm each). At both 6 MAP and 9 MAP, T<sub>2</sub> continued to have the highest stem girth measurements (5.31 cm and 6.08 cm, respectively), while the lowest stem girth was recorded in T<sub>3</sub> (4.28 cm at 6 MAP and 5.08 cm at 9 MAP).

### Plant spread (E-W)

Table 3. Variation in plant spread – East West direction (cm) among different varieties of guava

Treatment	3 MAP	6 MAP	9 MAP
T <sub>1</sub>	28.67 <sup>d</sup>	39.67 <sup>d</sup>	41.33 <sup>d</sup>
T <sub>2</sub>	31.00 <sup>c</sup>	38.67 <sup>e</sup>	50.67 <sup>c</sup>
T <sub>3</sub>	36.33 <sup>a</sup>	44.33 <sup>c</sup>	63.67 <sup>b</sup>
T <sub>4</sub>	37.33 <sup>a</sup>	54.33 <sup>a</sup>	74.67 <sup>a</sup>
T <sub>5</sub>	34.67 <sup>b</sup>	47.00 <sup>b</sup>	64.33 <sup>b</sup>
SEm±	0.39	0.30	0.49
CD(0.05)	1.24	0.94	1.56

Plant spread in the east-west (E-W) direction showed significant differences throughout the period among different varieties of guava (Table 3). During the initial stages 3 MAP, T<sub>4</sub> (37.33 cm) had the greatest plant spread which was on par with T<sub>3</sub> (36.33cm) and the lowest spread in T<sub>1</sub>(28.67cm). At 6 and 9 MAP, the highest plant spread was recorded in T<sub>4</sub> (54.33 cm and 74.67 cm, respectively). The lowest spread at 9 MAP was in T<sub>1</sub> (41.33 cm). Plant spread reflects the growth habit and is closely linked to flowering and fruiting ability. The findings of Singh *et al.* (2016) in guava cultivar Allahabad Safeda support this, as they reported a significant connection between plant spread, flowering, and fruit yield attributes.

### Plant spread (N-S)

Table 4. Variation in plant spread – North South direction (cm) among different varieties of guava

Treatment	3 MAP	6 MAP	9 MAP
T <sub>1</sub>	31.67 <sup>d</sup>	42.33 <sup>e</sup>	46.33 <sup>d</sup>
T <sub>2</sub>	38.67 <sup>b</sup>	44.67 <sup>d</sup>	47.67 <sup>c</sup>
T <sub>3</sub>	40.33 <sup>a</sup>	50.67 <sup>c</sup>	57.67 <sup>b</sup>
T <sub>4</sub>	37.67 <sup>b</sup>	55.67 <sup>a</sup>	63.33 <sup>a</sup>
T <sub>5</sub>	35.67 <sup>c</sup>	52.33 <sup>b</sup>	58.67 <sup>b</sup>
SEm±	0.33	0.42	0.33
CD(0.05)	1.05	1.33	1.05

The plant spread in the north-south (N-S) direction showed significant differences throughout the period among different varieties of guava (Table 4). At 3 MAP, T<sub>3</sub> (40.33 cm) had the greatest plant spread, followed by T<sub>2</sub> (38.67 cm), which was on par with T<sub>4</sub> (37.67 cm). The lowest spread was recorded in T<sub>1</sub> (34.67 cm). At 6 and 9 MAP, the highest plant spread was recorded in T<sub>4</sub> (55.67 cm and 63.33 cm, respectively). The lowest spread at 6 MAP and 9 MAP was in T<sub>1</sub> (42.33 cm) and (46.33 cm). Arka Rashmi excelled in plant spread (both N-S and E-W spread), whereas, Arka Mridula exhibited the least spread. The variation in growth characteristics among different guava cultivars has been documented by Patel *et al.* (2007). These differences in plant growth are largely attributed to the genetic traits of each cultivar, with each genotype being developed in distinct ecological zones, leading to potentially varied responses in different agro-climatic conditions. These results align with the findings of Dolkar *et al.* (2014) and Chopra *et al.* (2021) on guava growth patterns, emphasizing the influence of cultivar-specific traits on plant spread.

