**Evaluation of wood apple genotypes for yield traits under Tamil Nadu condition**

***Abstract***

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| **Aim:** Wood apple (*Feronia limonia* L.) is a hardy, indigenous fruit crop with significant nutritional and medicinal properties. Despite its adaptability to adverse agro-climatic conditions and its utility in traditional medicine and dryland horticulture, the species remains underexploited due to limited research on its genetic potential. This study aimed to evaluate the genetic variability in yield-related traits among selected wood apple genotypes to identify superior types for varietal development.**Methodology:** Field evaluation was carried out at the Department of Fruit Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University (TNAU), Periyakulam, over five years (2019–2024). Nine genotypes (WFL-01 to WFL-09), selected from preliminary germplasm collections for their promising yield and quality traits, were assessed under a Randomized Block Design (RBD) with three replications. Morphological and yield-related parameters were recorded using standard procedures.**Results:** Significant variability was observed among genotypes for all measured traits. Fruit length ranged from 6.80 to 11.00 cm, fruit width 6.90 to 10.00 cm, and fruit weight 150.00 to 470.00 g. Pulp weight varied from 75.00 to 340.00 g, with seed count ranging from 170 to 620. Shell thickness was between 0.28 and 0.40 cm. Yield per tree varied notably from 33.00 to 150.40 kg, and projected yield ranged from 7.20 to 30.80 t ha⁻¹.**Conclusion:** Among the evaluated genotypes, WFL-03 demonstrated the highest performance across all yield attributes, followed closely by WFL-08 and WFL-04. The considerable variation observed suggests a high degree of genetic diversity, offering significant opportunities for selection and genetic improvement in wood apple. These findings hold practical relevance for commercial cultivation, breeding programs, and sustainable utilization of this underutilized fruit crop. |

***Keywords:*** *Wood Apple, Genetic Diversity, Yield Traits.*

1. INTRODUCTION

Wood apple (*Feronia limonia* L.), a monotypic species of the family Rutaceae with 2n = 18 chromosomes (Mazumder *et al*., 2006), is an indigenous underutilized fruit tree valued for its ecological resilience and multipurpose utility. Commonly grown in the wild or along field margins, this drought-hardy and salinity-tolerant tree thrives in arid and semi-arid zones, especially in the degraded soils of central and peninsular India (Rajangam *et al*., 2021). Despite its wide distribution in states like Madhya Pradesh, Chhattisgarh, Uttar Pradesh, West Bengal, and Maharashtra (Debbarma and Hazarika, 2024), organized cultivation of wood apple remains limited due to a lack of improved varieties and agronomic standardization.

The yield potential of wood apple is influenced by a complex interplay of genotypic and environmental factors. However, due to its semi-wild status, minimal domestication, and long juvenile phase, the crop suffers from wide variability in yield-related traits such as fruit number, fruit weight, and pulp recovery. With increasing demand for nutritionally rich and climate-resilient crops, there is a pressing need to identify and evaluate elite genotypes with superior yield performance and adaptability to low-input systems.

Previous studies have reported significant genetic diversity among wood apple accessions for traits like tree vigor, fruit size, pulp weight, and seed number (Kumar and Deen, 2017; Singh *et al*., 2016). However, these evaluations were often localized and lacked a comprehensive multigenotypic comparison under uniform conditions. In this context, yield traits such as fruit weight, number of fruits per tree, shell thickness, pulp-to-fruit ratio, and total yield per plant serve as key indicators for selection and varietal improvement (Shukla *et al*., 2024).

Therefore, the present study was undertaken to assess the diversity in yield-contributing traits among selected wood apple genotypes collected from different agro-climatic regions. The objective is to identify high-yielding and agronomically promising accessions for potential use in breeding programs and commercial cultivation. This effort is expected to lay a strong foundation for the genetic enhancement and systematic domestication of this nutritionally significant but underutilized fruit crop.

2. material and methods

**Experimental Details**

The present investigation on the evaluation of wood apple (*Feronia limonia* L.) genotypes was carried out at the Department of Fruit Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India, during the period 2019–2024. Nine promising genotypes (WFL-01 to WFL-09) were selected from diversity-rich regions across Tamil Nadu and established under ex situ field gene bank conditions. The experiment was laid out in a Randomized Block Design (RBD) with three replications, and standard cultivation practices were followed.

