Automated Rubber Seed Clones Identification using QTR-1A Reflectance Sensor and PIC

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Abstract— **This paper describes research work in developing an automatic model for rubber seed clone identification. The objective of this project is to create an intelligent detector using QTR-1A reflectance sensor and interface with PIC16F877A microcontroller. Beside that, changes in distance between sensor and rubber seed surface during take a reading are main objective. Five types of clones from the same series of rubber seed have been used as samples in this project which is RRIM 2002, RRIM2015, RRIM 2020, RRIM 2023 and lastly RRIM 2024. Three reflectance sensors (QTR-1A) were used to ensure that all surface samples take the reading. The device measure the percentages of reflectance based on the intensity of light reflected from the rubber seed surface. Then, the Microsoft Office Excel was used to analysis the output voltage that converts from light reflectance of wavelength to get average voltage by takes 25 samples readings from 5 difference clones. Finally, the range of average output voltage for each clone have been made based on the analysis obtained and identification of rubber seed clone be done.**

Keywords— **Rubber seed clone, QTR-1A reflectance sensor**

I. INTRODUCTION

Systematic breeding and selection works of rubber clones to improve productivity has been an ongoing process in the Malaysian Rubber Board for almost nine decades. Since it embarked on the process, six series of clones with a total of 185 clones had been developed and recommended to the industry under the names RRIM 500 (1928-1931), RRIM 600 (1937-1941), RRIM 700 (1947-1958), RRIM 800 (1959-1965), RRIM 900 (1966-1973) and RRIM 2000 (1974 till now) series clones [9]. Conventionally, the fundamental rubber seed identification is by looking at the seed and later tries to match its appearance to the closest appearance photo from a library text. Experienced workers would just look at the shape, texture pattern or color spectrum of the seed for classification[1]. However, this method consumes time, low percentage accuracy and as well as high labour cost in order to trained new worker or farmer with regards to the identification of rubber seed clones.

Since color plays an important presentation for rubber seed clones identification[1], therefore for this project it be measured using QTR-1A reflectance sensor. This sensor measured the percentage of reflectance based on the intensity of light reflect from rubber seed surface. The factor that influenced of light reflectance usually depends on the brightness of surface material which reflects the visible light[2]. Beside that, the distance between the sensor and the surface decrease, the overall reflectance decrease and the total range of the sensor output decrease[3]. This project is further improvement from previous project. The difference is use different rubber seed clone from RRIM 2000 series. Beside that, distances between sensors and rubber seed surface are changed during take a reading. The minimum distance from sensor to rubber seed surface is 1 mm and the maximum is 6 mm. Later, the output voltage that converts from light reflectance of wavelength is analysed to get average voltage by using Microsoft Office Excel. Finally, the range of average output voltage for each clone have been made based on the analysis obtained and identification of rubber seed clone be done.

A. Clone Characteristic

Figures below describe the types of RRIM200 series clones that are being used as samples in this project.

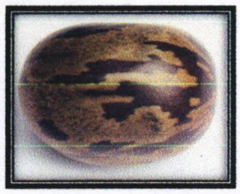

Figure 1. RRIM2002 rubber seed clone

RRIM2002: this seed size is medium, brownish with smooth and shining seed coat. The shape is square. Overall growth of the clone is considered good. The clone is recommended for both latex and timber production [4].

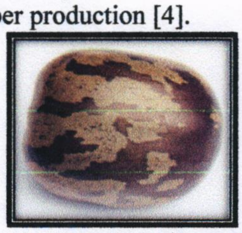

Figure 2. RRIM2015 rubber seed clone

RRIM2015: medium size, smooth, shining with light brownish seed coat. The shape is square to slightly ovoid. Overall growth of the clone is very good. Seed production is good and at nursery stage, it gives good budding success. The clones are highly recommended for latex and timber production [4].