### Girth of primary branches

Table 5. Variation in girth of primary branches (cm) among different varieties of guava

Treatment	3 MAP	6 MAP	9 MAP
T <sub>1</sub>	2.13 <sup>b</sup>	2.90 <sup>c</sup>	2.25 <sup>c</sup>
T <sub>2</sub>	2.65 <sup>a</sup>	2.97 <sup>b</sup>	1.86 <sup>e</sup>
T <sub>3</sub>	2.02 <sup>bc</sup>	2.82 <sup>d</sup>	2.16 <sup>d</sup>
T <sub>4</sub>	1.90 <sup>c</sup>	2.70 <sup>e</sup>	2.31 <sup>b</sup>
T <sub>5</sub>	2.10 <sup>b</sup>	3.20 <sup>a</sup>	2.55 <sup>a</sup>
SEm±	0.06	0.02	0.01
CD(0.05)	0.19	0.05	0.01

Girth of primary branches was significant across the measurement period among different varieties of guava, with assessments conducted at three-month intervals from 3 MAP to 9 MAP (Table 5). At 3 MAP, T<sub>2</sub> exhibited the thickest primary stem girth (2.65 cm), while T<sub>4</sub> had the thinnest primary stem girth (1.90 cm). At 6 MAP and 9 MAP, T<sub>5</sub> recorded the highest primary stem girth measurements (3.20 cm and 2.55 cm, respectively). By 9 MAP, the lowest primary stem girth was observed in T<sub>2</sub> (1.86 cm).

### Girth of secondary branches

Table 6. Variation in girth of secondary branches (cm) among different varieties of guava

Treatment	3 MAP	6 MAP	9 MAP
T <sub>1</sub>	1.72 <sup>a</sup>	2.32 <sup>a</sup>	1.75 <sup>c</sup>
T <sub>2</sub>	1.62 <sup>a</sup>	2.21 <sup>b</sup>	1.66 <sup>d</sup>
T <sub>3</sub>	1.27 <sup>bc</sup>	1.86 <sup>e</sup>	1.55 <sup>e</sup>
T <sub>4</sub>	1.43 <sup>b</sup>	2.00 <sup>d</sup>	1.78 <sup>b</sup>
T <sub>5</sub>	1.21 <sup>c</sup>	2.15 <sup>c</sup>	1.93 <sup>a</sup>
SEm±	0.06	0.01	0.01
CD(0.05)	0.17	0.01	0.01

The girth of secondary branches showed significant difference between the treatments across the observation period (Table 6). At 3 MAP, T<sub>1</sub> exhibited the highest secondary stem girth (1.72 cm), which was on par with T<sub>2</sub> (1.62 cm), while T<sub>5</sub> had the smallest secondary stem girth (1.21 cm). At 6 MAP, T<sub>1</sub> recorded the highest secondary stem girth (2.32 cm), and at 9 MAP, T<sub>5</sub> had the highest secondary stem girth (1.93 cm). The lowest secondary stem girth at both 6 and 9 MAP was recorded in T<sub>3</sub> (1.86 cm and 1.55 cm, respectively). Primary and secondary stem girth are the crucial indicators of a plant's vigour and sustained growth. In this study, Arka Mridula demonstrated the highest girth in both primary and secondary stems, aligning with the findings of Marak and Mukunda (2007) in Apple Colour guava, where they investigated the relationship between increased stem girth and overall plant vigour and growth. Their research indicated that thicker stems contribute significantly to enhanced vegetative development and robustness in guava plants. This observation aligns with the findings of Amrita *et al.* (2022), who reported that an increase in stem girth in guava cultivar Chittidar was associated with significant improvements in key vegetative growth parameters, including plant height, leaf area, and the number of branches, reflecting enhanced overall plant development.

### Flowering parameters

Table 7. Variation in days to flowering and number of flowers among different varieties of guava

Treatment	Days to flowering (days)	Number of flowers (days)
T <sub>1</sub>	117.67 <sup>d</sup>	5.67 <sup>d</sup>
T <sub>2</sub>	102.67 <sup>b</sup>	8.33 <sup>c</sup>
T <sub>3</sub>	106.33 <sup>c</sup>	10.33 <sup>b</sup>
T <sub>4</sub>	101 <sup>a</sup>	12.33 <sup>a</sup>
T <sub>5</sub>	132.33 <sup>e</sup>	5.33 <sup>d</sup>
SEm±	0.39	0.33
CD(0.05)	1.24	1.05

### Days to flowering

Days to flowering was recorded after pruning the main stem (Table 7). T<sub>4</sub> had the fewest days to flowering (101 days), while T<sub>5</sub> had the highest number of days to flowering (132.33 days). The study revealed a notable varietal influence on floral parameters of container grown guava layers particularly regarding the days to flowering and the number of flowers produced. Arka Rashmi presented earliest flowering, followed by Arka Kiran. This observation is in consonance with that of Singh (2003), who found that red-fleshed guava varieties exhibited earlier flowering, fruit set, and fruit ripening compared to other guava varieties.

