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# EVALUATION OF ACID LIME (*CITRUS AURANTIFOLIA* SWINGLE) VARIETIES FOR GROWTH, YIELD AND QUALITY PARAMETERS UNDER NORTHERN DRY ZONE OF KARNATAKA, INDIA

**Anand Nyamagoud[1], Siddanna Thoke[2]*, Kulapati Hipparagi[3], Sanaganabasava Golagi[4], Viresh Hiremath[5], Basavaraj Padashetti[6] and S N. Patil[7]**

[1]Department of Fruit Science, College of Horticulture, Bagalkot, Karnataka, India.
[2]Department of Fruit Science, Horticulture Research and Extension Centre, Tidagundi (Vijayapur) - 586 119, Karnataka, India.
[3]Dean, College of Horticulture, Almel, UHS Bagalkot, Karnataka, India
[4]College of Horticulture, Almel, UHS Bagalkot, Karnataka, India.
[5]Department of Post-Harvest Technology, UHS Bagalkot, Karnataka, India.
[6]Department of Fruit Science, College of Horticulture, Bagalkot, Karnataka, India.
[7]Department of Fruit Science, College of Horticulture, Bagalkot, Karnataka, India.
*Corresponding author E-mail : siddupom@gmail.com
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**ABSTRACT**

An experiment on evaluation of nine acid lime (*Citrus aurantifolia* Swingle) varieties under the Northern dry zone of Karnataka was conducted at HREC, Tidagundi (Vijayapura) for growth, yield and quality during 2024-25. Pramalini had the tallest plants (3.18 m), Vikram recorded maximum stem girth (49.99 cm), canopy volume (9.56 $m^3$), chlorophyll (44.15 SPAD) and superior fruit traits including fruit length, fruit diameter, fruit volume, fruit weight, TSS, vitamin C, yield (18.84 t/ha), longest shelf life (19.84 days) and lowest acidity (6.91%). Kagzi had the highest leaf area (25.43 $cm^2$), leaf area index (2.83), fruit set (28.33%) and highest juice content (56.09%). While Balaji produced the most fruits per plant (512). NRCC-8 flowered earliest (36.8 days) and Rasraj had the highest TSS:acid ratio (1.02). Overall, Vikram was superior with Balaji and Kagzi also showing promising potential during hasta bahar.

***Key words :*** Acid lime, Varieties, Evaluation, Yield, Quality.

## Introduction

Acid lime (*Citrus aurantifolia* Swingle), belonging to the family Rutaceae, is one of India's most important commercial fruits, believed to have originated in North Eastern India and adjoining regions of Burma and Northern Malaysia. Cultivated widely across states like Gujarat, Andhra Pradesh and Karnataka, it is valued for its high vitamin C, minerals and diverse uses in juices, pickles, condiments, beverages and cosmetics. With a short gestation period, early bearing and multiple harvests, acid lime has strong domestic and export demand (Waghaye *et al.*, 2019). In 2021, citrus covered 976 thousand hectares in India, of which acid lime occupied 252 thousand hectares, producing 2.5 million metric tonnes at 10.8 tonnes/ha (Anonymous, 2021). Its nutritional and medicinal properties further enhance its role in the food, nutraceutical and pharmaceutical industries.

Karnataka is a key lime-growing state, especially in Vijayapur, Bagalkot, Belgaum and Koppal districts. However, productivity is constrained by pests, diseases, nutrient and water stress and post-harvest losses, leading to more than 30% yield reduction annually. Export opportunities remain underutilized due to weak storage, grading and packaging systems, though traits like juice content, acidity and peel quality are highly valued abroad. Strengthening cold chain logistics, integrated pest and nutrient management and modern cultivation practices such as drip irrigation, mulching and canopy management can boost productivity and help India become more competitive in global lime markets. The main objective of the study is to identify suitable high yielding acid lime variety for the Northern dry zone of Karnataka.