Figure 3. RRIM2020 rubber seed clone

RRIM2020: seed is medium in size, smooth and shining with light brownish seed coat. It can be square to rectangular-shape. Overall growth of the clone is vigorous. Seed production is very good. At nursery stages it gives good budding success [4].

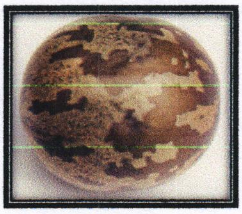

Figure 4. RRIM2023 rubber seed clone

RRIM2023: the size of seed is medium. It is smooth, shining and brownish seed coat. Colour of latex white. This clone recommended for both latex and timber production[4].

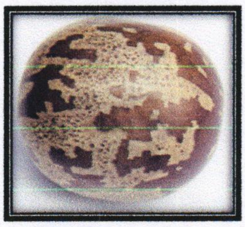

Figure 5. RRIM2024 rubber seed clone

RRIM2024: the size of seed is medium. It is smooth, shining and brownish seed coat. The shape is square to slightly rectangular. The colour is brighter compared to the other clones. Overall growth and seed production of the clone is below average. This clone is recommended only for latex production [5].

II. METHODOLOGY

A. Sample Collection

Total samples of rubber seed clones taken from the previous researcher. 5 types of rubber seed clones which are RRIM2002, RRIM2015, RRIM2020, RRIM2023 and RRIM2024. There are 25 samples was take for each clones respectively.

B. Hardware Design

The hardware proposed in this project consists of three main part which is input, controller and output. Below is the block diagram for the hardware design.

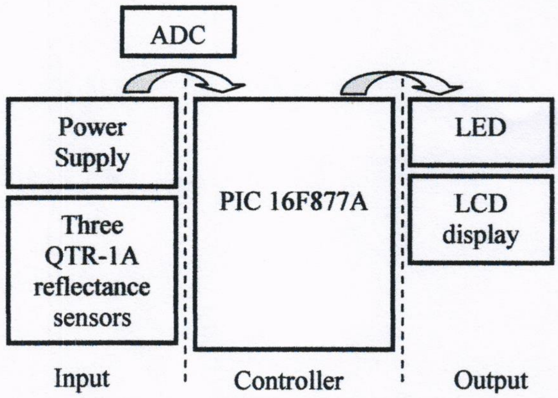

Figure 6. Block diagram for hardware design

For the input part included 5V power supply and three reflectance sensor connected at input of PIC16F877A microcontroller. PIC simulator IDE software is use to create a program. PIC16F877A microcontroller consist internal analog-to-digital (ADC) that convert total of light reflected from the rubber seed surface in analog to digital value through some calculation. Then, the LCD display 16x2 as indicator to display the type of rubber seed clone and the LED will light on to show the microcontroller is operating. Model hardware had been design as in Figure 7.

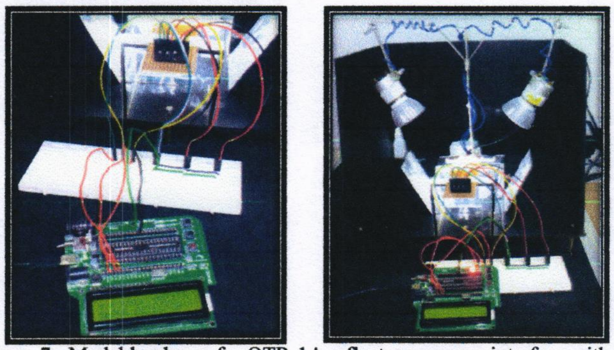

Figure 7. Model hardware for QTR-1A reflectance sensor interface with PIC microcontroller.

The QTR-1A reflectance sensor carries a single infrared LED and phototransistor pair. The phototransistor is connected to a pull-up resistor to form a voltage divider that produces an analog voltage output that ranges between 0 V and the supplied voltage (which is typically 5 V). With a strong reflectance, such as when the sensor is over a white surface, its output voltage will tend towards 0 V; with very weak reflectance, such as when the sensor is over a black surface, its output voltage will tend towards the supplied voltage[3].

