
**E-ISSN:** 2618-0618
**P-ISSN:** 2618-060X
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www.agronomyjournals.com
2024; 7(5): 30-35
Received: 21-02-2024
Accepted: 24-03-2024

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# A study on *Aegle marmelos* characteristics in the lateritic zone of Birbhum region

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**DOI:** https://doi.org/10.33545/2618060X.2024.v7.i5a.664

**Abstract**
An assessment of local *Aegle marmelos* genotypes in various parts of Birbhum district has unveiled significant variations in their vegetative, yield, and physico-chemical characteristics. Key vegetative parameters, such as tree height, tree spread, and trunk girth, displayed ranges of 9.43-15.83 m, 4.12-6.61 m, and 72.33-90.93 cm, respectively. Furthermore, leaf area, chlorophyll content, and yield showed wide variations of 68.03-155.90 $cm^2$, 1.96-3.06 mg $100^{-1}$g, and 61.34-211.12 kg $tree^{-1}$, respectively. In terms of fruit characteristics, there were notable differences in fruit weight (281.50-998.06 g), seed weight per fruit (3.36-18.53 g), total soluble solids (TSS) content (28.00-42.53°Brix), reducing sugar (1.03-3.58%), total sugar (7.21-11.59%), acidity (0.50-1.05%), TSS/acid ratio (32.68-80.00), ascorbic acid content (13.33-36.53 mg $100\text{-}^{1}$g), total carotenoids (0.98 to 2.36 mg $100\text{-}^{1}$g), and tannin content (2.16-3.76%). These variations provide valuable insights into the adaptability of *Aegle marmelos* to environmental factors. Notably, genotypes $SB_4$, $SB_6$, $SB_9$, $SB_{11}$, and $SB_{13}$ exhibit particular promise for improving the livelihoods of small family farming in the region.

**Keywords:** Characterization, genotypes, morphology, lateritic zone, livelihood and physico-chemical properties

## Introduction
*Aegle marmelos* L. Correa, known by various local names such as bael, bel, Holy fruit, Indian quince, Bengal quince, Golden apple, bela, stone apple, sirphal, maredoo, and Elephant apple, is a significant yet often underutilized fruit tree belonging to the Rutaceae family. It is believed to have its origins in the foothills of the Himalayas in India [1]. The fruit is commonly consumed fresh and used in the preparation of squash, jam, pudding, and delightful desserts [2]. *Aegle marmelos* occupies a special place in Indian traditional medicine, particularly in Ayurveda [3], where its distinct parts have been employed for centuries to treat various human ailments [4, 5, 6].

A notable feature of *Aegle marmelos* is its high morphological diversity [7]. This tree is found throughout India, with a significant concentration in the eastern Gangetic plain and adjacent regions, including West Bengal, Bihar, Uttar Pradesh, as well as certain states in central and southern India. Despite this rich diversity, *Aegle marmelos* remains somewhat overlooked and is classified as an underutilized minor fruit crop [8, 9]. The lack of improved cultivars for commercial cultivation [10] and limited research efforts contribute to its underutilization.

Recent studies, such as the one by Thind and Mahal [11], have highlighted *Aegle marmelos* as the premier or preferred fruit for semi-arid and arid regions due to its remarkable tolerance to adverse soil and climatic conditions. This tree can endure temperatures as low as -7°C [10], although it sheds its leaves as an adaptation mechanism during extremely cold conditions. The present study area, Birbhum district in West Bengal, represents a humid, semi-arid, sub-tropical agro-climatic region situated within the 'Red and lateritic' zone of India. The soil in this region is generally infertile and characterized by its rusty red coloration, indicative of high iron oxide content. It exhibits a hard rock texture, acidity, porosity, low organic matter, and low nutrient levels. In certain parts of this region, especially in the upper and mid-regions, many fruit crops have been cultivated successfully, thriving as wild crops and yielding high-quality fruits.

*Aegle marmelos* is a valuable fruit crop for plant breeders due to the extensive variation within the species and its adaptability to different agro-climatic conditions in India [12, 13, 14, 15, 16].

