



Short Communication

Evaluation of ecotypes of banana (*Musa* AAB plantain subgroup)

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Abstract

The present study was conducted at the Instructional Farm of the College of Agriculture, Vellayani, Thiruvananthapuram, during April 2016 - May 2017 to evaluate the various ecotypes of plantain with respect to biometric, yield, physiological and quality characteristics. The experiment was laid out in randomised block design with ten treatments and three replications. The study revealed that considerable variability existed among the different ecotypes of plantain. Mettupalayam Nendran produced the highest yield but it had long crop duration. Chengalikodan was found to be the best among the different ecotypes for quality parameters like acidity, TSS, TSS/acid ratio, reducing sugar, total sugar and total carotenoids. The ecotypes Mettupalayam Nendran, Myndoli etc. which have high yield, and ecotype Chengalikodan, which is best in quality parameters can be used in crop improvement programmes to develop superior Nendran varieties.

Key words: Ecotype, Evaluation, Nendran, Plantain, Quality, Yield.

The genus *Musa* is of great importance in the world due to the commercial and nutritional values of bananas and plantains. Banana and plantain are widely cultivated in India with great socio-economic significance, interwoven with cultural heritage of the country. It is referred to as 'Kalpatharu' which means plant of virtues due to its multifaceted uses (Chadha, 2003). The crop is grown in an area of 8,58,000 ha with an annual production of 2,91,63,000 MT and productivity of 33.98 t/ha (AGRISTAT, 2017) in India. All banana and plantain landraces are farmers' selections from intra and inter specific hybrids of two diploid species, *Musa acuminata* Colla and *Musa balbisiana* Colla. Plantains are cooking bananas containing more starch and less sugars than dessert bananas. Plantain subgroup includes french plantain represented by Nendran, horn plantain represented by Zanzibar and false horn plantain represented by Big Ebanga. De Langhe et al. (2005) states that 'Horn' Plantains are characterized by the

absence of male flowers at maturity and the presence of very large horn like fruits, while the french plantains have both male and female flowers with smaller fruit size. The concept of 'False Horn' plantains was used to identify 'Horn' type cultivars with a restricted number of neutral flowers, but without any male bud at maturity. Among the various varieties of banana in AAB plantain subgroup, Nendran is a well-known cultivar in Kerala, due to its high demand and its multifarious use, both for dessert and culinary purposes. Biodiversity in Nendran is a complex phenomenon. Nendran is represented by clones distinguishable by variation in plant stature, bunch, fruit morphology and degree of development of male phase (Choudhary et al., 2014). In Kerala, Nendran is grown in wide ecological and climatic conditions exploiting the wide varietal variability that exists in the crop. For the classification of banana cultivars into different genomic groups, morphological characterization is important. Clonal

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and ecotype variation with respect to growth and yield has been reported in Nendran. The results of clonal variation studies in Nendran conducted at Banana Research Station, Kannara showed that Nendran ecotypes or clones collected from various parts of Kerala showed difference in growth and yield when grown in a location other than the place of collection (KAU, 2015). So for crop improvement programmes, there is a need to know which clone is best for a particular region and to characterize various ecotypes. The present investigation was undertaken with the objective to characterize the various ecotypes of plantain with respect to biometric, yield, physiological and quality parameters.

Field experiment with ten treatments, each with three replications and four plants per replication at a spacing of 2m x 2m, was conducted under uniform conditions as per the Package of Practices Recommendations of Kerala Agricultural University for irrigated 'Nendran' (KAU, 2016). The site of the experiment was situated at 8°5' North latitude and 77°1' East longitude at an altitude of 29 m above mean sea level. Predominant soil type was red loam belonging to Vellayani series, texturally classified as sandy clay loam. Observations were recorded from all the plants in each replication and averages were worked out for analysis. The observations were analysed statistically in Randomized Block Design and significance was tested using analysis of variance technique (Panse and Sukhatme, 1985). Ten ecotypes of plantain (*Musa* AAB Nendran) collected from Banana Research Station, Kannara

and farmers fields were used for the study. The ecotypes were Attunendran, Big Ebanga, Chengalikodan, Kaliethan, Chenkal Local, Nedunendran, Myndoli/Quintal banana, Zanzibar, Perumatti Nendran and Mettupalayam Nendran (Table 1).

