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Characterization of selected accessions of 1981 germplasm of *Hevea* for early growth performance using morphological and physiological parameters

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Abstract: *Rubber [Hevea brasiliensis (Willd.ex A. Juss.) Mull.Arg.], which belongs to the family Euphor biaceae is the most economically important member of the genus Hevea whose center of diversity is the Amazon basin and it is the major source of commercial rubber in the world. The first commercial plantation in Sri Lanka was started subsequently in 1883. Rubber breeding in Sri Lanka is largely based on a small population of about 1919 seedlings introduced in 1876 from Wickham collection. Most of Hevea breeders believe that they have exploited the maximum genetic variability of Wickham's original introduction and have provided original materials for plant breeding programs and crop improvement. Therefore, to broaden the genetic base of the major producers of natural rubber, it was needed to undertake an expedition to the Amazon basin to obtain materials for the 'gene pool' this expedition, called "Germplasm 81". From this expedition, Sri Lanka received around 10,000 accessions and they were planted at Neuchatel estate in Kalutara district. But in Sri Lanka, a proper selection and evaluation of genotypes from 1981 Hevea germplasm collection has not been conducted. Therefore, this study was conducted to characterization of selected accessions from 1981 germplasm collection using morphological and physiological parameters and also to reveal their disease severity. Twenty-five accessions were selected out of around 2000 accessions by evaluating their girth, bark thickness, floral canopy and latex flow (g/t/t) as a preliminary selection. These 25 accessions were multiplied and planted in completely randomized blocked design with three replicates and each replicate contain five plants from each 25 accessions and control clones. RRIC 121 and RRISL 203 were used as control clones. Then, their girth, leaf area, chlorophyll content, leaf colour, tree height and inter-whorl length were measured. All these parametric data were analyzed using one-way ANOVA and Duncan's multiple range test to study the differences among accessions. According to results, accession MT 11-76 I, MT 11-76 II and MT 10-146 showed good growth performances than the other accessions and control clones as well. In addition to these three selections, accession MT 7-36 and RO 2-4 also showed good performances from observed parameters; but they could not meet adequate performances as MT 11-76 I, MT 11-76 II, and MT 10-146. However, it is important to take long term observations and yield parameters for further verifications of these accessions before adding them into the Breeding pool.*

Keywords: *Breeding, Hevea, Germplasm, Accession*

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I. Introduction

Rubber [*Hevea brasiliensis* (willd.ex Adr. de Juss.) Muell.Arg]., is the major source of natural rubber (NR) cultivated in 23 countries at present. It was first introduced to the world from its native, tropical rain forests of South America, when 70,000 seeds brought by Sir Henry Wickham were germinated at the Kew gardens, England. This Wickham genetic base has been utilized for *Hevea* breeding in past extensively.Even today, it contributes largely in *Hevea* genetic improvement. In 1970s, the need for new *Hevea* germplasm arose from the realization that there was a gradual erosion of the genetic variability of the rubber clones in many natural rubber plantations. This erosion occurred because most of the clones in cultivation were derived from the few surviving seeds collected in 1876 by Sir Henry Wickham. Hence, it was needed to broaden the genetic diversity of the major producers of natural rubber. Then, necessity of another expedition from Amazon basin to undertake materials for the current 'gene pool' was arisen and this expedition called "Germplasm 81".(Onokpise, 2004). Importation of these wild *Hevea* germplasm for selected countries has been carried out and Sri Lanka has already received about 10,000 genotypes from Malaysia and Ivory Coast (Withanage, 2015). Except few evaluations in the past and extensive direct selection of superior genotypes from 1981 *Hevea* germplasm has not been conducted. Therefore, this study was undertaken to analyze selected accessions from 1981 *Hevea* germplasm to develop genetically diverse clones with suitable characters using morphological and physiological parameters with the objective to evaluate, characterize to select the suitable accessions use for further hybridization programme or to develop as a clone.Morphological and physiological descriptors had been successfully utilized in germplasm characterization and other genetic diversity studies in various crops all over the world (Pereraand Fernando, 2000). Morphological traits are useful for preliminary characterization of large number of accessions to identify morphologically similar groups and for simple varietal identification of phenotypicallydistinguishable cultivars(Martinez *et al.*,2003).

Girth

Girth is a simple measurement of tree growth and it can be used for growth analysis of young *Hevea* plants. Girth can be easily taken by measuring the distance around the trunk perpendicular to the axis of a tree. Girth has a highly significant correlation with the above ground biomass of a tree (Chaudhuri *et al.*, 1995). The economically important part of rubber is latex. To have a higher number of latex vessels, girth increment is a very important factor (Nugawela, 1998).

Tree height

Tree height is the vertical distance between the base of the tree and the tip of the highest branch on the tree, and is difficult to measure accurately. Also, it is a key factor in growth determination.The tree height above the ground is significant to the tree in that, it determines the total amount of light that the tree intercepts for photosynthesis (Arzai and Aliyu, 2010).

Leaf Area

Plant leaf area is an important determinant of light interception and consequently of transpiration, photosynthesis and plant productivity (Goudriaan and Van Laar, 1994). Leaf area can be measured either by destructive or non-destructive measurements.