## Materials and Methods

The investigation on "Evaluation of acid lime (*Citrus aurantifolia* Swingle) varieties for growth, yield and quality parameters under the Northern dry zone of Karnataka" was carried out during 2024–25 at HREC, Tidagundi, Vijayapura (UHS, Bagalkot). The site is situated at 16°49′ N latitude, 75°43′ E longitude and 513 m above MSL, characterized by shallow medium black soils (pH 7.5–8.5), with temperatures ranging from 15.38–38.10°C, relative humidity between 31–91% and an annual rainfall of 589 mm.

| | |
|---|---|
| No. of treatments | : 9 |
| No. of replications | : 3 |
| No. of plants/ replication | : 5 |
| Spacing | : 6 × 6 m |
| Design | : RBD |
| Total number of plants | : 135 |

**Plant height and canopy volume**

Plant height was measured with the help of a measuring tape and a long stick. Canopy volume was measured in two perpendicular directions (North–South and East–West) using a measuring tape.

**Leaf area**

Estimated using the linear method (LBK method) by sampling ten leaves from each plant, calculating their average and expressing the values in square centimeters.

The mathematical equation to calculate it is as follows:

Leaf area (LA) = L × B × K

Where L = maximum length, B = maximum breadth and K = Correction factor

**Chlorophyll content**

Was measured in fully matured leaves with the help of a SPAD-502 chlorophyll meter. The various

**Days to flower initiation :** The date of first visible flower bud opening was noted for each replication or treatment. The mean number of days to flower initiation was calculated

**Days to full bloom :** Observations were made regularly, and the date when half of the tagged flowers reached full bloom was noted for each treatment and replication. The mean number of days to full bloom was calculated

**Fruit set (%)**

Fruit set percentage is calculated using the following formula:

Fruit Set (%) = (Number of Fruits Formed / Number of Flowers at Anthesis) ×100

**Fruit length and fruit diameter**

Fruit length and diameter were measured from mature, healthy fruits collected from each treatment and replication. A uniform number of representative fruits were randomly selected. Fruit length (cm) was taken from the pedicel to the stylar end and diameter (cm) at the widest equatorial portion using a Vernier caliper. For irregular fruits, two perpendicular diameter readings were averaged. Mean values were calculated and statistically analyzed to assess treatment differences.

**Fruit volume**

Fruit volume was determined by the water displacement method. Individual mature fruits from each treatment and replication were submerged in a graduated cylinder filled with a known volume of water and the volume of water displaced was recorded as the fruit volume ($cm^3$).

**Fruit yield**

Fruit yield was recorded from all plants in each treatment and replication at harvest. Mature fruits were collected, counted, and weighed using a digital balance. The total fruit yield per plant (g or kg) was calculated by dividing the total fruit weight by the number of plants harvested. Yield per hectare was estimated based on plant population per unit area.

**TSS, Titratable acidity, TSS to acid ratio and shelf life**

Five healthy fruits were selected randomly from each tree at full maturity stage. A hand refractometer was employed to measure the total soluble solids (TSS). Fruit acidity was determined through a standard acid–alkali titration procedure, while ascorbic acid content and juice per cent were analyzed following the method outlined by Ranganna (1986). Shelf life was assessed by recording the number of days from harvest until the fruits stayed in acceptable edible condition without signs of spoilage under ambient storage.

**Statistical analysis**

Data were analyzed using ANOVA (Fisher's method) in RBD. Treatment effects were tested at 5% significance, with CD values used for mean comparison.

## Results and Discussion

Among the acid lime varieties, maximum plant height was recorded in Pramalini (3.18 m) whereas, maximum stem girth (49.99 cm) and canopy volume (9.56 $m^3$) was recorded in Vikram (Table 1 and Fig. 1). Vikram exhibited superior growth characters among acid lime varieties due to longer internodes, strong apical dominance, genetic