Observations on yield attributes were recorded three months after planting (3 MAP) and at bunch emergence. Height of the plant was recorded from soil level to the base of the unopened leaf at 3 MAP and from base of the plant to point of emergence of peduncle at bunching and was expressed in metres. The girth of the plant was measured from the base at 20 cm height above ground level and expressed in centimetres. Number of swords and water suckers and total number of suckers at the time of harvest was noted. Time taken for flowering was recorded from the date of planting to visual bunch emergence and expressed in days. Time taken for harvest was recorded from the date of visual bunch emergence to date of harvest and expressed in days. Total crop duration was calculated from the date of planting to harvest and expressed in days. Weight of peel of index finger was taken and expressed in grams. The bunches were harvested at full maturity when fingers showed disappearance of angles and weight of the bunch including the portion of the peduncle up to the first scar was recorded and expressed in kilogram. The ratio between the weight of pulp and peel was worked out to find the pulp to peel ratio.

Physiological attributes were recorded at three months after planting and at harvest. Phyllochron

Table 1. Nendran ecotypes used in the experiment

| Treatments | Ecotype | Place of Collection |
|-----------------|------------------------|---|
| T ₁ | Attunendran | Banana Research Station, Kannara |
| T ₂ | Big Ebanga | Banana Research Station, Kannara |
| T ₃ | Changalikodan | Banana Research Station, Kannara |
| T ₄ | Kaliethan | Instructional Farm, Vellayani |
| T ₅ | Chenkal Local | Chenkal, Trivandrum |
| T ₆ | Nedunendran | Banana Research Station, Kannara |
| T ₇ | Myndoli/Quintal banana | Instructional Farm, Vellayani |
| T ₈ | Zanzibar | Banana Research Station, Kannara |
| T ₉ | Perumatti Nendran | District Agricultural Farm, Peringamala |
| T ₁₀ | Mettupalayam Nendran | Thodupuzha, Idukki |

was recorded by observing the time interval between the opening of two successive leaves and expressed in days.

Leaf area index was calculated using the formula;
LAI= Leaf area per plant/ area occupied by the plant.

Leaf area duration was determined using the formula;

LAD = Area of last three leaves x time taken from bunch emergence to harvest.

Raw fruit was used to estimate the starch content and ripe fruits were subjected to quality analysis. Total Soluble Solids and acidity was determined by the procedure proposed by Ranganna (1997) and the mean values were expressed as per cent anhydrous citric acid. The total sugar, reducing sugars and non – reducing sugar content of the samples were determined by using the method described by AOAC (1998) and expressed as per cent on fresh weight basis. Carotenoids were estimated using the procedure suggested by Saini et al. (2001) and expressed as microgram/100 g. Percentage of fibre in ripe banana was calculated using the formula (Sadasivam and Manickam, 1992):

% fibre = $(W_2 - W_3 / \text{weight of the sample}) \times 100$

Where,

W_2 - weight in g of the crucible with oven dried

residue

W_3 - weight in g of crucible with ash

Starch content of the raw banana was estimated by using potassium ferricyanide method and the values were expressed as per cent on fresh weight basis (Ward and Pigman, 1970). Peel thickness of ripe fruits was measured using a screw gauge and expressed in millimeter. Number of days from ripening to the stage when fruit skin turned black and become unsuitable for consumption was recorded.