**Observation Recorded**

**Fruit Length (cm) & Fruit Width (cm)**

A digital caliper was used to measure the fruit length (along the longest axis) and width (perpendicular to the length) of each fruit. Measurements were taken from freshly harvested fruits to ensure accuracy and recorded to the nearest millimeter (0.1 cm) (Takahashi *et al*., 2025; Neupane *et al*., 2023)

**Fruit Weight (g)**

Individual fruits were weighed using a digital top-pan balance with a sensitivity of at least 0.01 g. The balance was properly calibrated before use, and the gross weight of each fruit was recorded consistently (Guo *et al*., 2021).

**Pulp Weight (g)**

Each fruit was cut open carefully, and all seeds were manually extracted and placed on labeled paper towels. Seeds were then individually counted to ensure accuracy (Kerkar *et al*., 2020).

**Number of Seeds per Fruit**

Each fruit was cut open carefully, and all seeds were manually extracted and placed on labeled paper towels. Seeds were then individually counted to ensure accuracy (Guitián, 2023)

**Shell Thickness (cm)**

Shell thickness was measured using a digital caliper at multiple points on the fruit, including the equator, stem end, and stylar end. The average thickness was calculated for each fruit and recorded in centimeters (Guo *et al*., 2021; Härmark *et al*., 2016).

**Number of Fruits per Tree**

All mature fruits on each sample tree were manually counted. In trees with dense canopies, fruits on representative branches were counted, and the total number per tree was extrapolated based on the total number of branches (Malik *et al*., 2019).

**Yield per Tree (kg)**

All fruits from each tree were harvested and weighed. The total weight of fruits per tree was calculated and expressed in kilograms (kg) (Longworth & Freeman, 1963; Singh *et al*., 2006).

**Estimated Yield per Hectare (tons ha⁻¹)**

The number of productive trees per hectare was recorded. The average yield per tree (in kg) was multiplied by the tree population per hectare, and the result was converted to tons to estimate the yield per hectare (ICAR-CIAH, 2020; Khalid Hamada, 2023).

Yield (t ha-1) = $\frac{Number of trees per ha×Average yield per tree (kg)}{1000}$

**Statistical Analysis**

The pooled data recorded over multiple seasons were statistically analyzed using Analysis of Variance (ANOVA) in R software (version 2.4.1), employing the agricolae package for performing mean comparisons and experimental design analysis (De Mendiburu, 2020). Treatment means were compared at the 5% level of significance using the Critical Difference (CD) method to identify statistically significant differences among wood apple genotypes.

3. results and discussion

The data presented in Figure 1. revealed a wide range of variability among the evaluated wood apple genotypes for fruit morphological and yield-related attributes, indicating the presence of significant genetic diversity that can be exploited for selection and improvement.

**Fruit Length (cm)**

Fruit length varied significantly among the genotypes, ranging from 6.8 cm in WFL-01 to a maximum of 11.0 cm in WFL-03. Genotypes WFL-04 and WFL-08 also showed relatively longer fruits with lengths of 9.5 cm each. The observed variability in fruit length reflects considerable genetic diversity among the genotypes, which is a critical factor in selecting superior lines for breeding purposes Comparable variability has been reported in bael (*Aegle marmelos*) and wood apple (*Feronia limonia*), where fruit length ranged from 4.60 cm to 14.86 cm among genotypes (Sharma *et al*., 2020; Ghosh and Bera, 2012). These differences were primarily attributed to genotype-specific growth habits and fruit development patterns.

**Fruit Width (cm)**

Fruit width ranged from 6.9 cm in WFL-01 to 10.0 cm in WFL-03, indicating moderate variation among genotypes. WFL-04, WFL-05, and WFL-08 also recorded high fruit widths (9.2–9.7 cm), which often correlate with overall fruit volume and consumer preference Studies on wood apple accessions have shown a wide range of fruit width (5.57–15.62 cm), where genotypic effects were found to be predominant (Sheikh *et al*., 2019). Broader fruits tend to have more pulp and better market value.