Chlorophyll Content

Chlorophyll is the most important critical factor in photosynthesis, which assist for plants to absorb energy from sunlight. Chlorophyll is found in the chloroplasts of plants and mainly plants contain two types of chlorophyll as chlorophyll a and b. These two types of chlorophyll are having slightly different compositions (Ovington, 1967). Chlorophyll content is directly affected for canopy temperature and bio-mass production.

Leaf colour

Leaf colour also affect for plant canopy temperature and dry matter production (Ferguson *et al.*, 1972). Rubber trees consist with 6 to 12-inch-long, glossy, thick leaves. From the sunlight, chlorophyll can absorb blue and red light. When the light reflected from the leaf, that light contains more green light than red and blue light hence, the leaf appears green in color. (Nielsen *et al*., 2011).

Inter-whorl length

A severe decline in incident radiation reduces photosynthetic productivity and growth as the growth is directly related to the amount of radiation intercepted by a canopy. For an example, the photosynthetic rate of rubber leaves developed in full sunlight was higher than one-third that of plants grown in 25% of full sunlight, indicating that leaves developed in deep shade has substantially reduced assimilatory capacity (Nugawela *et al*., 1995). Under constant sunlight level assimilating capacity is higher in plants having a long inter-whorl length than short inter-whorl length.

II. Materials And Methods

Location

The experiment was carried out forcharacterization of selected accessions of 1981 germplasm of *Hevea* for early growth performance using morphological and physiological parametersfrom June 2013 to June 2015 at the 1981 germplasm nursery in Neuchatel estate (6.62^0 N and 80.02^0 E) at Galpatha, Horana in Kalutara district belongs to Genetics and Plant Breeding Department of Rubber Research Institute of Sri Lanka. The area is located in low country wet zone (WL_2) at an elevation of 9 m above the mean sea level. It has red yellow podsolic soil and the total extent of this ex-situ collection is 13 ha and from each genotype four plants were multiplied and planted in space (1m x 1m).

Materials

There are 25 accessions originated from IRRDB germplasm collection were used for this experiment.

Table 1. Material numbers, accession codes and their locations of selected accessions

Accession No;	Location	Material No:	Accession code
MT 7-36	Mato Grosso	MT/C/4	MT/C/7-36
MT 11-76 I	Mato Grosso	MT/C/6	MT/C/11-76 II
MT 11-13	Mato Grosso	MT/C/6	MT/C/11-13
MT 7-187	Mato Grosso	MT/C/4	MT/C/7-187
MT 11-76 II	Mato Grosso	MT/C/4	MT/C/11-76 I
MT 10-146	Mato Grosso	MT/C/4	MT/C/10-146
RO 3-467	Rodonia	RO/PB/2	RO/PB/3-467
RO 2-4	Rodonia	RO/PB/1	RO/PB/2-4
MT 7-23	Mato Grosso	MT/C/4	MT/C/7-23
1-4	Unknown	7/02/81	First consignment of germplasm
AC 6-13	Acre	AC/T/3	AC/T/6-13
1-44	Unknown	7/02/81	First consignment of germplasm
MT 7-61	Mato Grosso	MT/C/4	MT/C/7-61
1-53	Unknown	7/02/81	First consignment of germplasm
AC 4-58	Acre	AC/T/2	AC/T/4-58
MT 10-100	Mato Grosso	MT/C/4	MT/C/10-100
AC 5-163	Acre	AC/T/3	AC/T/5-163
MT 10-158	Mato Grosso	MT/C/6	MT/C/10-158
RO 2-96	Rodonia	RO/PB/1	RO/PB/2-96
RO 2-32	Rodonia	RO/PB/1	RO/PB/2-32
MT 10-161	Mato Grosso	MT/C/4	MT/C/10-161
RO 3-298	Rodonia	RO/PB/1	RO/PB/3-298
AC 5-153	Acre	AC/T/3	AC/T/5-153
RO 3-300	Rodonia	RO/PB/2	RO/PB/3-300
MT 11-88	Mato Grosso	MT/C/6	MT/C/11-88

(Source: Journal of Rubber Research Institute of Sri Lanka, vol. 95)

RRIC 121 and RRISL 203 were used from recommended clones as controls.

III. Methodology

Preliminary Selection

25 accessions were selected out of around 2000 accessions of 1981 *Hevea* germplasm established at Neuchatel estate. For further studies their girth, bark thickness, floral canopy and latex flow (g/t/t) were used as primary selection criteria and measurements were made from four plants of each 2000 accession.

•**Girth**: - Girth was measured in plants at 120cm above bud union using a “Measuring tape”.

- **Bark thickness**: - Bark thickness was measured at 120cm above bud union using a “Bark gauge”.
- **Floral canopy**: - Through visual observation, different ratings were given to each accession.

▪Ratings: - 1= Weak 2 = Moderate 3 = Good 4 = Very good

- **Latex flow (g/t/t)**: - Latex flow of each genotype was measured by tapping for 3 months.