### Number of flowers

The number of flowers was noted after pruning the main stem (Table 7). The highest number of flowers was observed in T<sub>4</sub> (12.33), followed by T<sub>3</sub> (10.33), and the lowest was noted in T<sub>5</sub> (5.33) which was on par with T<sub>1</sub> (5.67). The observed variation in flowering may be attributed to cultivar-specific traits and environmental conditions. Understanding the flowering and fruiting behaviours of fruit trees is crucial for both fruit growers and breeders. A similar pattern in flowering percentage was observed, supporting the findings of Dubey *et al.* (2004), who studied different varieties of guava focusing on flowering and fruit characteristics; Sharma *et al.* (2017) on the time and duration of guava flowering; and Sarkar *et al.* (2016) and Dolkar *et al.* (2014) on the growth and yield attributes of guava. Alam *et al.* (2018) investigated the variability among selected 12 guava genotypes of Bangladesh based on morphological and

RAPD markers. Azam *et al.* (2020) studied the variability of 22 guava (*Psidium guajava* L.) lines of Chattogra based on eleven qualitative and 11 quantitative characters. They selected two genotypes BARI Peyara 2 and BARI Peyara 4 for further breeding programmes.

## PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS

### Chlorophyll Content

Table 8. Variation in physiological and biochemical parameters among different varieties of guava

Treatment	Chlorophyll A (mg 100g <sup>-1</sup> )	Chlorophyll B (mg 100g <sup>-1</sup> )	Total Chlorophyll (mg 100g <sup>-1</sup> )
T <sub>1</sub>	0.85 <sup>a</sup>	0.84 <sup>a</sup>	0.91 <sup>b</sup>
T <sub>2</sub>	0.79 <sup>c</sup>	0.81 <sup>c</sup>	0.82 <sup>c</sup>
T <sub>3</sub>	0.78 <sup>d</sup>	0.82 <sup>b</sup>	0.81 <sup>c</sup>
T <sub>4</sub>	0.77 <sup>e</sup>	0.81 <sup>c</sup>	0.79 <sup>d</sup>
T <sub>5</sub>	0.82 <sup>b</sup>	0.84 <sup>a</sup>	0.98 <sup>a</sup>
SEm±	0.003	0.003	0.003
CD(0.05)	0.011	0.011	0.011

Chlorophyll A, chlorophyll B, and total chlorophyll content in guava leaves showed significant variation among different varieties of guava (table 8). The highest chlorophyll A content was observed in T<sub>1</sub> (0.85mg 100g<sup>-1</sup>), followed by T<sub>5</sub> (0.82 mg 100g<sup>-1</sup>), while the lowest was noted in T<sub>4</sub> (0.77 mg 100g<sup>-1</sup>). The highest Chlorophyll B content was observed in T<sub>5</sub> and T<sub>1</sub> (0.84 mg 100g<sup>-1</sup>each), while the lowest was noted in T<sub>4</sub> and T<sub>2</sub> (0.81 mg 100g<sup>-1</sup>). The highest total chlorophyll content was observed in T<sub>5</sub> (0.98 mg 100g<sup>-1</sup>), followed by T<sub>1</sub> (0.91 mg 100g<sup>-1</sup>), while the lowest was noted in T<sub>4</sub> (0.79 mg 100g<sup>-1</sup>). Arka Mridula exhibited the highest chlorophyll content among all guava varieties, although flowering was delayed. Elevated chlorophyll levels are indicative of enhanced photosynthetic efficiency (Zhu *et al.*, 2010; Thasleema, 2022), suggesting that the plant may allocate more energy towards vegetative processes such as leaf and stem development rather than reproduction. This prioritization of vegetative growth over flowering highlights the complex interplay between chlorophyll content, vegetative vigour, and reproductive development in guava cultivation. The higher chlorophyll content in Arka Mridula likely contributed to its superior vegetative growth, albeit at the expense of delayed flowering.

