Investigation on Identification of RRIM Clone Series using Various NIR LED sensor

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Abstract. The evolution of various rubber tree clone has been introduced by Malaysian Rubber Board since 1928 and it is known as Rubber Research Institute Malaysia (RRIM) clone series. To support this, it is suggested research to investigate the behavior of the clone series with the development from a sensing device with several opted NIR wavelength ranges through the latex samples. An optical sensor prototype has been built consist of four types of NIR LED at selected wavelength and the photodiode works as receptor of the light emission. As transmitter, the NIR sensors are obtain from the local distributor in Malaysia which is RC component. Arduino Uno is use as the processor for processing the data and obtain the output trough LCD. There are five selected clone use which are RRIM 3001, RRIM 2008, RRIM 2007, RRIM 2014 and RRIM 2002. The output result which represented by the voltage and then will be analysed using statistical analysis approach for data analysis. The outcome reveal that the selected rubber tree clone series is able to determine based on the NIR properties.

1. Introduction
Malaysian Rubber Board (MRB) have launched a systematic breeding program for rubber tree clone series named Rubber Research Institute of Malaysia (RRIM) series to support and sustain the yield and timber production [1]. This improvement in rubber sector may provide wide opportunity in Research & Development (R&D) from the government [2]. Due to this plan, MRB has released a few series of rubber trees clone breed that have capability to produce more and high quality of raw latex as well as good timber.

The usage of Near Infra-Red (NIR) nowadays is widely known because of its worldwide application and usage. The variety of NIR wavelength provide multiple options that can be used and suitable for various application. For example, the application of NIR in the food industries for analyzing the nutrient contents in manure samples by Asai et al. NIR optical technique also have been applied in baking industry to analyse raw ingredients for protein content, moisture, particle size, ash, starch damage and colour [3]. Other than that, NIR also can be applied to the design and development of the near infrared (NIR) cameras for industrial purpose [4].

There are several studies that have been carried out in agriculture field in Malaysia especially in rubber industry. For example, NIR is used in identification of white root disease that are caused by indigenous fungal parasites, then the data processed using Artificial Neural Network (ANN) techniques in order to classify a decision of early detection of rubber tree white-root disease [5]. This study uses...
ANN as analysis method and achieved 84.4% accuracy. By using optical properties of NIR, the characteristic of the white root disease can be identified at early stage and can be prevented from spread and infect other tree. Color spectrum (RGB) method to determine purity of the latex contain and finally able to determine the rubber clone series via Statistical Packages for Social Sciences (SPSS) analysis [6]. Work done by N.A. Khairuzzaman [7] able to achieve the total accuracy is 84.8% rather than previous study. It is used the combination of visible (VIS), NIR and ultraviolet (UV) to identify the early symptom of white root disease based on changes on leaf color using spectrometer Model Carl Zeiss MCS 600 which is it is the latest Micro Spectroscopy and the data then numerically analyzed using statistical approach to observe the significant findings [7].

However as refer to the Malaysian rubber industry, the problem for identification of the rubber clone breed had become crucial as the difference between clones cannot be identified physically and only scientific test or depends on expertise. The process of determination of rubber breed which may consume more time for decision making if using conventional method. Thus, with the combination research about the optical characteristic of NIR, Arduino Uno and the statistical analysis method will help various application in the agricultural industry especially in rubber clone identification. This also will help to understand the NIR specification base on the characteristic towards the rubber tree clone series. Therefore, it is an inspire for this study to take a step ahead to give more understanding and study to investigate the various type NIR wavelength for identification of rubber tree clone series. It is believed that this study may be a helpful resource as well as provide significant contribution towards society

2. Methodology

There were several steps taken in this research which involving the hardware development consists of the optical sensor and the receiver combination, signaling process to amplify the output, display systems using Arduino to display the output voltage from difference NIR. All the processes have been summarized in the flowchart shown in Figure 1.

![Figure 1. Flowchart of the experiment.](image-url)
2.1 Sensor and Signal Conditioning Circuit Development

![Figure 2. Block diagram of instrumentation system.](image)

Figure 2. Block diagram of instrumentation system.