Highest performing 25 accessions from all parameters were selected out and those were cut back to get new shoots for use as bud woods. Then, those selections multiplied by bud grafting and the new plants were planted in completelyrandomized blocked design with three replicates and each replicate contain fiveplants from each 25 accessions. Then as morphological and physiological measurements their girth, leaf area, chlorophyll content, leaf color, tree height and inter whorl-length were recorded as follows.

Girth

Growth of each plant of each accession was assessed by the girth which is the circumference of the tree trunk. Firstly, diameter was measured using a Vernier caliper and then the girth was calculated from the diameter value. The measurements were made at 60cm height above from the bud union on each tree at about 18 months after planting.

Leaf Area

Measurements were made on each plant of each accession and the newly emerging leaf whorl (at about 12 months after planting) was selected. After reaching full leaf expansion, leaf area was measured using a portable leaf area meter (LI-3000C, Ll-Cor, Nebraska, U.S.A.).

Chlorophyll Content

Measurements were made on each plant of each accession using a chlorophyll meter (SPAD-502). To minimize the diurnal influences measurements were made between 9:00am to 12:00 noon with temperature range between 30°C to 34°C. Measurements sites were at the middle of the leaf surface (apart from the main vein) in three different positions, (on the upper, middle and lower parts) of the plant.

Leaf Colour

In this study, Munsel colour chart for plant tissues was used to determine the intensity of the colour of leaves of each accession and control clones. The colour codes and ratings allotted to them according to colour intensity.

Tree height

The distance along the axis of the tree stem between the ground and the tip of the tree (Total height) was measured using measuring tape.

Inter-whorl length

The distance between the third and new leaf whorl along the axis was recorded.

IV. Statistical Analysis

Parametric data analysis

After the completion of measurements of girth, leaf area, leaf colour, tree height, chlorophyll content and inter-whorl length of 25 accessions and two control clones in all three replicates, their mean values were calculated. The significant differences in the means of girth, leaf area, leaf colour, tree height, chlorophyll content and inter-whorl length were analyzed using one-way ANOVA. When significant differences were detected, a multiple comparison procedure (Duncan’s Multiple Range Test) were performed to study the differences among the means.

V. Results And Discussion

Preliminary selection

As the preliminary selection criteria, girth, bark thickness, floral canopyrating and latex flow (g/t/t) were measured from around 2000 accessions (four plants for each accession) from 1981 germplasm nursery, according to average values for all criteria of each 2000 accessions, the highest performing 25 accessions were selected and their average values under each criterion are given below in Table 2.

Table 2. Average values of girth, bark thickness, floral canopy and latex flow (g/t/t) of each selected 25 accessions

Accession	Girth (cm)	Bark thickness (mm)	Floral canopy rating	Latex flow (g/t/t)
1	57.5	12	3	58.5
2	68.5	10	3	65.2
3	80	12.5	2	58
4	75.5	9	3	60.4
5	78.5	9	3	60.2
6	68.5	9	3	59.7
7	67.5	12	4	63.3
8	77	11	3	58.5
9	59	10.5	4	60.3

10	65	11	4	62
11	58.5	11	4	60.5
12	65.5	10.5	3	61
13	58	12.5	4	57.3
14	66	10	4	55
15	69	11	3	60.7
16	59	10	4	61
17	65	12	3	56.4
18	68.5	13	4	62
19	90	13	3	71.4
20	83.5	10.5	4	60.7
21	63	11	4	64.2
22	72.5	11.5	4	67.1
23	88	12	4	78.3
24	85	12	4	76.7
25	73.5	11	4	66.8

Girth

Based on the average values of girth of each selected 25 accession from preliminary selection criteria,their variations are shown in Figure 1.

Key	
No.	**Accession**
1	1-4
2	144
3	1-53
4	RO 2-4
5	RO 2-32
6	RO 2-96
7	RO 3-298
8	RO 3-300
9	RO 3-467
10	AC 4-58
11	AC 5-153
12	AC 5-163
13	AC 6-13
14	MT 7-23
15	MT 7-36
16	MT 7-61
17	MT 7-187
18	MT 10-100
19	MT 10-146
20	MT 10-158
21	MT 10-161
22	MT 11-13
23	MT 11-76 I
24	MT 7-76 II
25	MT 7-88

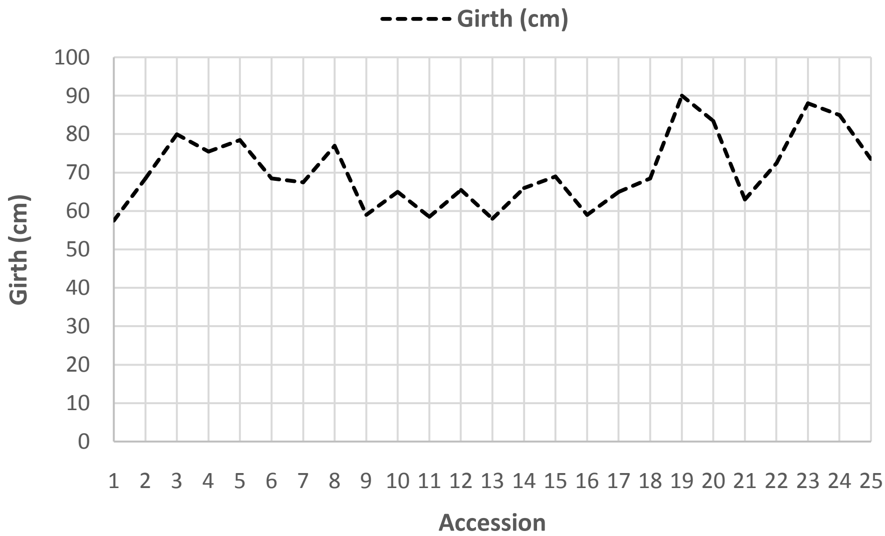

Figure 1. Average girth values of each selected 25 accessions.