The results of the study on the effect of different ecotypes of Nendran on biometric characters are presented in Table 2. The study showed that the height of plants varied significantly among the different ecotypes evaluated both at three months after planting and at bunch emergence. Among the different treatments, plant height at bunch emergence was the lowest in Attunendran (3 m) while the greatest plant height was observed in Mettupalayam Nendran (3.60 m) followed by Zanzibar (3.48 m) and Myndoli (3.41 m). Plant height and crop duration were significantly and positively correlated. Clones of Attunendran and Perumatti Nendran which had lower values for plant height had shorter crop duration, while, Myndoli (3.71 m) and Mettupalayam Nendran (3.60 m) which were taller compared to other ecotypes recorded higher crop duration (371.83 and

Table 2. Biometric characters of Nendran ecotypes

| Treatments | Plant height (m) | | Number of leaves | | Girth (cm) | |
|---|------------------|------|------------------|-------|------------|-------|
| | 3 MAP | BE* | 3 MAP | BE | 3 MAP | BE |
| T ₁ - Attunendran | 0.56 | 3.00 | 8.83 | 12.58 | 22.16 | 60.62 |
| T ₂ - Big Ebanga | 0.58 | 3.48 | 9.00 | 11.56 | 25.48 | 68.00 |
| T ₃ - Changalikodan | 0.80 | 3.08 | 9.00 | 12.61 | 21.36 | 61.03 |
| T ₄ - Kaliethan | 0.99 | 3.12 | 9.17 | 11.25 | 24.62 | 58.92 |
| T ₅ - Chenkal Local | 0.95 | 3.35 | 8.75 | 11.25 | 25.33 | 58.83 |
| T ₆ - Nedunendran | 0.57 | 3.07 | 8.83 | 11.36 | 23.23 | 59.35 |
| T ₇ - Myndoli/Quintal banana | 0.99 | 3.41 | 9.00 | 10.31 | 27.77 | 65.44 |
| T ₈ - Zanzibar | 0.72 | 3.49 | 8.83 | 12.08 | 22.04 | 67.33 |
| T ₉ - Perumatti Nendran | 0.87 | 3.05 | 8.83 | 11.56 | 24.41 | 61.24 |
| T ₁₀ - Mettupalayam Nendran | 0.95 | 3.60 | 8.50 | 12.00 | 25.00 | 73.33 |
| CD (0.05) | 0.14 | 0.24 | NS | 1.07 | NS | 3.96 |
| CV (%) | 0.10 | 4.35 | 7.29 | 5.33 | 9.61 | 3.64 |

*BE- Bunch emergence

341.17). In a comparative study of Manjeri Nendran with Nedunendran conducted at BRS, Kannara, it was found that Manjeri Nendran was taller (3.19 m) compared to Nedunendran (3.00 m) (ICAR, 2017). The present study revealed that girth of ecotypes did not vary significantly at 3 month after planting but significant difference was observed at bunch emergence. Mettupalayam Nendran showed the highest pseudostem girth of 73.33 cm and Chenkal Local recorded the lowest girth of 58.83 cm. During initial stages, rate of growth was comparable among the different clones, but between early vegetative phase and bunch emergence, significant variation in rate of growth was observed, resulting in a significant difference among clones regarding the girth of plant. It is proven that weight of bunch and girth of plant are positively correlated in banana (Rajamanickam, 2003). The findings of the present study are in conformity with this trait. Mettupalayam Nendran which had highest plant girth recorded the highest bunch weight (17.94 kg). Chenkal Local with lowest plant girth recorded the lowest bunch weight of 9.29 kg. Rajamanickam (2003) reported that among the triploids, the highest girth (96.00 cm) was found in Vellapalayankodan and the lowest in Chengalikodan (55.44 cm) both belonging to AAB group. He also reported that within clones of Nendran, Quintal banana recorded the highest pseudostem girth (78.68 cm) and the lowest was in Chengalikodan (55.44 cm). Of the ten ecotypes studied, variability in the number of leaves at 3

MAP was non-significant, but at bunch emergence showed significant difference. The highest number of leaves was recorded in Chengalikodan (12.61) followed by Attunendran (12.58) and the lowest was for Myndoli (10.31). Among the Nendran intracloves, the maximum number of leaves was recorded in Koonoor Ethan (11.00) and the lowest in Vellayani Nendran and Zanzibar (each with 8.39) (Rajamanickam, 2003). Significant differences in number of leaves have been seen among the accessions of Kaliethan (Sunilkumar, 1997). These earlier findings were in line with the reports of the present study.