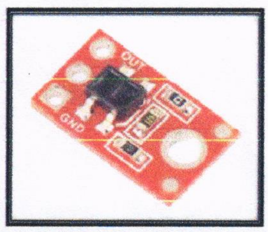

Figure 8: QTR-1A reflectance sensor

In order to measure the effect of reflectance light that reflected from rubber seed surface when the distance from rubber seed and sensor changed, base to put the rubber seed had been designed. This base are design like rectangular box that have height, width and length to ensure that when placing rubber seeds, the distance between sensors and rubber seeds surface is 1 mm and 6 mm. Metallic paper are used to wrap the base. It is because want the reflected light are focused on the sensor and rubber seed. Bellow is illustration for the base.

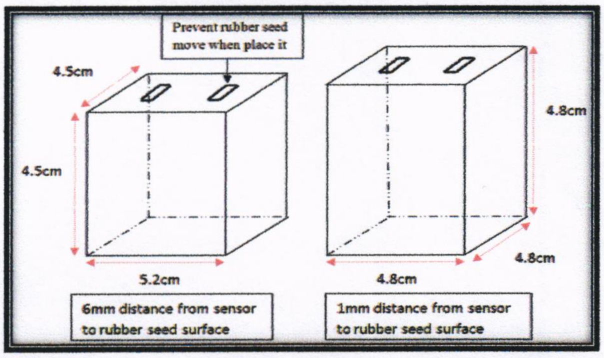

Figure 9. Illustration for base (a) at height 6mm from sensor (b) at height 1mm from sensor

C. *Experiment*

The three reflectance sensors (QTR-1A) are arranged in parallel, to ensure that all surface samples take the reading. At PIC16F877A microcontroller, port AN0 are connect to sensor 1, port AN1 to sensor 2 and lastly port AN2 at sensor 3.

The analog value was converted to digital value in 8 bit resolution for each sensor and it will be changed to output voltage by using the equation below [10]:

$$\textbf{V output} = 5 \times \frac{\textbf{DIGITAL VALUE}}{\textbf{256}} \tag{1}$$

The sensors will scan the each rubber seed clone 25 times to get an average reading of ADC. It is because each clone is use 25 sample. Additionally, the analog results are produced by internally averaging a number of samples for each sensor to decrease the effect of noise on the results[6].

Then, during take a reading for each clone, the distance between sensor and rubber seed surface are changed to 1 mm and 6 mm. Figure 10 shows sample are put at the base and produce the distance that required.

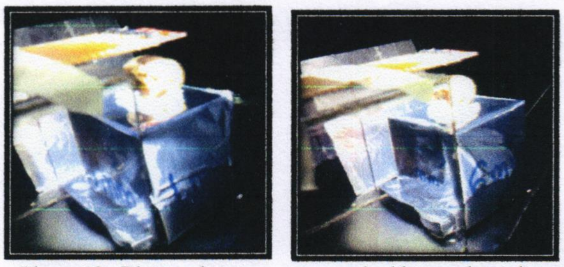

Figure 10. Distance between sensor and rubber seed are changed

Beside that, lighting and position of rubber seed clones for each experiment very need to consider. The best angle of light reflection is very important in order to get the best reflected light at the rubber seeds surface. The black background was chosen to prevent any reflected light from environment surface [7]. All these things are shows in figure 11 and figure 12.