However, it has not yet achieved the status of a commercial crop in this region. Effective and efficient cultivation of any fruit crop necessitates the evaluation and selection of suitable genotypes that can thrive within specific agro-climatic conditions.

To elevate *Aegle marmelos* from its current underutilized status, it is imperative to assess and identify superior genotypes based on physical characteristics, fruit size, physico-chemical properties, and bioactive attributes [17]. The collection, characterization, and utilization of genetic resources are pivotal for the development of fruit cultivars that can meet the present and future demands of consumers. As suggested by Zhang and colleagues [18], the morphological characterization of genotypes serves as a valuable tool in emphasizing the crop's importance, particularly for small family farming and commercial production, considering its nutritional and medicinal values, as well as its potential in processing industries.

Considering the vast scope for the exploration and adaptation of *Aegle marmelos* to various agro-climatic conditions, including challenging environments, the present evaluation study has been conducted with the aim of assessing its performance in the semi-arid, humid, subtropical region situated within the 'Red and lateritic' zone of Birbhum district, West Bengal. This research seeks to unlock the potential of this remarkable fruit tree, improve cultivation practices, and explore its adaptability to a range of environmental conditions, ultimately enhancing its significance in agriculture and benefiting the livelihoods of farmers in the region.

## Materials and Methods

The current research project was carried out in the 'Department of Horticulture and Post-Harvest Technology' at the Institute of Agriculture, Visva-Bharati, located in Sriniketan, West Bengal, in the year 2019.

To gather data, fourteen local genotypes of *Aegle marmelos* were selected from various parts of the Birbhum region, based on their physical characteristics and performance, through consultation with local residents (Table 1). Observations were conducted on the morphological features of these plants, such as stem girth, thorn length, and growth habits, following standard procedures. For leaf area estimation, 20 fully developed leaves were collected from the periphery of the trial trees. These leaves were measured for area in square centimeters using an Automatic Leaf Area Meter (Licor Model 3100). The initial mean leaf fresh weight was determined using a semi-analytical balance, and similarly, the oven-dried leaves were weighed after drying at 60°C for 48 hours. The total chlorophyll content in the leaves was estimated using the DMSO (Dimethyl Sulphoxide) method as described by Hiscox and Israelstam [19]. A digital caliper was employed to measure the thickness, length, and diameter of the fruit rind, expressed in millimeters. The total fruit weight, rind weight (g), pulp weight (g), and seed weight (g) were measured using a semi-analytical balance. The fruit volume was determined using the water displacement method and expressed in cubic centimeters ($cm^3$). The number of seeds per fruit was also computed. Furthermore, the total soluble solids (TSS) content of the fruits was assessed with a digital hand-held refractometer and expressed as degrees Brix (ºBrix). The percentages of total sugar, reducing sugar, titratable acidity, total carotenoids (mg per 100 g), ascorbic acid (mg per 100 g), and tannin content (%) in the fruits were also calculated using the methods described in AOAC [20].

The experiment was designed following a randomized block design (RBD) with fourteen different treatments. Each treatment was replicated three times. Analysis of variance (ANOVA) was performed using the PROC GLM program in SAS software. The CD (Critical Difference) values, calculated at a 5% level of probability, along with p-values, were used to assess the variance among the treatments.

## Results and Discussion

The current investigation revealed a notable diversity in tree morphology, with the exception of tree spread as depicted in Table 2. Among the genotypes examined, $SB_4$ exhibited the most impressive features, boasting a towering tree height of 15.83 m, an expansive tree spread spanning 6.61 m, a substantial tree volume of 362.15 $m^3$, and a trunk girth measuring 90.93 cm. Genotype $SB_{13}$ also showcased a remarkable trunk girth. Additionally, the study observed a range of tree growth habits, categorized as erect, semi-erect, and spreading types. Specifically, six genotypes displayed an erect growth pattern ($SB_1$, $SB_5$, $SB_7$, $SB_{11}$, $SB_{12}$ and $SB_{13}$), another six presented spreading characteristics ($SB_2$, $SB_3$, $SB_4$, $SB_8$, $SB_{10}$ and $SB_{14}$) while the remaining two fell under the semi-erect category ($SB_6$ and $SB_9$). These variations in morphological traits appear to be influenced by genetic factors and climatic conditions, in line with previous research [21]. Gene recombination resulting from crosses between different genotypes [22] and endogenous hormone activity in tree growth and development [23] may also contribute to this observed diversity. Earlier work by Kumar and colleagues [24] reported similar significant variations in tree morphology among different *Aegle marmelos* genotypes under various Indian agro-climatic conditions.