2. Bark thickness

Based on the average values of bark thickness of each selected 25 accession from preliminary selection criteria,their variations are shown in Figure 2.

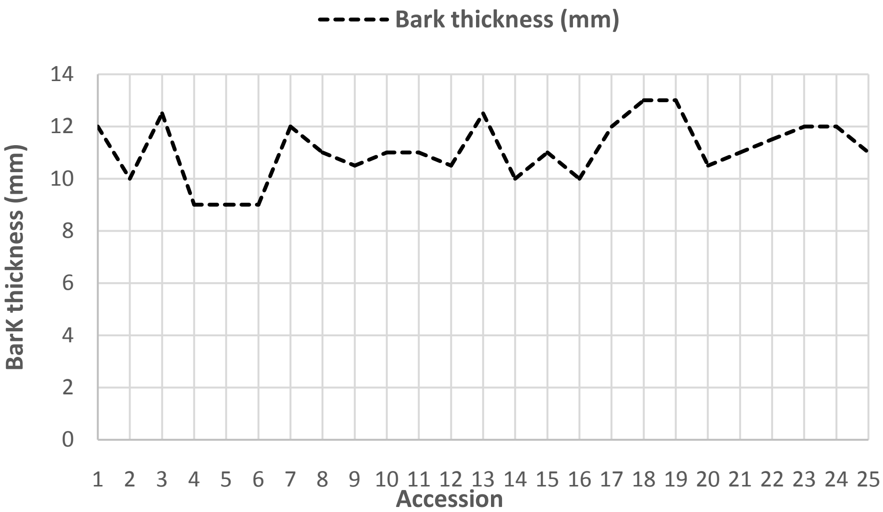

Figure 2. Average bark thickness values of each selected 25 accessions.

Floral canopy

Based on the average values of floral canopy of each selected 25 accessions from preliminary selection criteria,their variations are shown in Figure 3.

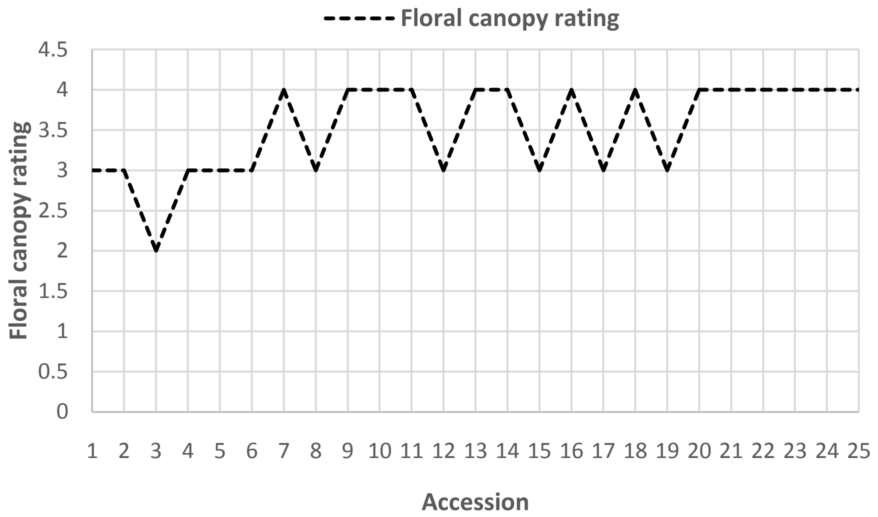

Figure 3. Average floral canopy values of each selected 25 accessions.

Latex flow (g/t/t)

Based on the average latex flow(g/t/t) values of of each selected 25 accessions from preliminary selection criteria,their variations are shown inFigure 4.