Table 9. Variation in physiological and biochemical parameters among different varieties of guava

Treatment	Total reducing sugars (%)	Total soluble proteins (%)	Total carotenoids (mg 100g <sup>-1</sup> )
T <sub>1</sub>	1.79 <sup>b</sup>	0.52 <sup>a</sup>	0.67 <sup>b</sup>
T <sub>2</sub>	1.53 <sup>e</sup>	0.47 <sup>b</sup>	0.62 <sup>d</sup>
T <sub>3</sub>	1.77 <sup>c</sup>	0.39 <sup>e</sup>	0.64 <sup>c</sup>
T <sub>4</sub>	1.56 <sup>d</sup>	0.41 <sup>d</sup>	0.61 <sup>e</sup>
T <sub>5</sub>	1.84 <sup>a</sup>	0.45 <sup>c</sup>	0.70 <sup>a</sup>
SEm±	0.01	0.004	0.004
CD(0.05)	0.02	0.014	0.012

#### Total reducing sugar

Total reducing sugar content of guava leaves varied significantly among the different varieties (table 9). Reducing sugar was the highest in T<sub>5</sub> (1.84 %) and the least was noted in T<sub>2</sub> (1.53 %). The leaves of Arka Mridula exhibited the highest reducing sugar content (1.84%) among all varieties studied, with its superior plant height and stem girth, but delayed flowering. Elevated sugar levels in the leaves, without inducing flowering, suggest that sugars were predominantly utilized for vegetative growth. This could be attributed to a limited sucrose transport system, which restricts sugar translocation to flower-inducing tissues, causing its accumulation in the leaves and promoting vegetative parameters such as height and girth over reproductive development (Slewinski *et al.*, 2009). This pattern aligns with the findings of Cai (2021), which highlights that an overemphasis on vegetative growth under certain conditions can suppress flowering, emphasizing the intricate balance between vegetative and reproductive phases in plants.

#### Total soluble proteins

Total soluble protein content showed significant variation among the different varieties of guava (Table 9). The highest soluble protein content was recorded in T<sub>1</sub> (0.52 %) least was noted in T<sub>3</sub> (0.39 %). On soluble protein analysis, Allahabad Safeda exhibited the highest soluble protein content (0.52%) followed by Arka Mridula. Arka Mridula outperformed the other varieties with respect to plant height and it was on par with Allahabad Safeda. This result aligns with findings by Jing *et al.* (2023), which demonstrated that higher soluble protein levels, particularly in alfalfa leaves, are significantly associated with increased plant height. The

research suggests that soluble proteins enhance photosynthetic capacity, thereby supporting better growth and taller plants.

### **Total Carotenoids**

Carotenoid content in guava leaves showed significant difference among the different varieties (Table 9). Carotenoid content was the highest in T<sub>5</sub> (0.70 mg 100g<sup>-1</sup>) and the least in T<sub>4</sub> (0.61 mg 100g<sup>-1</sup>).

### **Conclusion**

In conclusion, vegetative parameters including plant height and primary and secondary stem girth were the highest in Arka Mridula which was reflected in physiological and biochemical parameters like chlorophyll (0.98 mg 100 g<sup>-1</sup>), reducing sugar (1.84%) and carotenoid (0.70 mg100 g<sup>-1</sup>) contents that gave the highest values. However, in canopy spread and flowering parameters like days to flowering and number of flowers the highest values were in Arka Rashmi. Plants with a compact canopy and good reproductive parameters are ideal for container growing. Thus, the present study unveils the suitability of Arka Rashmi for container growing of guava.

### **FUTURE LINE OF WORK**

On the basis of the results obtained, the following suggestions are made for future line of work

- i. Media standardization: Standardization of growing media with enhanced water-holding capacity for use in air-pots is needed.
- ii. Root architecture analysis: In-depth studies on the root architecture of container-grown fruit crops to understand the growth dynamics would be highly pertinent.
- iii. Irrigation and nutrient management: Development of effective irrigation strategies and nutrient management protocols tailored for container-grown guava and other fruit crops would be useful.
- iv. Canopy Management: Standardization of effective canopy management practices is needed to improve the performance of perennial fruit crops grown in containers.
- v. Crop Load Optimization: Standardization of pruning practices and crop load management techniques has to be taken up to enhance the productivity of container-grown guava varieties.

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Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

## **REFERENCE:**

Alam, F., Islam, K. D., & Rahman, S. M. (2018). Variability among selective guava (*Psidium guajava* L.) varieties revealed by morphology and RAPD marker. *Jahangirnagar University Journal of Biological Sciences*, 7(2), 89-98.