Every genotype included in the study exhibited thorn-bearing habits (Table 2), with variations in thorn length ranging from 2 cm ($SB_2$, $SB_{10}$ and $SB_{12}$) to 3.2 cm ($SB_4$, $SB_{11}$ and $SB_7$). $SB_4$ and $SB_7$ stood out with the longest thorns. The development of thorns among the bael genotypes in these challenging agro-climatic conditions could be attributed to genetic adaptations of the stem to reduce transpiration water loss from the plant, aligning with Scherrer and Korner's assertion [25] that plants can modify their structures in response to environmental changes during growth and development. Thorn development can also serve as a defense mechanism against animal damage, as suggested by Hanley and co-workers [26]. Variations in thorn-bearing habits likely stem from differences in the degree of adaptation and modification exhibited by each genotype.

Regarding the leaf characteristics data (Table 2), the leaf area exhibited a considerable range, spanning from 68.03 $cm^2$ to 155.90 $cm^2$. Notably, this range of leaf area closely aligns with the findings of Nagar and co-workers [27] in the context of south Haryana conditions, where they reported leaf areas within the range of 60.29 $cm^2$ to 105.42 $cm^2$. $SB_6$ showcased the largest leaf area, while $SB_{12}$ had the smallest. Bhawna and Misra [28] had previously documented significant differences in leaf area among various *Aegle marmelos* leaves, affirming our findings.

Fresh leaf weight displayed substantial variability, with the highest weight (1.33 g) recorded for $SB_6$ and the lowest (0.66 g) for $SB_{12}$. Similarly, the maximum dry leaf weight (0.53 g) was found in $SB_6$, whereas both $SB_9$ and $SB_{10}$ exhibited the minimum dry leaf weight (0.24 g each). These observations are in concurrence with the recent findings of Nagar and co-wokers [27] in Haryana conditions, which also reported comparable ranges for fresh and dry leaf weights. The variations in leaf traits may be attributed to the influence of arid agro-climatic conditions, which, as observed by Yan and colleagues [29], can significantly impact leaf morphological and physiological characteristics at the species level.

The leaf chlorophyll content ranged from 1.96 to 3.06 mg 100 $g^{-1}$. $SB_{11}$ displayed the highest chlorophyll content, while $SB_3$ exhibited the lowest. These variations in chlorophyll content could be attributed to the combined effects of climate, soil quality, and the plant's phylogeny, all of which play a role in chlorophyll production within leaves, as suggested by Li and co-workers [30].

During the current investigation, notable variations were observed in the yield characteristics of each genotype (Table 2). The average fruit yield per tree ranged from 61.34 to 211.12 kg. These findings align with those of Mitra and co-workers [8], who reported similar yield ranges in six superior *Aegle marmelos* clones in different West Bengal conditions. The diversity in tree yield among the genotypes can be attributed to the complexity of yield traits, governed by multiple genes and highly influenced by environmental conditions [31].

An in-depth analysis of fruit physical characteristics data (Table 3) clearly indicates significant variations among different genotypes. Genotype $SB_{11}$ stood out with the largest fruit size, measuring 12.26 cm in length and 11.93 cm in breadth. This considerable fruit size translated to the highest recorded fruit weight (998.33 g), pulp weight (593.56 g), rind weight (277.53 g), and rind thickness (3.80 mm). The observed variations in fruit physical characteristics may arise from the balance in the allocation of photo-assimilates to the fruit and the overall vigor of the plant or tree [32]. Additionally, genetic factors specific to each genotype may contribute to these differences [33]. These findings are consistent with the results of various studies on *Aegle marmelos* genotypes in different Indian agro-climatic conditions [8, 12, 16, 24, 34].