Results of the statistical analysis of duration of vegetative phase, shoot-to-harvest and total crop duration showed significant difference among various treatments (Table 3). The longest vegetative phase (273.17 days), shoot-to-harvest duration (98.67 days) and total crop duration (371.83 days) were observed for Myndoli. In the present study, the ecotypes Myndoli and Mettupalayam Nendran with the longest crop duration produced the heaviest bunches. According to a study conducted by Dhanyasree et al. (2019), among Rasthali clones, Venneer Poovan which had the longest duration of 434.92 days produced heaviest bunches (9.90 kg).

The results of the study on the variation of different ecotypes of Nendran with regard to physiological attributes are presented in Table 4. The study revealed that all the physiological parameters varied

Table 3. Yield attributes of Nendran ecotypes

| Treatments | Bunch weight (kg) | Number of suckers | Duration of vegetative phase (days) | Shoot to harvest duration (days) | Total crop duration (days) |
|---|-------------------|-------------------|-------------------------------------|----------------------------------|----------------------------|
| T ₁ - Attunendran | 11.13 | 10.58 | 250.69 | 75.92 | 326.61 |
| T ₂ - Big Ebanga | 11.38 | 11.00 | 255.67 | 72.58 | 328.25 |
| T ₃ - Changalikodan | 10.69 | 8.92 | 223.50 | 73.33 | 296.83 |
| T ₄ - Kaliethan | 8.13 | 9.50 | 198.25 | 79.33 | 277.58 |
| T ₅ - Chenkal Local | 9.29 | 8.58 | 201.58 | 79.08 | 280.67 |
| T ₆ - Nedunendran | 10.00 | 7.50 | 259.89 | 78.75 | 338.64 |
| T ₇ - Myndoli/Quintal banana | 14.42 | 7.92 | 273.17 | 98.67 | 371.83 |
| T ₈ - Zanzibar | 9.36 | 12.17 | 261.25 | 70.00 | 331.25 |
| T ₉ - Perumatti Nendran | 8.27 | 8.17 | 196.67 | 78.00 | 274.67 |
| T ₁₀ - Mettupalayam Nendran | 17.94 | 10.50 | 253.92 | 87.25 | 341.17 |
| CD (0.05) | 1.16 | 1.93 | 12.53 | 5.79 | 13.11 |
| CV (%) | 6.11 | 11.89 | 3.08 | 4.27 | 2.41 |

Table 4. Physiological attributes of Nendran clones at 3 MAP and at harvest

| Treatments | Phyllochron (days) | Leaf area (m ²) | | Leaf Area Index | | Leaf Area Duration (days) |
|---|-----------------------|-----------------------------|---------|-----------------|---------|------------------------------|
| | | 3 MAP | Harvest | 3 MAP | Harvest | |
| T ₁ - Attunendran | 6.67 | 0.18 | 1.07 | 0.41 | 0.96 | 245.51 |
| T ₂ - Big Ebanga | 6.67 | 0.19 | 1.48 | 0.43 | 1.12 | 322.48 |
| T ₃ - Chengalikodan | 6.00 | 0.17 | 0.93 | 0.36 | 1.01 | 221.78 |
| T ₄ - Kaliethan | 6.33 | 0.28 | 0.87 | 0.65 | 0.72 | 209.04 |
| T ₅ - Chenkal Local | 5.33 | 0.26 | 0.95 | 0.56 | 0.86 | 222.56 |
| T ₆ - Nedunendran | 5.00 | 0.16 | 0.99 | 0.36 | 1.05 | 243.08 |
| T ₇ - Myndoli/Quintal banana | 6.33 | 0.23 | 1.10 | 0.53 | 1.07 | 326.03 |
| T ₈ - Zanzibar | 5.67 | 0.21 | 1.23 | 0.44 | 1.12 | 264.35 |
| T ₉ - Perumatti Nendran | 6.00 | 0.14 | 0.80 | 0.31 | 0.78 | 193.54 |
| T ₁₀ - Mettupalayam Nendran | 6.67 | 0.27 | 1.30 | 0.57 | 1.19 | 338.50 |
| CD (0.05) | 0.87 | 0.04 | 0.11 | 0.09 | 0.20 | 11.55 |
| CV (%) | 8.34 | 11.52 | 6.03 | 11.36 | 11.69 | 2.61 |