**Fruit Weight (g)**

The highest fruit weight was recorded in WFL-03 (470.45 g), followed by WFL-08 (460.65 g), while the lowest was seen in WFL-01 (150.23 g). The trend followed that of fruit size, showing a significant positive relationship between fruit length/width and weight. Such significant variation in fruit weight has been documented in bael and jackfruit genotypes, where fruit weight varied from 200 to 1000 g depending on genetic variation and agro-climatic conditions (Singh *et al*., 2006). A high fruit weight is desirable in breeding programs aimed at improving productivity.

**Pulp Weight (g)**

Pulp weight followed a similar trend to total fruit weight. WFL-03 had the highest pulp weight (340.5 g), while WFL-01 showed the lowest (75.13 g). Genotypes with larger fruit also showed proportionally higher pulp content, indicating better edible yield. Ghosh and Panigrahi (2013) reported that pulp weight in wood apple significantly correlates with fruit size, and high pulp content is an essential trait for processing varieties.

**Number of Seeds Per Fruit**

The number of seeds ranged widely from 170 in WFL-07 to 620 in WFL-03. Seeds are essential components of fruit development and play a role in determining nutritional and processing quality. Excessive seeds may be undesirable for fresh consumption.In wood apple studies, the number of seeds per fruit was reported to vary from 210 to over 600 depending on genotype (Thakur *et al*., 2017). Genotypes with moderate seed content are often preferred for pulp extraction.

**Shell Thickness (cm)**

Shell thickness differed slightly but meaningfully across genotypes. The thickest shell was observed in WFL-01 (0.40 cm) and thinnest in WFL-03 (0.28 cm), which is advantageous for easier processing. A thinner shell is preferred in genotypes intended for pulp processing. In bael and wood apple, shell thickness ranged from 0.25 to 0.45 cm (Srivastava *et al*., 2018). Varieties with thinner shells are more suitable for processing industries due to less industrial waste.

**Number of Fruits per Tree**

The number of fruits per tree ranged from 220 (WFL-01) to 320 (WFL-03). WFL-03, WFL-05, and WFL-08 exhibited high fruit set potential, which contributes significantly to overall yield. Studies in tropical and subtropical fruit trees like bael and ber have reported genotypic differences in fruit-bearing capacity ranging from 180 to over 350 fruits per tree under uniform orchard conditions (Kumar *et al*., 2015). Similar findings were reported by Rajangam and Sankar (2022) in wood apple.

**Yield per Tree (kg)**

Yield per tree ranged from 33.00 kg in WFL-01 to 150.40 kg in WFL-03. High-yielding genotypes (WFL-03, WFL-08, WFL-04) are ideal candidates for large-scale cultivation due to their superior productivity. According to studies on bael (Singh *et al*., 2012) and wood apple (Reddy *et al*., 2016), yield per tree can vary from 30 to over 160 kg depending on genotype, cultural practices, and climatic adaptation.

**Estimated Yield per Hectare (tons ha-1)**

The estimated yield per hectare followed the same trend as per-tree yield, ranging from 7.2 tons ha­-1 in WFL-01 to 30.8 tons/ha in WFL-03. WFL-03 showed outstanding performance, making it a promising candidate for high-density orcharding and commercial exploitation. Yields as high as 25–35 tons ha­-1 have been documented in elite bael and wood apple genotypes under improved orchard management (ICAR-CIAH, 2020). Selecting high-yielding lines can significantly boost farm profitability.

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**Fig. 1. Diversity of yield characteristics among wood apple genotypes**

*Test the significant at P < 0.05 and Each bar represents the mean value ± standard error (SE) of pooled data across multiple seasons.*

4. Conclusion

The evaluation of yield-related characters among the nine-wood apple (*Feronia limonia* L.) genotypes revealed considerable variation, indicating the presence of valuable genetic diversity. Among the genotypes, WFL-03 consistently outperformed others by recording the highest fruit length (11.0 cm), fruit width (10.0 cm), fruit weight (470.0 g), pulp weight (340.0 g), and number of seeds per fruit (620), along with superior fruit count per tree (320), yield per tree (150.40 kg), and projected yield per hectare (30.80 t ha-1). This suggests that WFL-03 holds significant potential for commercial cultivation and future breeding programs aimed at improving fruit size and yield. Other genotypes such as WFL-08 and WFL-04 also exhibited promising yield traits, making them suitable for dual-purpose use in both table and processing markets. The wide variability observed in yield attributes highlights the scope for further selection and genetic enhancement in wood apple.

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