Data in Table 3 reveal that genotype $SB_{14}$ exhibited the highest seed weight at 18.53 g, followed by genotype $SB_7$. Furthermore, the mean seed count per fruit was highest in genotype $SB_7$ (104.33), closely followed by genotype $SB_{14}$. Previous studies [34, 35] have also observed variations in seed weight and seed count per fruit among different bael genotypes in diverse agro-climatic conditions. Similar variations have been reported by Mandal and Thokchom [36] in other fruit types in the lateritic zone of Birbhum.

Upon close examination of the data concerning the bio-chemical properties of the *Aegle marmelos* fruits (Table 4), it becomes evident that there are significant variations among the different *Aegle marmelos* genotypes. Notably, the highest Total Soluble Solids (TSS) content was observed in $SB_4$ and $SB_8$ genotypes, both registering 42.33°B, with $SB_6$ following closely at 40°B. In contrast, the lowest TSS content was noted in $SB_{13}$ at 28.0ºB. This range in TSS content aligns with previous findings reported by various researchers [8, 12, 13] in different agro-climatic regions of India. The data presented in Table 3 also reveal that the $SB_4$ genotypes exhibited the highest sugar content, a result that is in line with the observations made by various researchers [37, 38, 39]. It's worth noting that variations in sugar content among different genotypes of other fruits in the lateritic zone of Birbhum have been documented previously by Mandal and Thokchom [40]. These variations in TSS and sugar content among the genotypes may be attributed to differences in the conversion of starch into simple sugars, a trait inherent to each variety [41]. Additionally, environmental elements like light intensity and temperature can play a role in such variation [42].

Among the various *Aegle marmelos* genotypes, the minimum titratable acidity was recorded in $SB_1$ at 0.50%, while the maximum titratable acidity was observed in $SB_8$ at 1.05%. Singh and co-workers [41] suggest that such variations in acidity content within genotype evaluations might be due to inherent varietal characteristics in which the contribution of pyruvic acid or acetic acid in the respiration process can be substantiated and expressed as titratable acidity. This range and variations in acidity content among *Aegle marmelos* genotypes have also been reported by Pavani and co-workers [43].

The TSS/acid ratio showed the maximum value in $SB_1$ at 80.00 and the minimum in $SB_2$ at 32.68. These findings align with the results of Kumar and Nath [13], who reported significant variations in the sugar/acid ratio among different *Aegle marmelos* genotypes in Odisha conditions.

As for ascorbic acid content, it ranged from 13.33 to 36.53 mg 100 $g^{-1}$, with the $SB^4$ genotype recording the highest content. Similar variations and a close range of ascorbic acid content in *Aegle marmelos* genotypes have been previously reported by Mitra and co-workers [8] in the evaluation study of over 1200 *Aegle marmelos* trees in West Bengal conditions. These variations in ascorbic acid content of different *Aegle marmelos* genotypes' fruits may be attributed to the influence of abiotic climatic factors such as temperature and light on the 'AsA' (ascorbate) pool in fruit crops [44, 45, 46].

Total carotenoid content in the fruits significantly varied among the different genotypes, with the highest (2.36 mg 100 $g^{-1}$) in $SB_6$ genotypes and the lowest (0.98 mg 100 $g^{-1}$) in $SB_1$ genotypes. Similarly, tannins content ranged from 2.16% ($SB_1$; $SB_{13}$) to 3.76% ($SB_{14}$) among the different genotypes. These results are consistent with findings by Pandey and co-workers [12, 13], who conducted extensive surveys on *Aegle marmelos* germplasm in various regions, reporting comparable ranges for total carotenoids and tannins content. The variations in carotenoid content among different bael genotypes can be attributed to the quantitative nature of carotenoids, which are influenced by both genotypes and environmental conditions, exhibiting broad-sense heritability [47, 48]. In contrast, tannin content in fruits appears to be primarily influenced by plant genotypes [49].