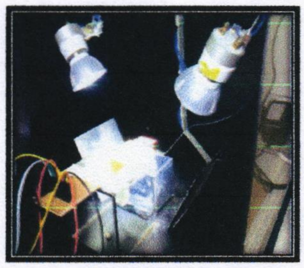

Figure 11. Position for rubber seed clones and lighting

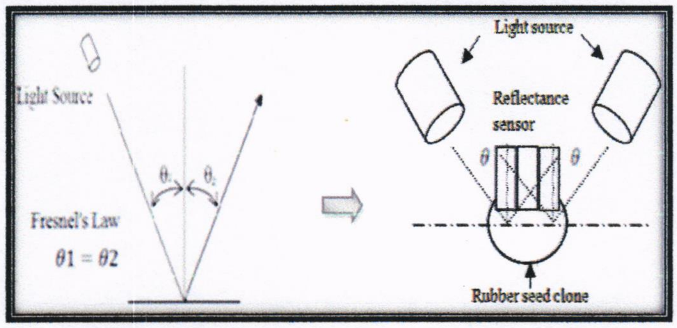

Figure 12. Fresnel's law are applied to get the best reflected light

Reflected light often behaves as Lambertian light, and it is the light that carries most of the color and texture appearance of the rubber seed surface. The reflected light is the light that is reflected at the air or surface and it in accordance with Fresnel's Law[8]. Fresnel's law said the angle between the incident ray and the normal (Θ_1) to the surface is equal to the angle between the reflected ray and the normal (Θ_2). To apply the concept of Fresnel's law, the position of light source are adjust at angle 45° in order to get the reflected angle at 45°. In that position, the sensor will get most the reflected light and it will measure the percentage of reflectance based on the intensity of light reflect from rubber seed surface.

The data collection was done at the Advanced Signal Processing (ASP) of Faculty of Electrical Engineering in UiTM Shah Alam. The Microsoft Office Excel was used as statistical measurement to get average output voltage for each rubber seed clone using graphical method. Next, all the results were analysed to get necessary range of average output voltage to identify the rubber seed clone and finally create the programming based on the result obtained.

III. RESULT AND DISCUSSION

Graph below show the output voltage produce by each rubber seed clone. The results for distance 6mm from reflectance sensor to rubber seed surface.