**Table 1 :** Plant height, stem girth, canopy volume, leaf area, leaf area and chlorophyll content of different acid lime varieties during hasta bahar

| Treatment | Plant height (m) | Stem girth (cm) | Canopy volume ($m^3$) | Leaf area ($cm^2$) | Leaf area index | Chlorophyll content (SPAD) |
|---|---|---|---|---|---|---|
| **Kagzi** | 2.96 | 33.49 | 8.55 | 25.43 | 2.83 | 39.19 |
| **Sai Sharbati** | 3.08 | 42.13 | 8.03 | 22.68 | 2.52 | 42.93 |
| **NRCC-7** | 3.14 | 46.31 | 9.40 | 20.58 | 2.29 | 39.27 |
| **NRCC-8** | 3.01 | 39.36 | 7.66 | 18.40 | 2.04 | 40.21 |
| **Balaji** | 3.04 | 40.46 | 8.18 | 20.79 | 2.31 | 31.20 |
| **Pramalini** | 3.18 | 44.22 | 9.29 | 18.34 | 2.04 | 40.79 |
| **Vikram** | 2.92 | 49.99 | 9.56 | 19.76 | 2.20 | 44.15 |
| **Phule Sharbati** | 2.98 | 41.32 | 9.23 | 19.65 | 2.18 | 42.93 |
| **Rasraj** | 2.96 | 34.79 | 7.66 | 20.59 | 2.29 | 41.03 |
| **S.Em ±** | **0.05** | **0.65** | **0.12** | **0.27** | **0.04** | **0.53** |
| **CD at 5%** | **0.15** | **1.94** | **0.37** | **0.81** | **0.12** | **1.59** |

**Table 2 :** Days to flower initiation, days to full bloom, fruit set, fruit volume, number of fruits/plants, average fruit, yield of different acid lime varieties during hasta bahar.

| Treatment | Days to flower initiation | Days to full bloom | Fruit set (%) | Fruit length (mm) | Fruit diameter (mm) | Fruit volume ($cm^3$) | Number of fruits/ plants | Average fruit weight (g) | Yield t/ha |
|---|---|---|---|---|---|---|---|---|---|
| **Kagzi** | 39.60 | 41.60 | 28.33 | 43.53 | 39.80 | 46.67 | 451.3 | 40.33 | 15.16 |
| **Sai Sharbati** | 41.20 | 42.10 | 27.87 | 41.33 | 39.58 | 38.00 | 281.21 | 42.00 | 9.84 |
| **NRCC-7** | 37.50 | 41.60 | 26.35 | 41.42 | 39.90 | 45.33 | 312.12 | 30.33 | 7.89 |
| **NRCC-8** | 36.80 | 41.20 | 25.65 | 41.85 | 41.25 | 51.33 | 336.00 | 34.00 | 9.52 |
| **Balaji** | 38.20 | 42.50 | 26.23 | 43.67 | 40.42 | 54.67 | 512.00 | 32.33 | 13.79 |
| **Pramalini** | 40.50 | 40.90 | 25.33 | 40.72 | 39.37 | 37.00 | 492.67 | 30.33 | 12.45 |
| **Vikram** | 39.50 | 40.20 | 27.67 | 44.06 | 42.10 | 61.33 | 495.12 | 45.67 | 18.84 |
| **Phule Sharbati** | 40.90 | 42.60 | 24.56 | 43.72 | 41.91 | 52.00 | 285.21 | 32.33 | 7.68 |
| **Rasraj** | 41.30 | 40.35 | 24.43 | 41.61 | 40.15 | 54.00 | 386.23 | 36.33 | 11.69 |
| **S.Em ±** | **0.51** | **0.73** | **0.39** | **0.69** | **0.40** | **1.09** | **7.79** | **0.93** | **0.15** |
| **CD at 5%** | **1.53** | **NS** | **1.17** | **2.07** | **1.21** | **3.27** | **23.36** | **2.81** | **0.45** |

vigour and adaptability. Greater stem girth enhances photosynthesis and carbohydrate accumulation, supporting xylem and phloem development which are consistent with Kumar *et al*. (2011), Patel *et al.* (2005), Kamatyanatti *et al*. (2016) and Rajamanickam (2023). Well-adapted varieties also developed fuller canopies, increasing canopy volume (Shrivastava *et al*., 1987; Singh *et al.*, 2021). Leaf area (25.43 $cm^2$) and leaf area index in Kagzi (2.83) and chlorophyll content in Vikram (44.15 SPAD). Larger leaf area and higher leaf area index (LAI) improve photosynthetic efficiency and growth, while chlorophyll content varies with genetics and leaf morphology, aligning with observations by Reynolds and Wardle (2016) and Bascunan-Godoy *et al*. (2017).