**Table 1:** Details of *Aegle marmelos* genotypes

| Sl. No. | Genotypes | Symbol assigned | Source (Geographical location) |
|---|---|---|---|
| 1. | Sriniketan Bael 1 | $SB_1$ | 23º67′25″ N latitude, 87º66′05″ E longitude |
| 2. | Sriniketan Bael 2 | $SB_2$ | 23º66′99″ N latitude, 87º66′11″ E longitude |
| 3. | Sriniketan Bael 3 | $SB_3$ | 23º66′94″ N latitude, 87º66′11″ E longitude |
| 4. | Sriniketan Bael 4 | $SB_4$ | 23º66′92″ N latitude, 87º66′12″ E longitude |
| 5. | Sriniketan Bael 5 | $SB_5$ | 23º66′85″ N latitude, 87º66′18″ E longitude |
| 6. | Sriniketan Bael 6 | $SB_6$ | 23º66′85″ N latitude, 87º66′21″ E longitude |
| 7. | Sriniketan Bael 7 | $SB_7$ | 23º66′92″ N latitude, 87º66′16″ E longitude |
| 8. | Sriniketan Bael 8 | $SB_8$ | 23º67′22″ N latitude, 87º66′25″ E longitude |
| 9. | Sriniketan Bael 9 | $SB_9$ | 23º66′78″ N latitude, 87º66′21″ E longitude |
| 10. | Sriniketan Bael 10 | $SB_{10}$ | 23º66′77″ N latitude, 87º66′18″ E longitude |
| 11. | Sriniketan Bael 11 | $SB_{11}$ | 23º66′79″ N latitude, 87º66′17″ E longitude |
| 12. | Sriniketan Bael 12 | $SB_{12}$ | 23º66′80″ N latitude, 87º66′16″ E longitude |
| 13. | Sriniketan Bael 13 | $SB_{13}$ | 23º66′84″ N latitude, 87º66′08″ E longitude |
| 14. | Sriniketan Bael 14 | $SB_{14}$ | 23º66′81″ N latitude, 87º66′13″ E longitude |

**Table 2:** Diversity in plant morphology and yield among different *Aegle marmelos* genotypes in the red lateritic zone of West Bengal

| Genotype | Tree height (m) | Tree spread (m) | Tree volume ($m^3$) | Trunk girth (cm) | Growth habit | Thorn length (cm) | Leaf area ($cm^2$) | Leaf fresh weight (g) | Leaf dry weight (g) | Chlorophyll content | Yield (Kg $tree^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $SB_1$ | 10.34 | 4.5 | 109.63 | 73.41 | Erect | 2.5 | 118.34 | 1.09 | 0.39 | 2.87 | 92.11 |
| $SB_2$ | 12.74 | 6.11 | 249.03 | 84.70 | Spreading | 2.0 | 146.37 | 1.02 | 0.32 | 2.64 | 88.45 |
| $SB_3$ | 10.45 | 4.12 | 92.88 | 76.43 | Spreading | 2.5 | 94.33 | 0.93 | 0.48 | 1.96 | 87.12 |
| $SB_4$ | 15.83 | 6.61 | 362.15 | 90.93 | Spreading | 3.2 | 125.28 | 1.05 | 0.35 | 2.11 | 198.45 |
| $SB_5$ | 13.11 | 6.04 | 250.42 | 83.63 | Erect | 2.5 | 106.31 | 0.76 | 0.35 | 1.99 | 141.12 |
| $SB_6$ | 12.54 | 5.87 | 226.24 | 80.55 | Semi-erect | 2.2 | 155.90 | 1.33 | 0.53 | 3.06 | 76.00 |
| $SB_7$ | 9.43 | 4.89 | 118.07 | 72.33 | Erect | 3.2 | 108.14 | 0.85 | 0.38 | 2.87 | 73.00 |
| $SB_8$ | 10.11 | 4.56 | 110.07 | 73.38 | Spreading | 2.5 | 88.77 | 0.86 | 0.33 | 3.00 | 117.45 |
| $SB_9$ | 13.55 | 6.35 | 286.08 | 86.80 | Semi-erect | 2.8 | 107.70 | 0.63 | 0.24 | 2.18 | 211.12 |
| $SB_{10}$ | 12.23 | 6.11 | 239.06 | 81.60 | Spreading | 2.0 | 97.17 | 0.68 | 0.24 | 2.60 | 73.23 |
| $SB_{11}$ | 11.05 | 5.67 | 186.01 | 78.50 | Erect | 3.2 | 142.11 | 1.17 | 0.42 | 2.95 | 71.16 |
| $SB_{12}$ | 10.54 | 5.55 | 169.99 | 76.43 | Erect | 2.0 | 68.03 | 0.66 | 0.33 | 2.73 | 68.12 |
| $SB_{13}$ | 14.13 | 6.12 | 277.11 | 89.93 | Erect | 2.5 | 106.37 | 0.85 | 0.42 | 2.22 | 66.11 |
| $SB_{14}$ | 11.63 | 5.67 | 195.77 | 79.53 | Spreading | 3.1 | 122.22 | 1.02 | 0.41 | 2.14 | 61.34 |
| CD (0.05) | 1.76 | NS | 8.76 | 0.91 | - | NS | 5.24 | NS | 0.15 | 0.11 | 6.76 |