Figure 2 shows the overall instrument system that had been used to the combination of three major part which are sensor, signal processing/signal processor and data presentation/display element. Each part play an important role to deliver the output in term of voltage.

Meanwhile the following Figure 3(a) and 3(b) show the sample of NIR LED used and Table 1 show the characteristics of the NIR LEDs as LED sensors with four difference wavelength which is ranging from 850nm up to 950nm. This value is chosen due to the availability of this NIR LEDs in the market.

The sensor circuit is design using Proteus 8 software with contain four difference type of NIR LEDS, four LEDS indicator to indicate which NIR is use during the data taken and four switch to control on/off of the NIR. The named for each NIR LEDS is denoted according to Table 1.

![Figure 3. Example of NIR and photodiode use in this study.](image)

### Table 1. NIR LED characteristics

| Name | Wavelength (nm) | Half Angle (°) | Radiant Intensity (mW/sr) | Power Dissipation (MV) |
|------|----------------|---------------|--------------------------|-----------------------|
| NIR1 | 850            | 22            | 50                       | 150                   |
| NIR2 | 870            | 10            | 120                      | 180                   |
| NIR3 | 940            | 25            | 120                      | 220                   |
| NIR4 | 950            | 23            | 120                      | 170                   |

The optical sensor circuit is the improvise version from the previous study by researcher team on identification rubber clone using optical properties [8]. This circuit use LM 324 as the processing element. LM 324 contain buffer and non-inverting amplifier that will amplified the output which detected by the photodiode SFH 229. This photodiode capable to detect NIR wavelength from 380nm to 1100 nm. Figure 4 show the Arduino Uno and the LCD display 16X2 is use for data representation. LCD display which NIR will be use and the output voltage. Arduino Uno have the ADC (analog to digital converter) to convert the analog signal to digital signal for display purpose [9].
2.2 Schematic Configuration Setup

Figure 5 represent the construction that have been improvised from the previous studies and suitable for this work. Method of where the sample is placed in the black box to prevent the interference of other optical wavelength that might present during the data observation and collection. The distance of each NIR from the photodiode is 1.5cm. The height of the sample can adjust between 3 cm and 4 cm, according to some circumstances during the experimental work.

![Figure 5. Location of the sample and NIR inside black box 10cm height x 10cm width x 20cm length](image)

Figure 6 display the whole instrument chart is combine and ready to be tested for functionality and troubleshooting purposes.
Figure 6. Hardware development on progress

Figure 7 show the principal reflection, scattering and reflection of NIR light emission towards on a surface of latex sample. Photodiode then will collect the reflection of the NIR light. Latex sample from difference rubber clone have difference concentration that will cause difference output voltage displayed. Distance sample from NIR will also affect the photodiode absorption due to the each of NIR have difference half angle for NIR emission detection [10].

Figure 7. The reflection, scattering and reflection of NIR light

While Figure 8 shows the LED emission of a normal modal. The other major reason to choose NIR other than LED emission in spectrum is because the NIR wavelength is suitable for latex composition [11]. The following Figure 9 shows the white and black card which is used during the circuit testing and troubleshooting. Another element used in data calibration before the data collection is distilled water. The purpose of this process is to calibrate the circuit and make some changes if there is any problem. Material such as card box doesn’t reflect the NIR emission as the reading output usually still in millivolt, while the plain water reading have quite significant value due to the emission can reflect more on water. This prove the functionality of the circuit before the clone sample is use. Table 2 shows the result for calibration purpose.
Figure 8. LED emission spectrum distribution for a standard model for different wavelength

Figure 9. Black and white board used to test the reflection of NIR during circuit development.