Among the different acid lime varieties, NRCC-8 took less number of days to flower initiation (36.80 days), while Rasraj had maximum number of days (41.30 days). The days taken to full bloom did not vary significantly among the varieties. Kagzi recorded the highest fruit set percentage (28.33%), whereas the lowest fruit set was observed in Rasraj (24.43%). The longest fruit length was recorded in Vikram (44.06 mm), and the shortest in Pramalini (40.72 mm). Vikram also exhibited the highest fruit diameter (42.10 mm), while the smallest diameter was noted in Sai Sharbati (39.58 mm). The highest fruit volume was observed in Vikram (61.33 $cm^3$) and the lowest in Pramalini (37.00 $cm^3$). The maximum number of fruits per plant was recorded in Balaji (512.00), with the lowest in Sai Sharbati (281.21). The highest average fruit weight was recorded in Vikram (45.67 g), while the lowest was in NRCC-7 (30.33 g). Finally, Vikram also recorded the highest yield (18.84 t/ha), whereas Phule Sharbati recorded the lowest yield (7.68 t/ha) (Table 2). The data shows significant differences in flowering and

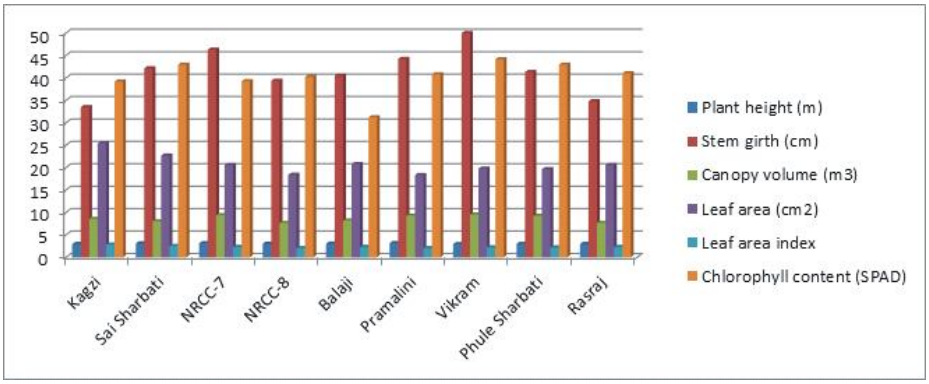


**Fig. 1 :** Plant height, stem girth, canopy volume, leaf area, leaf area index and chlorophyll content of acid lime varieties.

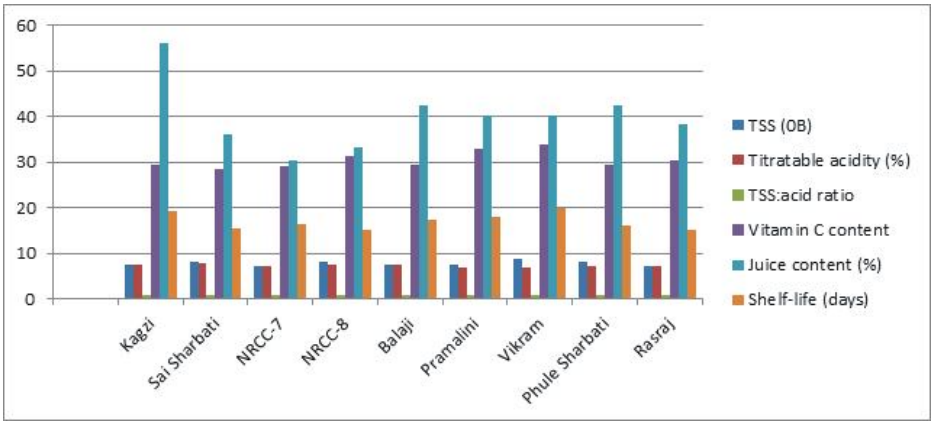


**Fig. 2 :** TSS, titratable acidity, TSS to acid ratio, vitamin c content, juice content and shelf life of different acid lime varieties.

