Statistical Discrimination of Latex between Healthy and White Root Infected Rubber Tree based on Dry Rubber Content

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Abstract. Dry rubber content (DRC) is one of main material existing inside latex. It is usually in ranged of 25\% – 45\% of rubber latex. Statistical analysis are done to determine the discrimination of dry rubber content of latex between healthy and white root infected rubber tree. Based on 150 rubber trees and 10 clones tested, parametric test which include normality test, error-bar plot, and paired samples test are done. The result outcomes have shown that both data of dry rubber content of latex for healthy and white root infected rubber tree are normally distributed. Error-bar plot test is clearly indicated that there is visible discrimination between both cases. Paired samples test are done to reinforce this findings in terms of numerical p-value which is found to be less than 0.05. Thus, this indicate overwhelming evidence that healthy group can be discriminated from white root. Conclusively, changes in DRC content in latex can be correlated with white root disease infections of rubber tree.

1. Introduction

Heavea Brasiliensis or known as Rubber was originated from Brazil introduced to South East Asia in 1876 by Farris, Cross and Hendry Wickham [1]. Rubber product is one of the main contributors to Malaysia economy growth[2]. Latex and timber from rubber trees are used in many industries such as furniture, automotive, buildings, medical and etc. Latex is a milky white fluid consisting of proteins, alkaloids, starches, sugar, oils, tannins, resins, and gums. The gums or dry rubber content plays a very important roles in determining the quality and the price of latex. Higher dry rubber content will result in much higher price for the latex. Malaysia supply for about 60\% of the world consumption of disposable rubber gloves which mainly made from latex [3].

Usually, rubber latex is consist of 50-80\% water, 25-45\% dry rubber content and 2-5 \% non-rubber particle[4-6]. The dry rubber content of latex differs due to several factors such as its morphology and environment [6]. The latex price is higher if the dry rubber content is high as it is the only component needed in latex for rubber product manufacturing industries [5].

White root disease (WRD) is one of the main problems faced by rubber tree [1,8]. White root disease is said to be the most threatening among other rubber tree disease. The cause of this disease is from fungus named Rigidoporus lignosus which infect the surface of tree root in three stages which are penetration, colonization and degradation [7]. Throughout the infection phase, the colonization of the pathogen will affect the nutrient absorption of the rubber tree [9]. Since the white root disease infection affect the nutrient absorption of the tree, its effect on the latex should also be investigated. This paper objective was to compare the dry rubber content of healthy and white root infected rubber tree by using statistical analysis techniques.
2. Methodology

2.1. Determination of White Root Disease and Healthy Rubber Tree
The determination of white root disease were done with help of expertise from Integrated Pest and Disease Management Programme (IPDM) of Rubber Research Institute Malaysia (RRIM). Samples classes were determined by tree morphology and presence of white root disease fungus. Basically there are 5 types of infection for white root disease. It is evaluated based on fungus infection on how many segmentation (a,b,c,d) at root has occur. As example, type 3 infection is determine if any three out of four segmentation has been infected by white root fungus. The tree is said to be type 5 infected if it is unable to produce latex and dying. Figure 1 shows the segmentation of root area for infection type determination.

![Figure 1. Tree root area (top view) segmentation for white root infection categories](image)

2.2. Samples Collection
Experiment was conducted at Rubber Research Institute Malaysia (RRIM) Kota Tinggi on Jun 2014 and January 2015. The experiment were tested on 150 rubber trees from 10 different clones which are 2010, 2013, 2014, 2019, 2020, 2023, 2024, 2025, 2026, 3001. These clones were obtained from three main stations in RRIM Kota Tinggi named Pelepah, Permatang and Pemandi. The clones were chosen based on the availability of white root disease samples in their group. Predetermination of white root disease infected trees were done several days before sample collection by a trained RRIM officer based on the tree morphology and presence of white root disease fungus. In other words, if there was a white root disease from a specific clone, a healthy samples from the same clone was also obtained. Latex samples were collected directly from tree trunk at where the tree were usually tapped. The container used to store latex was ensured to be uncontaminated. Minimum amount of 60 ml of latex must be collected from each tree in order to do a dry rubber content test. Preservative was inserted into the samples to avoid coagulation and maintain its freshness.

2.3. Dry Rubber Content (DRC) Test
After the samples were obtained from the field, dry rubber content test were done by using RRIM Dry Rubber Content (DRC) Standard Test Method. This test were based on ISO 126: 1989 which was developed by RRIM in order to determine the DRC of the samples. This method involves process to dry the latex into dry rubber [10]. Latex with 25g in quantity is dried into dry sheet to measure DRC content. The DRC was calculated as below:
\[
\text{DRC} = \left[\frac{m_1 - m_0}{m_0}\right] \times 100\% 
\]

Where

\(m_0\) = the mass, in grams, of the latex test portion
\(m_1\) = the mass, in grams, of the dried sheet

2.3. Statistical Analysis
Statistical analysis were done in order to determine the relationship of the dry rubber content with the health condition of a tree. Comparison of DRC of latex from healthy rubber tree and white root infected rubber tree was initiated using normality test in order to investigate the samples population follow normal distribution or not. The data is said to be normal if frequency of data is highest in middle and lowest towards extreme [11]. Since it follows normal distribution, then parametric test was applied using error bar plotting and followed by paired samples test for conclusive numerical findings.