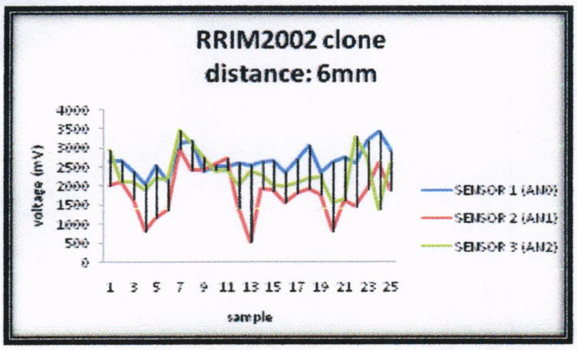

Figure 13. RRIM2002 rubber seed clone

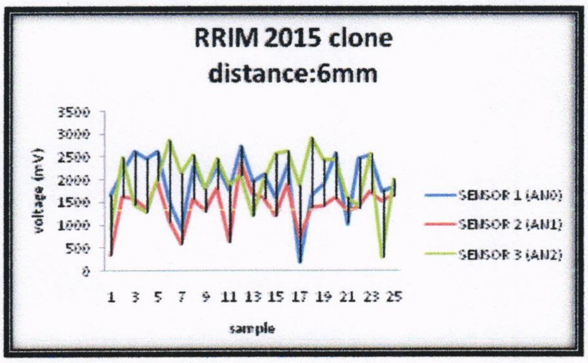

Figure 14. RRIM2015 rubber seed clone

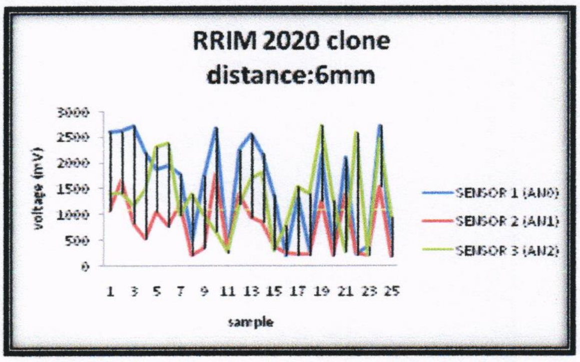

Figure 16. RRIM2020 rubber seed clone

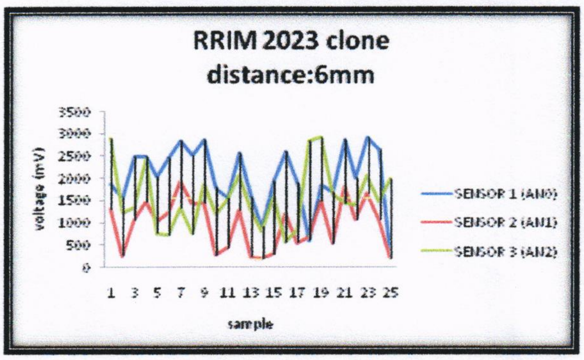

Figure 17. RRIM2023 rubber seed clone

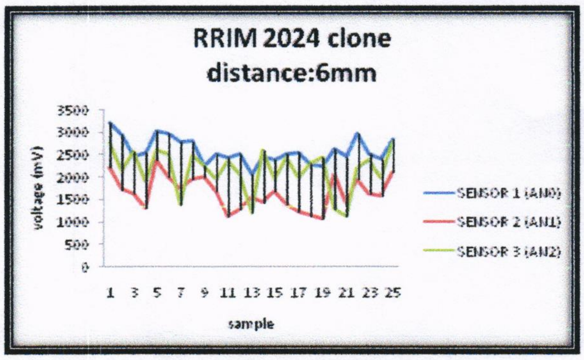

Figure 18. RRIM2024 rubber seed clone

After the output voltage for 25 samples are recorded, next is the average output voltage for each clone respectively to the sensor 1, sensor 2 and sensor 3. Table below show the result obtained.

TABLE 1. AVERAGE OUTPUT VOLTAGE FOR EACH RUBBER SEED CLONE

clone	Average output voltage (mV)		
	Sensor 1 (AN0)	Sensor 2 (AN1)	Sensor 3 (AN2)
RRIM 2002	2649.05	1799.10	2324.77
RRIM 2015	1960.30	1401.47	1986.59
RRIM 2020	1560.06	753.86	1346.01
RRIM 2023	2023.28	962.44	1552.24
RRIM 2024	2581.27	1646.04	2139.87

Then, the three graphs below shows the output voltage reading for 5 rubber seed clone were plotted together at three different sensors. This results for 6 mm distance from reflectance sensor to rubber seed surface.