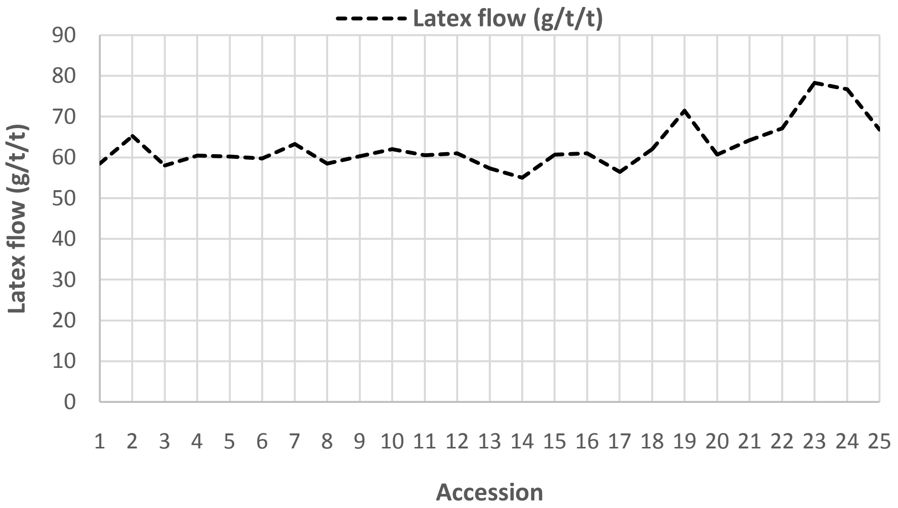

Figure 4. Average latex flow(g/t/t) values of each selected 25 accessions.

Key	
No.	**Accession**
1	1-4
2	144
3	1-53
4	RO 2-4
5	RO 2-32
6	RO 2-96
7	RO 3-298
8	RO 3-300
9	RO 3-467
10	AC 4-58
11	AC 5-153
12	AC 5-163
13	AC 6-13
14	MT 7-23
15	MT 7-36
16	MT 7-61
17	MT 7-187
18	MT 10-100
19	MT 10-146
20	MT 10-158
21	MT 10-161
22	MT 11-13
23	MT 11-76 I
24	MT 7-76 II
25	MT 7-88

4.1.5 All preliminary selection criteria

Based on the average values ofgirth, bark thickness, floral canopyratingand latex flow (g/t/t)ofeach selected 25 accessions from preliminary selection criteria, their variations are shown in Figure 5.

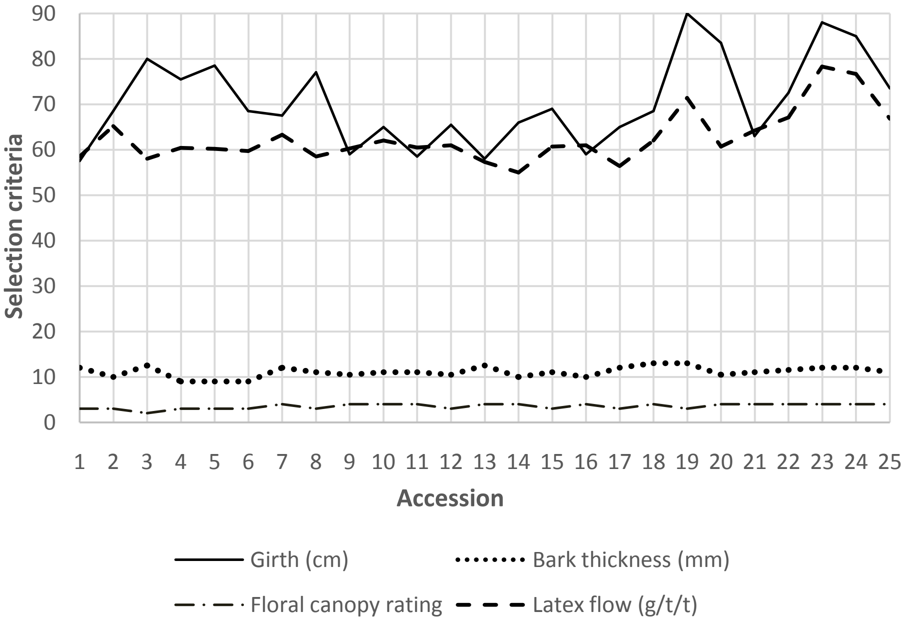

Figure 5. Average values of girth, bark thickness, floral canopy ratingand latex flow (g/t/t) of each selected 25 accessions.

No.	Accession
1	1-4
2	144
3	1-53
4	RO 2-4
5	RO 2-32
6	RO 2-96
7	RO 3-298
8	RO 3-300
9	RO 3-467
10	AC 4-58
11	AC 5-153
12	AC 5-163
13	AC 6-13
14	MT 7-23
15	MT 7-36
16	MT 7-61
17	MT 7-187
18	MT 10-100
19	MT 10-146
20	MT 10-158
21	MT 10-161
22	MT 11-13
23	MT 11-76 I
24	MT 7-76 II
25	MT 7-88

Evaluation of Parametric data

Tree height

From the analysis of variance (ANOVA), it was found that the differences in the means of 25 accessions and control clones were statistically significant at P≤0.05 which indicated that tree height is significantly difference among different accessions and control clones as shown in Table 3.