**Table 3 :** TSS, titratable acidity, TSS: acid ratio, vitamin C content, juice content, shelf-life of different acid lime varieties during hasta bahar.

| Treatment | TSS ($^0$B) | Titratable acidity (%) | TSS:acid ratio | Vitamin C content (mg/100g) | Juice content (%) | Shelf-life (days) |
|---|---|---|---|---|---|---|
| **Kagzi** | 7.67 | 7.59 | 0.99 | 29.34 | 56.09 | 19.25 |
| **Sai Sharbati** | 8.17 | 7.75 | 0.99 | 28.42 | 36.06 | 15.62 |
| **NRCC-7** | 7.20 | 7.24 | 1.01 | 29.15 | 30.33 | 16.41 |
| **NRCC-8** | 8.10 | 7.40 | 0.91 | 31.24 | 33.21 | 15.23 |
| **Balaji** | 7.67 | 7.42 | 0.97 | 29.40 | 42.48 | 17.25 |
| **Pramalini** | 7.53 | 6.94 | 0.92 | 33.02 | 40.29 | 18.12 |
| **Vikram** | 8.73 | 6.91 | 0.94 | 34.03 | 40.30 | 19.84 |
| **Phule Sharbati** | 8.17 | 7.28 | 0.89 | 29.60 | 42.52 | 16.18 |
| **Rasraj** | 7.17 | 7.30 | 1.02 | 30.42 | 38.37 | 15.12 |
| **S.Em ±** | **0.19** | **0.08** | **0.02** | **0.67** | **0.73** | **0.26** |
| **CD at 5%** | **0.58** | **0.25** | **0.06** | **2.02** | **2.20** | **0.78** |

fruiting pattern among acid lime varieties. Early flowering and fruit set were crucial for yield, which were linked to greater plant height, wider canopy and more primary branches (Manoj and Misra, 2007). Variations in fruit size, fruit volume and fruit weight were influenced by genetics, nutrient uptake, cellular expansion and environmental factors (Prasanna *et al*., 2023; Jadhav *et al*., 2019). Genotypic differences in branch number affected flower and fruit count (Naik *et al*., 2019), while broader canopy spread improved light interception and physiological efficiency, supporting higher fruiting (Ranpise *et al*., 2003; Chaudhary *et al*., 2018).

Among the acid lime varieties, Vikram recorded the highest total soluble solids (8.73 °B) while, Rasraj had the lowest TSS (7.17 °Brix). Titratable acidity ranged from a maximum of (7.75) in Sai Sharbati to a minimum

of (6.91) in Vikram. The highest TSS to acid ratio was observed in Rasraj (1.02) whereas, Phule Sharbati recorded the lowest ratio (0.89). Regarding vitamin C content, Vikram had the highest value (34.03 mg/100g) while, Sai Sharbati had the lowest (28.42 mg/100g). Juice content was highest in Kagzi (56.09%) and lowest in NRCC-7 (30.33%). The longest shelf-life was observed in Vikram (19.84 days), while the shortest shelf-life was recorded in Rasraj (15.12 days) (Table 3 and Fig. 2). Variations in TSS among acid lime varieties are due to genetic differences and chemical composition, with higher TSS enhancing sweetness and flavor (Grierson and Kader, 1986; Ladaniya, 2008). Acidity is influenced by temperature, sunlight and metabolic activity (Shrestha *et al*., 2012; Kumar *et al*., 2011), while the TSS:acid ratio is a reliable indicator of fruit quality. Varieties with thin peel and smaller albedo have higher juice content (Kurbett and Khyadagi, 2023) and shelf life depends on varietal traits, low respiration and resistance to microbial spoilage (Kader, 2002).

## Conclusion

The study revealed significant variation among acid lime varieties for growth, yield and quality traits. Vikram excelled in stem girth, canopy volume, chlorophyll content, fruit size, yield, vitamin C, TSS and shelf life, making it the most promising variety. Kagzi showed superiority in leaf traits, fruit set and yield while Balaji produced the most fruits per plant. NRCC-8 flowered earliest and Rasraj recorded the highest TSS:acid ratio. Overall, Vikram was best for productivity, Kagzi for profitability, highlighting their potential for commercial cultivation.

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**Competing interests :** Authors have declared that no competing interests exists.

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