- Amoroso, G., Frangi, P., Piatti, R., Ferrini, F., Fini, A., & Faoro, M. (2010). Effect of container design on plant growth and root deformation of little leaf linden and field elm. *HortScience*, 45(12), 1824-1829.
- Amrita, S., Mishra, S., Singh, A. K., & Suhashi. (2022). Effect of plant growth regulators on plant growth and establishment of Guava (*Psidium guajava* L.) cv. Chittidar. *Pharma Innovation*, 11(7), 3411-3413.
- Azam, M. G., Uddin, M. S., Chowdhury, S. K. H., Rashid, A. H., Barua, H., Chhanda, R. A., ... & Islam, M. N. (2020). Variability studies of guava (*Psidium guajava* L.) genotypes for growth, yield and quality attributes in Chattogram region of Bangladesh. *Journal of Agricultural Science & Engineering Innovation (JASEI)*, 1(2), 3-9.
- Cai, Y. (2021). Sugar traffic jam: impaired cellulose deposition in the phloem retards long-distance sucrose transport.
- Chopra, M. L., Kumar, K., Vikas, M. A., & Jat, P. K (2021). Studies on Variability in Growth, Foliage and Flowering characteristics of Seedling Origin Guava (*Psidium guajava* L.).
- Dinesh, M. R., & Vasugi, C. (2010). Guava improvement in India and future needs. *J. Hort. Sci.*, 5(2), 94-108
- Dolkar, D., Bakshi, P., Wali, V. K., Bhushan, B., & Sharma, A. (2013). Growth and yield attributes of commercial guava (*Psidium guajava* L.) cultivars under sub-tropical condition. *Indian Journal of Plant Physiology*, 19(1), 79-82.
- Gopinath, P.P., R Prasad, B. Joseph and V.S. Adarsh, 2020. GRAPES: General R- shiny based Analysis Platform Empowered by Statistics, <<https://www.kaugrapes.com/home.version1.0.0>.DOI:10.5281/zenodo.4923220.
- Hiscox, J. D., & Israelstam, G. F. (1979). A method for the extraction of chlorophyll from leaf tissue without maceration. *Canadian Journal of Botany*, 57(12), 1332-1334.
- Jiménez-Escrig, A., Rincón, M., Pulido, R., & Saura-Calixto, F. (2001). Guava fruit (*Psidium guajava* L.) as a new source of antioxidant dietary fiber. *Journal of Agricultural and Food Chemistry*, 49(11), 5489-5493.
- Jing, F., Shi, S., Guan, J., Lu, B., Wu, B., Wang, W., Ma, R., & Nan, P. (2023). Analysis of phenotypic and physiological characteristics of plant height difference in alfalfa. *Agronomy Journal*, 13(7), 1744.
- Kadam, M., Kaushik, P., & Kumar, P. (2012). Evaluation of guava products quality. *International Journal of Food Science and Nutrition Engineering*, 2(1), 7–11.
- KAU [Kerala Agricultural University] 2016. Package of Practices Recommendations: Crops (15 th Ed.). Kerala Agricultural University, Thrissur, 215pp.
- Kumar, A. (2012). Importance of *Psidium guajava*. *International Journal of Research in Pharmaceutical and Biomedical Sciences*, 3(1), 137–143.