3. Results
3.1 Cataloging
Tables 1-3 show cataloging of samples collection on June 2014 and January 2015 for this work. With respect to these figures, a total 71 suitable trees are selected on June 2014 and 79 on January 2015 to be used in conducting the DRC Test. For both session, samples taken from Pelepah has the highest quantity with 42.7 % followed by Permatang (36.7 %) and lastly, Pemandi (20.7%). Among 150 trees being sampled, there are 34 white root infected and 116 healthy rubber trees.

| Table 1. Numbers of Samples Collected based on session. |
|--------------------------------------------------------|
| Session      | Frequency | (%)   |
|--------------|-----------|-------|
| 14-Jun       | 71        | 47.3  |
| 15-Jan       | 79        | 52.7  |
| Total        | 150       | 100   |

| Table 2. Numbers of Samples Collected based on station |
|--------------------------------------------------------|
| Station      | Frequency | Percent |
|--------------|-----------|---------|
| Pelepah      | 64        | 42.7    |
| Pemandi      | 31        | 20.7    |
| Permatang    | 55        | 36.7    |
| Total        | 150       | 100.0   |

| Table 3. Numbers of Samples Collected based on Clones. |
|-------------------------------------------------------|
| Clone   | Type          | Total |
|---------|---------------|-------|
| 2010    | WRD           | 5     |
| 2013    | HEALTHY       | 6     |
| 2014    | 26            | 29    |
| 2019    | 10            | 19    |
3.2 Normality Test
From 150 trees that were obtained from sample collection works, 116 DRC samples for each cases were extracted. These obtained DRC values were firstly evaluated using normality test. Normality test using Kolmogorov-Smirnov algorithm was done to determine normally distribution for any sample population if the \(p\)-value is more than 0.05. As shown in Table 4, both healthy and white root disease samples has \(p\)-value of 0.2. Thus, this indicate the data follows normal distribution and with such, other parametric tests can be applied.

Table 4. Normality test of DRC value for each categories of samples.

| Tests of Normality | Kolmogorov-Smirnov |
|--------------------|--------------------|
|                    | Statistic | df   | Sig.   |
| Healthy            | .071      | 116  | .200*  |
| WRD                | .046      | 116  | .200*  |

3.3. Error Bar Plots Analysis
Figure 2 shows the result of applying error bar plot while Table 5 depicted the descriptive measurements of the test. By observation, the lower confidence limit of healthy samples (36.30) does not overlap with the upper confidence limit of white root disease (36.01). Therefore, implying both samples population means range differed from each other.

Figure 2. Error bar plot for Healthy and White Root Disease DRC Values.
Table 5. Measurements of Error Bar Plot for Healthy and White Root Infected Samples

|          | Mean ± Std. Error | UCL  | LCL  |
|----------|-------------------|------|------|
| Healthy  | 37.22 ± 0.46      | 38.13| 36.30|
| WRD      | 34.87 ± 0.58      | 36.01| 33.71|

For numerical analysis, data for this work is then further tested using paired samples $t$-test and the outcomes are depicted in Table 5. With respect to table, the $p$-value for this test is less than 0.05 which indicates that there is an overwhelming evidence that both samples population can be discriminated from each other.

Table 6. Paired Samples Test for Healthy and White Root Diseases (WRD)

| (I) category | (J) category | Mean Difference (I-J) | Std. Error | Sig. (2-tailed p-value) | 95% Confidence Interval |
|--------------|--------------|-----------------------|------------|-------------------------|-------------------------|
| Healthy      | WRD          | 2.352                 | .68126     | 0.001                   | 1.0033, 3.7022          |

4. Conclusions
The investigation of discrimination between healthy and white root disease (WRD) infected rubber tree latex for 150 trees tested indicates that there are a good correlation between white root disease infection and DRC in latex. By statistical analysis, the result shown a very distinguishable value for both cases. There were no overlap in error bar between both cases, and $p$-value 0.001 of paired samples test, signal the discrimination between both cases. This indicates that white root disease infection has effect on rubber latex. In field investigated, there were many white root infected rubber trees. But, in order to get enough latex samples for DRC test, suitable trees were limited as only infected trees with mild infection would still able to produce enough latex. However, this work able to discriminate white root infected and healthy latex based on DRC.

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