Table 3: Meansof each accession with control clones for tree height

Accession	Mean (cm)&DMRT's Group
MT 10-146	155.09^{a}
MT 11-76 II	152.53^{ab}
MT 11-13	152.2^{abc}
RRIC 121	148.2^{abcd}
MT 7-36	140.23^{abcd}
MT 7-23	138.51^{abcd}
RO 2-4	135.5^{abcd}
AC 6-13	131.42^{abcd}
RO 2-96	130.67^{abcd}
1-44	125.37^{abcd}
MT 7-187	125.29^{abcd}
1-53	123.08^{abcd}
MT 7-61	118.8^{abcd}
1-4	115.47^{abcd}
MT 11-76 I	114.73^{abcd}

RO 3-467	114.65^{abcd}
RO 2-32	114.16^{abcd}
RRISL 203	111.07^{abcd}
AC 5-163	109.14^{abcd}
AC 4-58	107.51^{abcd}
MT 10-158	104.17^{bcde}
AC 5-153	102.14^{cde}
MT 10-100	100.25^{de}
RO 3-298	98.22^{de}
MT 10-161	96.97^{e}
MT 11-88	93.02^{e}
RO 3-300	90.4^{e}

(Means of the same letter in the column are not significantly different at P≤0.050)
According to Duncan's Multiple Range Test for tree height, the accession MT 10-146 was recorded the highest and it was significantly different from other accessions. The second highest was MT 11-76 II and it was significantly different from rest of accessions.

Chlorophyll content
Means of chlorophyll content of each accession and control clones were statistically significant at P≤0.05 which indicated that chlorophyll content is significantly difference among different accessions and control clones as shown in Table 4.

Table 4. Meansof each accession with control clones for chlorophyll content

Accession	**Mean (spade value) & DMRT's Group**
MT 11-76 I	56.02^{a}
MT 11-13	55.45^{ab}
MT 10-100	50.19^{abc}
MT 10-146	50.04^{abcd}
AC 4-58	46.88^{abcd}
AC 6-13	46.23^{abcd}
RO 2-96	44.8^{abcd}
AC 5-163	44.16^{abcd}
RRIC 121 - Control Clone	44.02^{abcd}
MT 11-76 II	42.43^{abcd}
MT 7-187	42.4^{abcd}
RRISL 203 - Control Clone	42.28^{abcd}
AC 5-153	40.55^{abcd}
MT 7-36	39.90^{abcd}
RO 2-32	38.07^{abcd}
MT 10-161	38.02^{abcd}
1-4	37.78^{abcd}
MT 7-23	36.45^{abcd}

MT 7-61	36.41^{abcd}
MT 10-158	36.05^{abcd}
RO 3-467	35.77^{abcd}
1-44	35.64^{abcd}
RO 3-298	35.08^{bcd}
1-53	34.77^{cd}
RO 3-300	33.81^{cd}
MT 11-88	31.2^{cd}
RO 2-4	29.62^{d}

(Means of the same letters in the column are not significantly different at $P \leq 0.050$)

The accession MT 11-76 I was recorded the higher value and it was significantly different from other accessions and controls clones. Twenty-six accessions were grouped with control clones and accession RO 2-4 was recorded the lowest value.

Girth

It was found that the different means of the girth of these accessions and control clones were statistically significant at $P \leq 0.05$ which indicated that girth is significantly difference among different accessions and control clones as shown in Table 5.

Table 5. Means of each accession with control clonesfor girth

Accession	**Mean(cm)& DMRT's Group**
MT 11-76 II	18.75^{a}
MT 11-13	18.4^{ab}
1-53	16.4^{abc}
AC 6-13	16.12^{abcd}
RO 2-4	16.11^{abcd}
RRIC 121- Control Clone	16.0^{abcd}
MT 7-36	15.71^{abcd}
MT 10-146	15.55^{abcd}
MT 11-76 I	15.09^{abcde}
1-4	14.73^{abcdef}
RRISL 203- Control Clone	14.49^{bcdefg}
RO 3-467	13.95^{cdefg}
MT 7-187	13.75^{cdefg}
RO 2-32	13.52^{cdefg}
MT 7-23	13.22^{cdefg}
AC 5-163	13.17^{cdefg}
1-44	12.8^{cdefg}
AC 4-58	12.55^{cdefg}
MT 11-88	12.47^{cdefg}
RO 2-96	12.45^{cdefg}
MT 7-61	12.25^{cdefg}
MT 10-158	12.12^{defg}
RO 3-298	11.0^{efg}
AC 5-153	10.94^{efg}

MT 10-161	10.85[fg]
RO 3-300	10.51[fg]
MT 10-100	10.4[g]

(Means of the same letter in the column are notsignificantly different at P≤0.050)

Leaf Colour
From the analysis of variance (ANOVA), it was found that the differences in the means of these accessions and control clones were statistically significant at P≤0.05 which indicated that leaf colour is significantly difference among different accessions and control as shown in Table 6.

Table 6. Meansof each accession with control clones for leaf colour

Accession	**Mean& DMRT'sGroup**
MT 11-76 II	10[a]
MT 11-76 I	10[a]
AC 6-13	9[b]
MT 11-88	9[b]
1-4	9[b]
MT 7-23	9[b]
RO 3-300	9[b]
MT 7-36	9[b]
RO 3-467	9[b]
RRIC 121- Control Clone	8[c]
RO 2-4	8[c]
AC 5-153	8[c]
RO 3-298	8[c]
MT 7-187	7[d]
RO 2-32	7[d]
1-44	6[e]
MT 10-161	6[e]
MT 10-100	5[f]
RO 2-96	4[g]
AC 5-163	4[g]
AC 4-58	4[g]
RRISL 203- Control Clone	3[h]
MT 10-158	3[h]
1-53	2[i]
MT 10-146	2[i]
MT 7-61	2[i]
MT 11-13	2[i]

(Means of the same letter in the column are not significantly different at P≤0.050)

According to Duncan's Multiple Range Test for leaf color in all accessions and control clones were in between 2 to 10. The accession MT 11-76 I and MT 11-76 I were recorded higher values and they were significantly different from other twenty three accessions as well from controls clones. Accessions 1-53, MT 10-146, MT 7-61 and MT 11-13 were shown the lowest leaf colour.