significantly. Interval of leaf production was higher in Attunendran, Big Ebanga and Mettupalayam Nendran (6.67 days) and lowest was in Nedunendran (5 days). In the present study, phyllochron was found to be higher in ecotypes which ultimately recorded higher crop duration indicating their slow rate of growth compared to other crops.

Leaf area varied significantly among the treatments at 3 MAP and at harvest. At 3 MAP, leaf area was the highest in Kaliethan, followed by Mettupalayam Nendran and Chenkal Local. However at harvest, the leaf area was the highest for Big Ebanga followed by Mettupalayam Nendran and Myndoli. Leaf area is the critical factor controlling efficiency of photosynthesis which further contributes to increased yield. The ecotypes, Myndoli, Mettupalayam Nendran and Big Ebanga which showed higher leaf area recorded higher yield. Study conducted by Dhanyasree et al. (2019) in Rasthali clones revealed that Venneer Poovan which had highest leaf area (12.26 m²) recorded highest bunch weight (9.90 kg). The study indicated that both at 3 MAP and at harvest, leaf area index (LAI) varied significantly. Devi (1996) reported that among the Nendran clones studied, Chengalikodan and Kothala recorded the highest LAI values while Kaliethan, Pandaloor and Puthur types had low LAI. In the present study, leaf area duration (LAD) varied significantly among the treatments studied. The

highest leaf area duration was recorded in Mettupalayam Nendran (338.50 days), followed by Myndoli (326.03 days). Leaf area duration is an indication of the functional longevity of leaves, determining the photosynthetic efficiency. Ecotypes like Mettupalayam Nendran (17.94 kg) and Myndoli (14.42 kg) with high leaf area duration recorded higher yield. According to Sunilkumar (1997), high phenotypic association of LAD on bunch yield can be explained as due to the high indirect effect through plant height and girth.

Statistical analysis of the bunch weight of different ecotypes of Nendran varied significantly. The highest bunch weight of 17.94 kg was recorded in Mettupalayam Nendran followed by Myndoli (14.42 kg) and the lowest bunch weight was recorded in Kaliethan (8.13 kg). According to Babu (2001), variation in bunch weight occurs due to change in place of cultivation or inherent genetic variations. Rajamanickam (2003) has reported that among the triploids evaluated, maximum bunch weight was recorded in Quintal banana (30.4 kg) while the lowest was in Zanzibar (6.50 kg).

Analysis of the data on peel weight and pulp/peel ratio revealed the existence of significant difference among the ecotypes of Nendran. The peel weight ranged from 64.50 g in Zanzibar to 32.67 g in Nedunendran. High pulp/peel ratio is a desirable character of the fruits. In the present study, pulp/peel ratio was the highest in Chengalikodan (3.85)