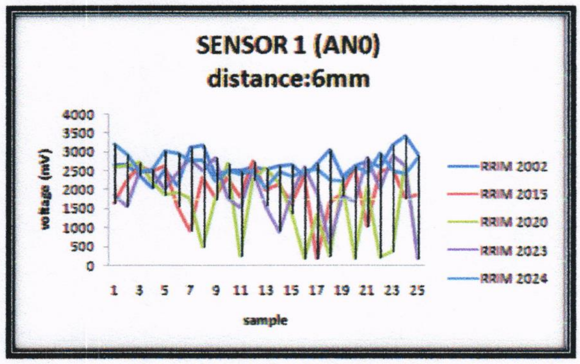

Figure 19. Sensor 1

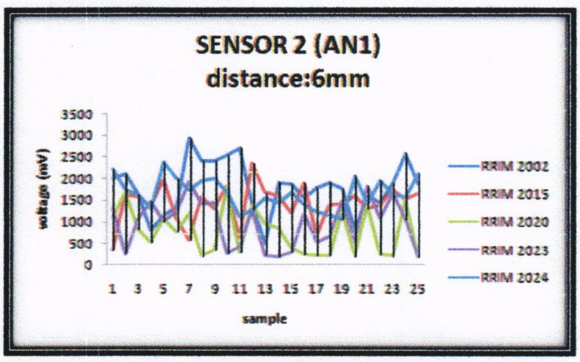

Figure 20. Sensor 2

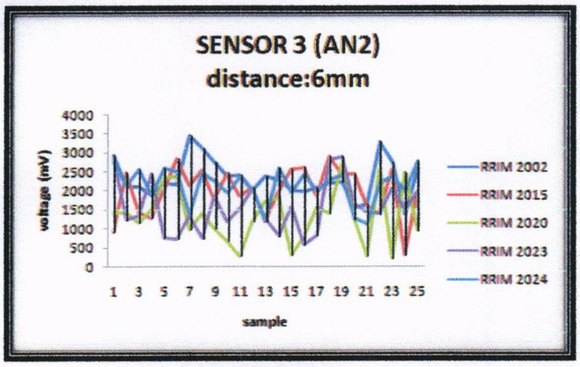

Figure 21. Sensor 3

From the all graph above, the range for average output voltage for all rubber seed clone are made and it simplify at the table 2 below. It can be said that all the clone range are close with each other.

TABLE 2. RANGE OUTPUT VOLTAGE FOR EACH CLONE

No	clone	Range of average output voltage (mV)
1.	RRIM 2002	1800-2700
2.	RRIM 2015	1500-2000
3.	RRIM 2020	800-1600
4.	RRIM 2023	1000-2100
5.	RRIM 2024	1700-2600

Next, the distance of reflectance sensor to rubber seed surface is changed from 6 mm to 1 mm. The data were collected and below is graphs output voltage produce by each rubber seed clone.