**Table 3:** Diversity in fruit physical attributes and seed characteristics among different *Aegle marmelos* genotypes in the red lateritic zone of West Bengal

| Genotype | Fruit size | | Fruit weight (g) | Pulp weight (g) | Pulp fibre (%) | Pulp moisture (%) | Rind weight (g) | Rind thickness (mm) | Seed weight $fruit^{-1}$ (g) | Number of Seeds $fruit^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | Length (cm) | Breadth (cm) | | | | | | | | |
| $SB_1$ | 10.60 | 9.73 | 607.13 | 260.86 | 3.11 | 52.55 | 132.06 | 3.18 | 6.60 | 58.00 |
| $SB_2$ | 8.46 | 8.23 | 443.33 | 298.33 | 4.00 | 51.83 | 114.83 | 3.58 | 9.06 | 59.00 |
| $SB_3$ | 10.00 | 9.66 | 518.46 | 241.13 | 3.07 | 52.42 | 220.83 | 3.72 | 7.66 | 49.00 |
| $SB_4$ | 7.90 | 7.56 | 375.93 | 200.20 | 3.00 | 49.14 | 139.90 | 3.24 | 10.96 | 77.33 |
| $SB_5$ | 6.73 | 6.36 | 281.50 | 133.86 | 2.98 | 46.88 | 71.60 | 3.59 | 3.36 | 20.66 |
| $SB_6$ | 7.60 | 7.23 | 387.80 | 170.00 | 2.78 | 48.86 | 105.06 | 2.90 | 5.36 | 30.00 |
| $SB_7$ | 8.33 | 7.90 | 350.40 | 223.06 | 3.08 | 50.26 | 110.56 | 3.29 | 18.26 | 104.33 |
| $SB_8$ | 8.10 | 7.80 | 371.66 | 140.64 | 2.54 | 45.50 | 89.13 | 3.79 | 6.16 | 40.66 |
| $SB_9$ | 10.33 | 9.76 | 752.86 | 437.35 | 3.18 | 54.05 | 277.53 | 3.80 | 14.53 | 68.33 |
| $SB_{10}$ | 10.33 | 9.93 | 744.86 | 371.32 | 3.34 | 51.16 | 143.10 | 3.39 | 17.63 | 118.66 |
| $SB_{11}$ | 12.26 | 11.93 | 998.06 | 593.56 | 5.02 | 57.27 | 267.60 | 3.31 | 14.30 | 92.00 |
| $SB_{12}$ | 10.66 | 10.26 | 783.13 | 438.20 | 3.98 | 53.11 | 182.30 | 3.38 | 15.40 | 83.33 |
| $SB_{13}$ | 11.73 | 11.40 | 991.40 | 577.46 | 4.88 | 59.59 | 238.40 | 3.26 | 8.46 | 54.33 |
| $SB_{14}$ | 11.70 | 11.06 | 641.53 | 440.03 | 4.02 | 55.19 | 211.10 | 3.55 | 18.53 | 100.00 |
| CD (0.05) | 2.44 | 2.28 | 162.23 | 146.54 | NS | 4.73 | 74.92 | 0.38 | 6.82 | 49.01 |