Table 2. Calibration result of the used NIR.

| Samples       | The output voltage V |       |       |       |
|---------------|----------------------|-------|-------|-------|
|               | NIR1     | NIR2  | NIR3  | NIR4  |
| White         | 0.31     | 0.27  | 0.21  | 0.23  |
| Black         | 0.27     | 0.19  | 0.21  | 0.23  |
| Distilled water | 2.54   | 2.23  | 2.29  | 2.31  |

2.3 Sample and Data Collection

The latex sample of RRIM 3001, RRIM 2008, RRIM 2007, RRIM 2014 and RRIM 2002 is used in this experiment to study and observe the NIR performance. The samples were collected from the Rubber Research Institute Malaysia at Kota Tinggi, Johor during high yielding period which falls on November to February [12]. The total 1500 sample have been collected for all clone.

Figure 10. Preservation of latex sample for RRIM 3001

Figure 10 shows how the latex sample stored in specimen cups. The specimen cup then stored in freezer to preserve the quality of the latex, under controlled environment and can be used for other analysis in future [13].
One of the reasons choosing Infrared light's in this study is because it have long wavelength which often allows for less scattering from part surfaces and higher transmission rates through them. Besides a higher transmission means it can pass through more materials which is show that infra-red (IR) light ideal for identification of the breed.

Table 3. Output test based on Distance.

| clone | 3CM | 4CM | 3CM | 4CM | 3CM | 4CM | 3CM | 4CM |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|
| 2002  | 3.15| 3.07| 3.03| 2.99| 3.13| 3.04| 3.13| 3.04|
| 2007  | 3.15| 3.08| 3.02| 2.99| 3.14| 3.03| 3.12| 3.03|
| 2008  | 3.20| 3.13| 3.07| 3.03| 3.17| 3.08| 3.17| 3.10|
| 2014  | 3.20| 3.12| 3.08| 3.03| 3.16| 3.08| 3.17| 3.09|
| 3001  | 3.23| 3.14| 3.10| 3.04| 3.19| 3.08| 3.18| 3.10|

Table 3 shows the output voltage result tested using difference distance to obtain the most accurate highest reading. The highest reading from all clones is using 3cm distance. Therefore, 3cm distance is use for further data collection for analysis cause the output voltage is higher than 4cm. Hence, further analysis can be done by using 3cm measurement distance.

The output result that obtained from the experiment will be analyzed using Statistical Package for the Social Science (SPSS) software for empirical hypothesis so that the study can be proven with the strong analysis to support. SPSS is chosen because this software stored the data in the spreadsheet condition that look alike Microsoft Excel and can generate routine descriptive statistical data. Statistical analysis that will be carried out for this study is normality test, Error plot and Analysis of Variance (ANOVA) Test approach.

3. Results and Discussion

Table 4 are the behavior of the data distribution according to the maximum and minimum reading obtained for each of the NIR output.

Table 4. Data behavior for Output voltage.

|   | N   | Minimum | Maximum |
|---|-----|---------|---------|
| NIR1 | 1500 | 3.11 V  | 3.23 V  |
| NIR2 | 1500 | 3.01 V  | 3.11 V  |
| NIR3 | 1500 | 3.06 V  | 3.20 V  |
| NIR4 | 1500 | 3.08 V  | 3.21 V  |

3.1 SPSS Analysis

Statistical analysis is the important preliminary analysis should be conducted before proceeding with other analysis. This research recommended several relevant analysis such as the Normality Test for testing the population behaviour whether it is normal or not normal distribution. If the population is normal then the Parametric Test (error plot, T Test, ANOVA test etc.) is suggested if not the Non-Parametric Test (Man–Whittney, Kruskal Wallis Test etc.) is the alternative [14, 15].
3.1.1 Normality Test Analysis.

SPSS analysis approach is used to investigate the performance of the NIR during data collection. The purpose of the analysis is to understand the behavior of the data whether it’s normally distributed or not. This study using Kolmogorov-Smirnova (K-S test) to determine the normality. If the sig (p-value) value more than 0.05, then the population is normal. If not, it will be not normal and the data would be non-significant thus it can’t be use or the suitable analysis can be done via Non-Parametric Test [14,16].