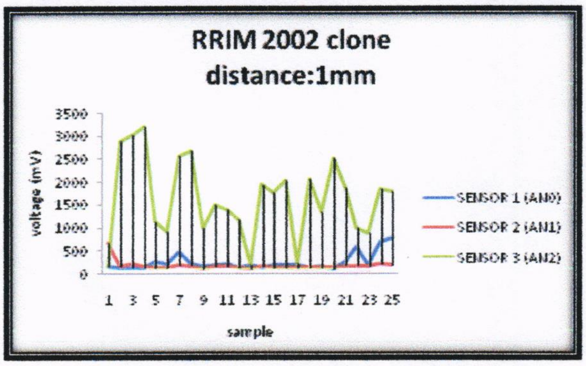

Figure 22. RRIM2002 rubber seed clone

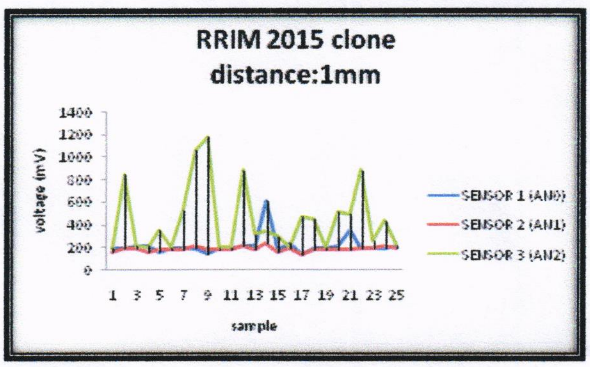

Figure 23. RRIM2015 rubber seed clone

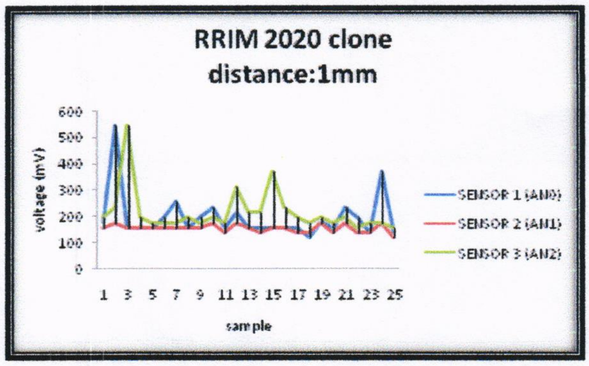

Figure 24. RRIM2020 rubber seed clone

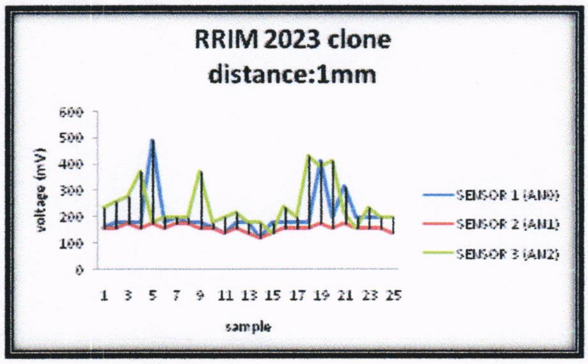

Figure 25. RRIM2023 rubber seed clone

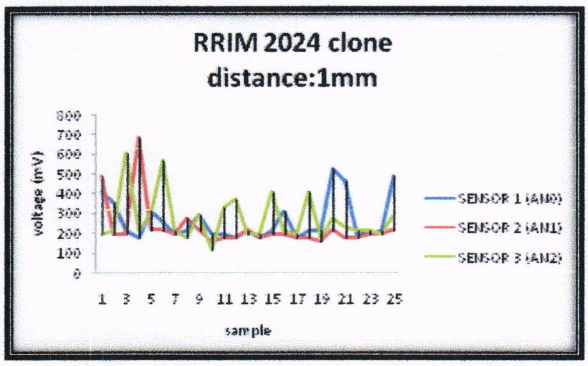

Figure 26. RRIM2024 rubber seed clone

Table below show the average output voltage for each sensor based on analysis done.

TABLE 3. AVERAGE OUTPUT VOLTAGE

clone	Average output voltage (mV)		
	Sensor 1 (AN0)	Sensor 2 (AN1)	Sensor 3 (AN2)
RRIM 2002	259.36	177.33	1635.05
RRIM 2015	217.44	183.58	440.32
RRIM 2020	196.08	153.90	215.61
RRIM 2023	202.33	156.24	239.86
RRIM 2024	264.05	225.77	272.64

Then, the graphs for output voltage of 5 type's rubber seed clone were plotted together according to each sensor were shown in figure below.