Table 5a. Quality parameters of ripe fruits of Nendran ecotypes

| Treatments | Acidity (%) | TSS (°Brix) | TSS/ Acid ratio | Non-Reducing sugars (%) | Reducing sugars (%) | Total sugars (%) |
|---|-------------|-------------|-----------------|-------------------------|---------------------|------------------|
| T ₁ - Attunendran | 0.31 | 29.10 | 95.61 | 14.39 | 4.68 | 19.07 |
| T ₂ - Big Ebanga | 0.33 | 27.43 | 84.58 | 14.65 | 4.09 | 18.73 |
| T ₃ - Chengalikodan | 0.30 | 29.16 | 98.25 | 17.71 | 6.39 | 24.10 |
| T ₄ - Kaliethan | 0.42 | 23.57 | 56.35 | 13.94 | 4.39 | 18.33 |
| T ₅ - Chenkal Local | 0.37 | 26.00 | 70.30 | 13.25 | 5.35 | 18.60 |
| T ₆ - Nedunendran | 0.36 | 26.10 | 73.25 | 14.87 | 4.30 | 19.17 |
| T ₇ - Myndoli/Quintal banana | 0.33 | 24.17 | 73.13 | 12.97 | 4.33 | 17.30 |
| T ₈ - Zanzibar | 0.37 | 28.60 | 76.62 | 17.77 | 6.11 | 23.88 |
| T ₉ - Perumatti Nendran | 0.39 | 28.83 | 73.71 | 14.40 | 4.83 | 19.23 |
| T ₁₀ - Mettupalayam Nendran | 0.34 | 25.40 | 75.98 | 12.67 | 4.22 | 16.89 |
| CD (0.05) | 0.07 | 1.72 | 17.16 | 1.43 | 1.34 | 2.00 |
| CV (%) | 12.06 | 3.75 | 12.86 | 5.67 | 15.98 | 5.97 |

Table 5b. Quality parameters of ripe fruits of Nendran ecotypes

| Treatments | Starch* content (%) | Total carotenoids (µg/100g) | Fibre (%) | Peel weight (g) | Pulp/peel ratio | Peel thickness (mm) | Shelf life (days) |
|--|---------------------|-----------------------------|-----------|-----------------|-----------------|---------------------|-------------------|
| T ₁ - Attunendran | 12.61 | 266.27 | 0.87 | 48.13 | 2.90 | 2.26 | 6.00 |
| T ₂ - Big Ebanga | 17.27 | 231.93 | 0.92 | 62.83 | 3.24 | 4.20 | 8.33 |
| T ₃ - Chengalikodan | 20.55 | 333.23 | 1.03 | 35.78 | 3.85 | 2.40 | 6.67 |
| T ₄ - Kaliethan | 22.67 | 304.67 | 1.03 | 41.09 | 3.22 | 2.50 | 6.67 |
| T ₅ - Chenkal Local | 16.50 | 234.67 | 1.17 | 47.83 | 3.02 | 2.60 | 7.00 |
| T ₆ - Nedunendran | 22.33 | 235.00 | 1.03 | 32.67 | 3.24 | 2.70 | 6.67 |
| T ₇ - Myndoli/ Quintal banana | 21.65 | 310.80 | 0.93 | 44.28 | 3.16 | 2.90 | 7.33 |
| T ₈ - Zanzibar | 24.07 | 244.07 | 0.91 | 64.50 | 3.32 | 4.70 | 8.00 |
| T ₉ - Perumatti Nendran | 21.56 | 320.17 | 1.01 | 39.38 | 3.30 | 2.40 | 6.33 |
| T ₁₀ - Mettupalayam Nendran | 23.22 | 260.13 | 0.92 | 46.58 | 2.92 | 3.15 | 7.33 |
| CD (0.05) | 2.75 | 15.58 | NS | 6.20 | 0.38 | 0.33 | 0.94 |
| CV (%) | 7.89 | 3.32 | 10.24 | 7.79 | 6.82 | 0.65 | 7.78 |

*- raw fruit

followed by Zanzibar (3.32) and Perumatti Nendran (3.30). Studies in similar lines with banana clones indicated a variation in pulp/peel ratio from 2.94 in Mysore Ethan to 6.60 in Changanasseri Nendran (Rajamanickam, 2003).

Data on the quality characters of various treatments are presented in Tables 5a and 5b. Except for fibre, all the other quality characters such as sugars, TSS, starch, total carotenoids, peel thickness and shelf life showed significant variation. These were highest in Chengalikodan. Non reducing sugar was observed to be the highest in Zanzibar (17.77 per cent) followed by Chengalikodan (17.71 per cent) and Nedunendran (14.87 per cent). The lowest acidity was observed in Chengalikodan (0.30 per cent) followed by Attunendran (0.31 per cent) and Big Ebanga and Myndoli (0.33 per cent each). Peel

thickness which is a contributing factor towards shelf life, was the highest for Zanzibar, Big Ebanga and Mettupalayam Nendran. So Big Ebanga had the longest shelf life followed by Zanzibar and Mettupalayam Nendran.