Leaf Area
According to results of the Duncan's Multiple Range Test there is no significant difference among accessions and control clones as shown in Table 7.

Table 7. Meansof each accession with control clones for leaf area

Accession	Mean(cm^2) &DMRT's Group
MT 11-88	67.12[a]
MT 11-76 I	66.28[a]
1-53	66.24[a]
MT 11-13	64.98[a]
RRISL 203- Control Clone	63.84[a]
MT 7-187	62.82[a]
RRIC 121- Control Clone	58.94[a]
1-4	58.16[a]
MT 7-23	57.99[a]
AC 6-13	57.50[a]
MT 11-76 II	55.78[a]
MT 7-36	55.77[a]
RO 3-298	55.08[a]
RO 2-32	53.83[a]
AC 4-58	53.80[a]
1-44	53.07[a]
RO 2-4	52.90[a]
MT 10-161	52.79[a]
AC 5-163	52.15[a]
MT 10-100	50.30[a]
RO 3-467	48.75[a]
AC 5-153	48.63[a]
MT 10-158	47.79[a]
RO 2-96	47.17[a]
MT 10-146	46.58[a]
RO 3-300	43.13[a]
MT 7-61	42.52[a]

(Means of the same letter in the column are not significantly different at P≤0.050)
According to Duncan's Multiple Range Test for leaf area, it was clearly seen that there were no any accession which was significantly different each other. Therefore, it may be given minimal contribution to characterize the accession.

Inter-Whorl Length
It was found that the different means of the inter whorl length of these accession and control clones were statistically significant at P≤0.05 which indicated that inter whorl length is significantly difference among different accession and control clones as shown in Table 8.

Table 8. Meansof each accession with control clonesfor inter-whorl length

Accession	Mean(cm) &DMRT's Group
MT 10-146	87.53[a]
RO 2-4	85.31[ab]
MT 7-36	75.53[abc]
AC 4-58	73.65[abcd]
MT 7-187	72.1[bcde]
MT 10-100	71.58[bcde]
RO 2-96	71.48[bcde]
RO 2-32	71.28[bcde]
1-53	70.76[bcde]

MT 7-23	69.93^{cde}
MT 10-158	66.93^{cdef}
RRIC 121- Control Clone	66.73^{cdefg}
MT 10-161	66.65^{cdefg}
MT 11-13	65.4^{cdefg}
1-44	64.36^{cdefg}
AC 5-163	63.6^{cdefg}
RO 3-300	59.03^{defgh}
MT 11-76 II	58.86^{defgh}
RO 3-298	57.78^{defgh}
RO 3-467	57.33^{efgh}
MT 7-61	57.3^{efgh}
1-4	56.4^{efgh}
MT 11-88	56.11^{efgh}
AC 6-13	54.0^{fgh}
MT 11-76 I	51.8^{fgh}
AC 5-153	51.03^{gh}
RRISL 203- Control Clone	46.26^{h}

(Means of the same letter in the column are not significantly different at P≤0.050)

Accession MT 10-146 and RO 2-4 were significantly different from other twenty-one accessions and both control clones. Other accessions were grouped as above. Surprisingly, the control clone RRISL 203 was shown the lowest inter-whorl length value.

The time taken for improvement of tree crops through breeding programmes is alarmingly long, compared to that in annual crops. The reason is obviously the long immature phase of tree crops therefore; a method for predicting the breeding value of material in the juvenile stage would be one of the most needed inventions in the tree breeding (Gordon and Promnitz, 1976). Therefore, this study will be a better tool for forecasting the breeding value of material in their juvenile stage.

4.1.7 Multivariate cluster analysis for parametric data.

Average linkage multivariate cluster analysis was done to combine the relationships of each 25 accession for all morphological and physiological parameters.

According to the dendrogram, it was shown seven different clusters at average distance of 0.85 (Figure 6).