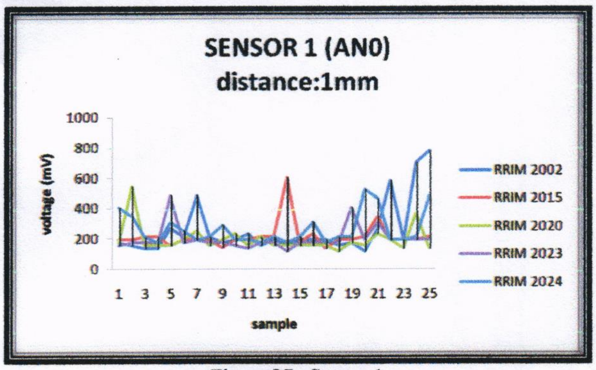

Figure 27. Sensor 1

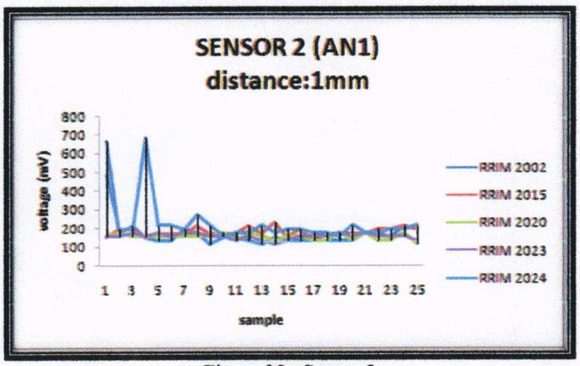

Figure 28. Sensor 2

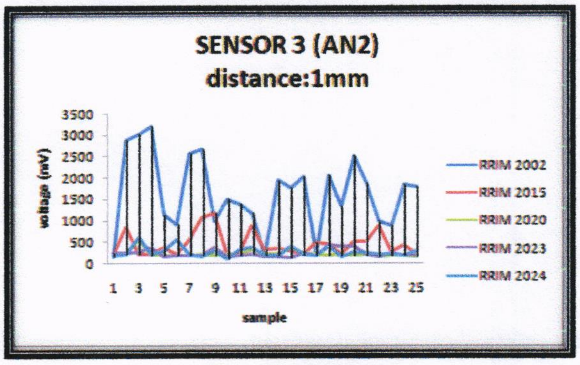

Figure 29. Sensor 3

Finally, the range of output voltage at 1 mm distance for each rubber seed clone is made based on the result obtained. The range voltage condition is same with range voltage at distance 6 mm, close with each other. For RRIM 2002, the range voltage is large compared with other rubber seed clone.

TABLE 4. RANGE OUTPUT VOLTAGE AT DISTANCE 1MM

No	clone	Range of average output voltage (mV)
1.	RRIM 2002	180-1700
2.	RRIM 2015	190-450
3.	RRIM 2020	160-220
4.	RRIM 2023	170-240
5.	RRIM 2024	230-280

From all the result that is state above, there have two different range output voltages for each rubber seed clone. When the distance from reflectance sensor to rubber seed surface far, the output voltage is large and when the distance is closer with each other, the output voltage is small. Decrease the sensor, will decreases the overall reflectance of the surface, which makes distinguishing between the two surfaces much harder and much more prone to error caused by noise [3].

Beside that, the rubber seed surface had a smooth and shining surface. In general, the smoother the surface is, the higher the shining surface is and it typically perceived to have higher color saturation[8]. Moreover, at the smooth surface, it can produce the best reflection light compared to rough surface like in figure below. So, the rubber seed clone identification is easily to identify.

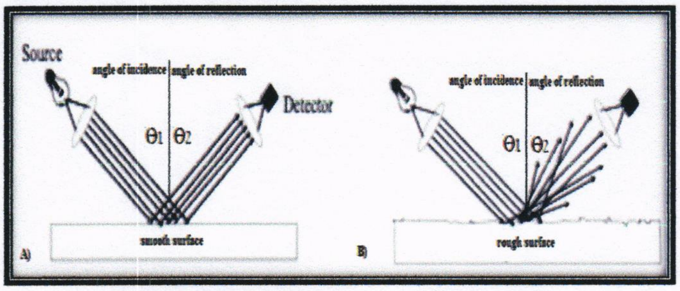

Figure 30. Angle of reflectance at difference surface

IV. CONCLUSIONS

The five types of rubber seed clones from RRIM2000 series are being tested in order to observe the differences among the clones in terms of voltage. The samples from all the clones are analyzed using reflectance sensor and PIC microcontroller. Fresnel's law concept was applied to get the best angle of reflectance light that are reflect from rubber seed surface. From the observation, it was found that rubber seeds had different shape and size. It can cause the reflectance light will scattered to others and only a small part will received by reflectance sensor. To overcome it, in this project, the three reflectance sensors are arranged in parallel, by taking a significant difference on the 3 surface areas, the process of differentiation was more accurate. The range output voltages for all clone at different distance is closer with each other. Therefore, it can conclude from visual observation it is possible that the rubber clones can be identified from the reflectance property of the seed.

V. FUTHER DEVELOPMENT

In the future, select the best rubber seed among the clone can improve the result to identify the clone types. For example, make sure the seeds in good condition and also without any dirty on the surface. Beside that, difference rubber seed clone have difference shining surface. To reduce the noise, polish rubber seed surface to get same shining at the all sample that will be used.

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