From the present study, it was concluded that Mettupalayam Nendran had large bunch compared to all other clones. Chengalikodan was found to be the best among the different ecotypes for most of the quality parameters, and also recorded highest pulp/peel ratio. The ecotypes Mettupalayam Nendran, Myndoli etc. which produced high yield and ecotype Chengalikodan, which was best in quality parameters could be used in crop improvement programmes to develop superior Nendran varieties.

References

- AGRISTAT, 2017. Agricultural Statistics 2016-17. Department of Economics and Statistics, Government of Kerala, Thiruvananthapuram 228p.
- AOAC [Association of Official Agricultural Chemists], 1998. Official Methods of Analysis, AOAC International (16th Ed.). Association of Official Agricultural Chemists, Washington, D.C. 899p.
- Babu, N. 2001. Performances of some genotypes of banana (*Musa* spp.) under foot hills of Nagaland. New Agricst., 12: 13-16.
- Chadha, K. L. 2003. Hand book of horticulture, Indian Council of Agricultural Research, New Delhi, p.1018.
- Choudhary, R., Keshavachandran, R., Menon, R., Khalekar, G, Singh, N. and Maruthyottu, D. 2014. Molecular variability of plantain ecotypes from the genus *Musa* (Musaceae). Turk. J. Bot., 38: 827-834.
- Devi, B.V. 1996. Evaluation of 'Nendran' (*Musa* AAB group) ecotypes. M.Sc. (Hort.) thesis, Kerala Agricultural University, Thrissur, 186p.
- De Langhe, E., Pillay, M., Tenkouano, A., and Swennen, R. 2005. Pl. Syst. Evol., 255: 225-236.
- Dhanyasree, K., Sobhana, A., Suma, A., and Pushpalatha, P. B. 2019. Evaluation of clones of banana *Musa* spp. 'Rasthali' (AAB group). J. Trop. Agric., 57 (1): 35-39.
- ICAR [Indian Council of Agricultural Research]. 2017. Research Report 2017. ICAR-All India Coordinated Research Project on Fruits, ICAR-Indian Institute of Horticultural Research, Bengaluru, 283p.
- KAU [Kerala Agricultural University]. 2015. Research Report 2011-14. Kerala Agricultural University, Vellanikkara, Thrissur, Kerala, pp.93-95.
- KAU [Kerala Agricultural University]. 2016. Package of practices recommendations: crops (14th Ed.). Kerala Agricultural University, Vellanikkara, Thrissur, Kerala, 360p.
- Panse, V. G. and Sukhatme, P. V. 1985. Statistical Methods for Agricultural Workers. ICAR, New Delhi, 359p.
- Ranganna, S. 1997. Handbook of Analysis and Quality Control for Fruits and Vegetable Products (2nd Ed.). Tata McGraw Hill Publishing Company Limited, New Delhi, 1112p.
- Rajamanickam, C. 2003. RAPD analysis of Banana (*Musa* spp.). Ph.D. (Hort.) thesis, Kerala Agricultural University, Thrissur, 229p.
- Sadasivam, S. and Manickam, A. 1992. Biochemical Methods for Agricultural Sciences. Wiley Eastern Limited, New Delhi, p.256.
- Saini, R. S., Sharma, K. D., Dhankar, O. P., and Kaushik, R. A. 2001. Laboratory manual of analytical techniques in horticulture. Agro Bios, India, 135p.
- Sunilkumar, K. 1997. Selection of superior types of Kaliethan [(*Musa* AAB Group) 'Nendran']. M. Sc. (Hort.) thesis, Kerala Agricultural University, Thrissur, 116p.
- Ward and Pigman, 1970. Analytical Methods for Carbohydrates – The Carbohydrates Vol. II B. Academic Press, New York and London. 763p.