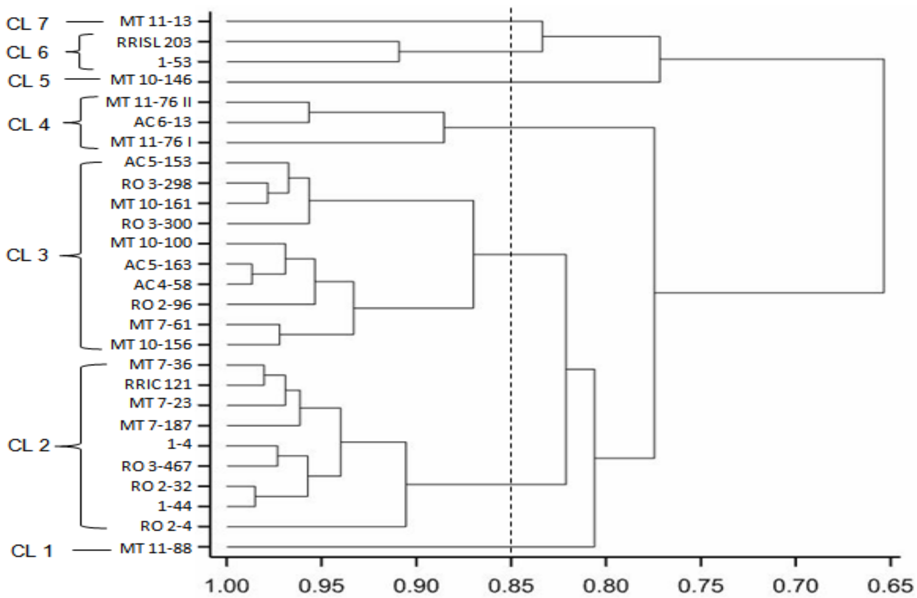

Figure 6. Dendrogram for 25 accessions and two control clones based on average linkage multivariate cluster analysis using all the morphological and physiological data.

(CL 1, CL 2, CL 3, CL 4 CL, 5, CL 6 and CL 7 are the different clusters at average distance of 0.85).

Table 9. Cluster composition of different accessions and control clones based on average linkage multivariate cluster analysis using all the morphological and physiological data.

Cluster No.	No. of accessions and control clones	Accession number
1	1	MT 11-88
2	9	MT 7-36, RRIC 121, MT 7-23,MT 7-187, 1-4,RO 3-467, RO 2-32,1-44, RO 2-4
3	10	AC 5-153,RO 3-298,MT 10-161,RO 3-300, MT 10-100,AC 5-163,AC 4-58,RO 2-96,MT 7-61, MT 10-158
4	3	AC 6-13, MT 11-76 II, MT 11-76 I
5	1	MT 10-146
6	2	RRISL 203, 1-53
7	1	MT 11-13

Table 10. Explainable relationships of among all accessions and control clones under different clusters.

Cluster No.	Explainable relationship for cluster divergence
1	There is no explainable relationship within cluster and between clusters
2	There is no explainable relationship within cluster and between clusters
3	There is no explainable relationship within cluster and between clusters
4	•MT 11-76 I and MT 11-76 II have shown significantly higher values than both of control clones and all the accessions under the leaf color measurements •MT 11-76 II has shown significantly higher values than control clone RRISL 203 and anothersixteen accessions from girth measurements •MT 11-76 II has shown significantly higher values than another six accessions from tree height measurements •MT 11-76 I has shown significantly higher values than another five accessions from chlorophyll content measurements •MT 11-76 I has shown significantly higher values than another three accessions from girth measurements •There is no explainable relationship with accession AC 6-13
5	•MT 10-146 has shown significantly higher values than another five accessions from girth measurements •MT 11-76 I has shown significantly higher values than another six accessions from tree height measurements •MT 11-76 I has shown significantly higher values than another 23 accessions from inter - whorl length measurements
6	There is no explainable relationship within cluster and between clusters
7	There is no explainable relationship within cluster and between clusters

Considering this study and the performances of each accession for all parameters, it could be found that there are three accessions always prominent. For instance, MT 11-76 I, MT 11-76 II and MT 10-146 always showed the highest performance for all observations except leaf area, but even accession MT 11-76 I has shown the second highest value for leaf area.

VI. Conclusion

In this study, 25 accessions have been evaluated. According to parameters of girth, inter-whorl length and leaf colour; some accessions have shown good performances when compared with control clones: RRISL 203 and RRIC 121.From inter-whorl length measurements, accessionMT 10-146 has shown significantly higher value than both of the control clones and all the accessions except accessions RO 2-4, MT 7-36 and AC 4-58.

Under the leaf colour measurements, accessions MT 11-76 I and MT 11-76 II have shown significantly higher values than both of control clones and all the other accessions.Furthermore, from girth measurements, accession MT 11-76 II has shown significantly higher values than control clone RRISL 203 and anothersixteen accessions.According to parametric data analysis, accessions MT 11-76 I, MT 11-76 II and MT 10-146 have shown significantly higher values compared to control clones and all the other accessions.

Another important matter is, these three accessions were originated in Cartriquacu district in Mato Grosso state.Moreover, considering preliminary selection criteria results, these three accessions were in first three highest performing accessions among around 2000 accessions which were observed to select the 25 accessions.

In addition to these three accessions, accessions RO 2-4 and MT 7-36 have shown significantly higher values compared to other accessions and control clonesfrom observed parameters.But they could not meet adequate performances as accessions MT 11-76 I, MT 11-76 II and MT 10-146.

Therefore, accessions MT 11-76 I, MT 11-76 II and MT 10-146 can be considered as the best early performing accessions among selected 25 accessions which were used in this study.

However, it is needed to be observed further period at bud wood nursery as well as in field conditions to confirm their performances. Also, it is important to evaluate their actual yield figures before go for selections and it will help to find out the correlation of measured parameters with their yield performance.
Finally, molecular screening of these 25 accessions could be a better tool for further characterizations.

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