Table 5. Test of Normality of Rubber Tree Clone Series

| CLONE   | Kolmogorov-Smirnova | df   | Sig   |
|---------|---------------------|------|-------|
| REIM2002 | .032               | 300  | .200  |
| REIM2007 | .031               | 300  | .200  |
| REIM2008 | .047               | 300  | .200  |
| REIM2014 | .048               | 300  | .095  |
| REIM3000 | .057               | 300  | .021  |

| CLONE   | Kolmogorov-Smirnova | df   | Sig   |
|---------|---------------------|------|-------|
| REIM2002 | .030               | 300  | .200  |
| REIM2007 | .040               | 300  | .200  |
| REIM2008 | .027               | 300  | .200  |
| REIM2014 | .037               | 300  | .200  |
| REIM3001 | .044               | 300  | .200  |

| CLONE   | Kolmogorov-Smirnova | df   | Sig   |
|---------|---------------------|------|-------|
| REIM2002 | .043               | 300  | .200  |
| REIM2007 | .042               | 300  | .200  |
| REIM2008 | .035               | 300  | .200  |
| REIM2014 | .029               | 300  | .200  |
| REIM3001 | .030               | 300  | .200  |

| CLONE   | Kolmogorov-Smirnova | df   | Sig   |
|---------|---------------------|------|-------|
| REIM2002 | .037               | 300  | .200  |
| REIM2007 | .036               | 300  | .200  |
| REIM2008 | .032               | 300  | .200  |
| REIM2014 | .022               | 300  | .200  |
| REIM3001 | .062               | 300  | .045  |

*df: degree of freedom
*sig.: significant value (p value)

Table 5 shows the normality test on each NIR towards the rubber tree clone series. NIR2 and NIR3 show a normal distributed data which can be accepted for further analysis. While NIR1 and NIR4 show un-normal data distribution, thus this implies that NIR1 and NIR4 cannot be used for identification purpose due significant value on RRIM3001 less than 0.05. Hence the parametric analysis only applicable to NIR2 and NIR3.
3.1.2 Error Plot.

The first analysis on identification of rubber tree clone series is on using error bar plot. The error plot shows the initial overview graphical analysis on the results. NIR2 and NIR3 then analysed using error plot toward the regularity five rubber clone of latex for further identification.

*Figure 11.* Error plot NIR2 towards five clone.

From Figure 11 represent NIR2 for which only can be differentiated clearly RRRIM2002, RRIM2007 and RRIM3001. However, between RRIM2008 and RRIM2014 the output result is about the same, which conclude that NIR2 cannot be used for identification because it is could not differentiate well for clone RRIM2008 and RRIM2014.

*Figure 12.* Error plot NIR3 towards five clone.

Hence Figure 12 represent analysis for NIR3 which perform very well in which each of clone can be measured significant difference between each other. Thus NIR3 is suggested to use for rubber clone identification purpose. Hence ANOVA test being conducted to enhance finding done by Error Bar Plot.
3.1.3 **ANOVA Test Analysis.**

The following results are based on the numerical value. This is to proven the previous graphical observation using Error Bar Plot. The ANOVA Test suitable for more than three means to be analysed [14]. As can be seen that Table 6 tabulated the ANOVA output analysis. By this method, NIR2 and NIR3 can be used to identify five clone series due to the fact that the sig value is less than 0.05. Thus this implies that rubber tree clone can be identified using both NIR.

| Table 6. ANOVA Test Output Result. |
|-------------------------------------|
| **Sum of Squares** | df | **Mean Square** | **F** | **Sig.** |
|---------------------|----|----------------|------|--------|
| **NIR2** &nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&n

4. **Conclusion**

The process of identification the numerous rubber clone series is an impossible if it does not depending on the expertise. Hence by this research, the types of clones can be identified using an electrical approach and it could help any individuals and institution to recognize the clone types according to the numerical information. It can be concluded that the difference type of NIR might cause of difference output. This is supported by the datasheet provided by the manufacturer. Even though the NIR have high wavelength but other aspect such as forward current, half angle, relative radiant intensity might affect the NIR performance. Thus, it can be concluded that the investigation process is successfully able to identify the suitable NIR LED sensor to recognize RRIM clone series and it can be used to support the future works in developing sophisticated system.

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