- Lowry, O. H., Rosebrough, N. J., Farr, A. L., & Randall, R. J. (1951). Protein measurement with the Folin phenol reagent. *Journal of Biological Chemistry*, 193(1), 265-275.
- Marak, J. K., & Mukunda, G. K. (2005). AC Seln. 6/10-A promising progeny of apple colour. *Acta Hortic.*, 735, 105-108.
- Mercadante, A. Z., Steck, A., & Pfander, H. (1999). Carotenoids from guava (*Psidium guajava* L.): Isolation and structure elucidation. *Journal of Agricultural and Food Chemistry*, 47(1), 145-151.
- Mitra, S. K., Gurung, M. R., & Pathak, P. K. (2007). Guava production and improvement in India. *International Journal of Tropical and Subtropical Fruits*, 787, 59-66.
- Ohto, M. A., Onai, K., Furukawa, Y., Aoki, E., Araki, T., & Nakamura, K. (2001). Effects of sugar on vegetative development and floral transition in *Arabidopsis*. *Plant Physiology*, 127(1), 252-261.
- Pandey, D., Shukla, S. K., Yadav, R. C., & Nagar, A. K. (2007). Promising guava (*Psidium guajava* L.) cultivars for north Indian conditions. *Acta Horticulturae*, 735(1), 91-94.
- Patel, R. K., Yadav, D. S., Babu, K. D., Singh, A., & Yadav, R. M. (2007). Growth, yield and quality of various guava (*Psidium guajava* L.). *Acta Horticulturae*, 735(1), 57-59.
- Praveen M., 2019. *Varietal evaluation of guava for morpho-physiological traits under semi-arid condition of Haryana.*, M.Sc thesis, CCSHAU, Hisar. 120p.
- Rai, M. K., Asthana, P., Jaiswal, V. S., & Jaiswal, U. (2010). Biotechnological advances in guava (*Psidium guajava* L.). *Trees*, 24, 1-12.
- Rao, K. D., & Subramanyam, K. (2009). Growth and yield performance of aonla varieties under scarce rainfall zone. *Agricultural Science Digest*, 29(2), 45-47.
- Sadasivam, S., & Manickam, A. (1996). *Biochemical methods for agricultural sciences*. Wiley Eastern Ltd.
- Sahoo, J. (2017). *Performance of guava (Psidium guajava L.) genotypes under Bhubaneswar condition* (Ph.D. diss., Orissa University). 98 p.
- Salangsang, M. C. D., Sekine, M., Akizuki, S., Sakai, H. D., Kurosawa, N., & Toda, T. (2022). Effect of carbon to nitrogen ratio of food waste and short resting period on microbial accumulation during anaerobic digestion. *Biomass and Bioenergy*, 162, 106481.
- Sarkar, T., Sarkar, S. K., Sarkar, T., & Sau, S. (2016). Growth and yield attributes of guava (*Psidium guajava* L.) varieties under West Bengal condition. *International Journal of Agricultural Sciences*, 8, 3499-501.
- Sharma, S., Sehwat, S. K., & Sharma, K. D. (2017). Studies on time and duration of flowering, floral bud development and morphology of guava (*Psidium guajava* L.) under semi-arid region of India. *International Journal of Current Microbiology and Applied Sciences*, 6, 4176-4186.

- Singh, A., Kumar, S. A., & Kulloli, R. N. (2016). Performance evaluation of guava (*Psidium guajava* L.) introductions in arid conditions of western Rajasthan. *Annals of Arid Zone*, 55, 25-28.
- Singh, I. P. (2003). Performance of different guava (*Psidium guajava* L.) cultivars under Tripura climatic conditions. *Progressive Horticulture*, 35(1), 55-58.
- Slewinski, T. L., Meeley, R., & Braun, D. M. (2009). *Sucrose transporter1 functions in phloem loading in maize leaves. Journal of Experimental Botany*, 60(3), 881-892.
- Solankey, S. S., Akhtar, S., Maldonado, A. I. L., Rodriguez-Fuentes, J. A. V., Contreras, J. M. M., & Reyes. (2020). *Urban horticulture: Necessity of the future*.
- Somogyi, M. (1952). Notes on sugar determination. *Journal of Biological Chemistry*, 195, 19-23.
- Srivastava, K. K., Kumar, D., & Rajan, S. (2019). Standardization of container size and fruit crop for growing in containers. *Progressive Horticulture*, 51(2), 155-160.
- Tharene, R. S. 2024. *Performance evaluation of guava (Psidium guajava L.) in containers*. M.Sc thesis, Kerala Agricultural University, Thrissur. 124p.
- Thasleema Nasreen, J. S. (2022). *Effect of branch level and leaf pruning in vegetative growth, yield and quality of guava: A review. The Pharma Innovation Journal SP*, 11(1), 471-475.
- Tripathi, P. C., Karunakaran, G., & Kumar, S. (2016). Performance of aonla cultivars under humid tropical conditions of Western Ghats. *Progressive Horticulture*, 48(1), 29-33.
- Zhu, X. G., Long, S. P., & Ort, D. R. (2010). Improving photosynthetic efficiency for greater yield. *Annual Review of Plant Biology*, 61(1), 235-261.



Fig. 1. Variation in plant height among different varieties of guava (A. Arka Mridula; B. Allahabad Safeda; C. Lucknow 49; D. Arka Kiran; E. Arka Rashmi)



Fig. 2. Variation in plant spread among different varieties of guava (A. Arka Rashmi, B. Arka Kiran, C. Allahabad Safeda D. Arka Mridula and E. Lucknow 49)



Fig. 3. Plant height measured using a measuring scale



Fig. 4. Plant spread measured using a measuring scale



Fig. 5. Stem girth measured with the help of a twine and scale

UNDER PEER REVIEW