**Table 4:** Diversity in biochemical traits of fruits among different *Aegle marmelos* genotypes in the red lateritic zone of West Bengal

| Genotype | TSS (°Brix) | Reducing sugar (%) | Total sugar (%) | Acidity (%) | TSS:Acid | Ascorbic acid (mg 100 $g^{-1}$) | Total carotenoids (mg 100 $g^{-1}$) | Tannins (%) |
|---|---|---|---|---|---|---|---|---|
| $SB_1$ | 40.00 | 2.64 | 8.49 | 0.50 | 80.00 | 13.33 | 0.98 | 2.16 |
| $SB_2$ | 33.34 | 3.23 | 8.22 | 1.03 | 32.68 | 14.40 | 1.07 | 3.49 |
| $SB_3$ | 38.16 | 3.21 | 10.76 | 1.00 | 38.66 | 28.63 | 1.83 | 2.77 |
| $SB_4$ | 42.53 | 3.58 | 11.59 | 0.84 | 50.39 | 36.53 | 2.04 | 2.55 |
| $SB_5$ | 38.00 | 3.10 | 8.46 | 1.04 | 36.54 | 18.56 | 1.29 | 2.73 |
| $SB_6$ | 42.00 | 2.54 | 10.32 | 0.57 | 73.68 | 35.07 | 2.36 | 3.28 |
| $SB_7$ | 35.62 | 1.03 | 8.89 | 0.98 | 36.39 | 22.66 | 1.38 | 2.63 |
| $SB_8$ | 42.02 | 2.77 | 9.30 | 1.05 | 40.31 | 29.86 | 2.12 | 3.07 |
| $SB_9$ | 33.29 | 2.01 | 8.46 | 0.87 | 37.93 | 19.23 | 1.23 | 2.42 |
| $SB_{10}$ | 37.00 | 2.56 | 7.21 | 0.80 | 46.25 | 22.97 | 1.46 | 2.60 |
| $SB_{11}$ | 32.36 | 2.77 | 8.36 | 0.78 | 41.87 | 26.16 | 1.58 | 2.68 |
| $SB_{12}$ | 39.67 | 2.98 | 7.81 | 0.86 | 46.12 | 28.27 | 1.72 | 2.77 |
| $SB_{13}$ | 28.00 | 2.64 | 9.73 | 0.54 | 52.85 | 30.56 | 1.95 | 2.16 |
| $SB_{14}$ | 29.33 | 3.31 | 7.61 | 0.72 | 40.74 | 26.56 | 1.55 | 3.76 |
| CD (0.05) | 6.26 | 0.77 | 1.43 | 0.35 | 9.47 | 1.68 | 0.21 | 0.17 |

## Conclusion

As a consequence, the local population in the lateritic zone of West Bengal has been extensively felling trees, including *Aegle marmelos*, for various purposes such as fodder, fuel, and as a source for making murabba, squash, juices, candy, jam, and syrups, along with using them in Hindu religious rituals. This rampant exploitation of *Aegle marmelos* has led to a rapid decline in its population. Consequently, it is imperative to prioritize the conservation of both natural and cultivated *Aegle marmelos*, taking into account the economic and ecological significance of this endeavor. Sustainable cultivation and responsible harvesting practices for *Aegle marmelos* are essential, especially following a comprehensive assessment of the population, to promote the economic well-being and environmental sustainability of the rural communities in the lateritic zone of West Bengal. Based on the average performance observed, genotypes $SB_4$, $SB_6$, $SB_9$, $SB_{11}$, and $SB_{13}$ have demonstrated suitability for small orchards and family farming in the 'Red and lateritic Zone' of Birbhum district in West Bengal. However, it is crucial to note that before recommending these genotypes for large-scale orchard establishment, further investigations are warranted. These should encompass a broader selection of cultivars and local genotypes, coupled with a more comprehensive assessment of both plant and fruit characteristics.

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