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NPK SOIL NUTRIENTS IDENTIFICATION FOR CORN USING OPTICAL TRANSDUCER WITH MOBILE APPLICATION

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ABSTRACT: Agriculture is a system of food production that remains important source of food in every country in the world. In the Philippines, corn is one of the two most produced crops grown by Filipino farmers. For a farmer to plant corn, it is important to analyse the soil nutrients. The three main nutrients are Nitrogen (N), Phosphorus (P), and Potassium (K). Since, corn required high availability of Nitrogen (N), phosphorus (P), and Potassium (K) to create high quality output. Farmers must ensure proper soil nutrients before planting corns. Currently, to check soil nutrients, soil samples were sent to Department of Agriculture for laboratory analysis. Another option is the use of commercially available soil test kits. In this study, the researchers developed a device, "N-P-K-lyzer" to identify the presence of Nitrogen (N), Phosphorus (P), and Potassium (K) using Optical Transducer. The optical transducer as a wavelength detection sensor, which consists of three LEDs as light source, and a photodiode sensor as the light detector. Testing soil samples shows that N-P-K-lyzer was able to read the same remarks as the readings from the Department of Agriculture Soil Laboratory. The remarks are LOW in Nitrogen, LOW in Phosphorous and LOW in Potassium respectively. A mobile application developed in this study allows the user to retrieve and view the stored readings.

KEYWORDS:*Optical Transducer; NodeMCU; Soil Nutrients Identification; Mobile Application; NPKlyzer*

1.0 INTRODUCTION

Agriculture is a system of sourcing food for mass production, and still crucial source

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of food supply of all the countries in this world regardless of any economic status or political influence.

Philippines is an agricultural country with a land area of 30 million hectares, 47% of which is agricultural land [1]. The country's major agricultural crops are rice, corn, coconut, sugarcane, banana, cassava, pineapple, mangoes and vegetables [2].

After rice, corn is the second highly produced crop in the Philippines, with a constantly increasing productivity since 2005. The province of Bukidnon ranked second on producing corn in the country from year 2010–2014. The said region produced 10.4 percent share to the national output. There were many farmers have expanded and occupied higher areas for cultivation. The province was one of the productive upland area-producing crop, which also ranked first in production of white and yellow corn in Northern Mindanao [3].

Soil recognized as one of the most important natural resources in the field of agriculture. In order to maximize the yield, examining the soil nutrients is important. Result of analyzed soil samples revealed that light clay soils dominated the province [4]. This type of soil is best type of soil in growing corns.

To address the stable production of corn crops, the availability of nutrient values in the soil is vital. Since corn required high availability of Nitrogen (N), phosphorus (P), and Potassium (K) to create high quality output.

However, despite on the increase of productivity, corn production in the Philippines is still low and less efficient compared to other countries that can be considered as mass corn-producers like Thailand or United States. The Lack of availability of N-P-K test and analysis have resulted on some diseases to corn such as discoloration and underdeveloped length of the leaf [5].

Soil testing is the best way to determine the level nutrients available in soil and the kinds and amounts of supplemental fertilizer needed. The development of soil testing is evolving with the help of technology; it comes easier and more effective for the farmers to practice proper nutrient management towards their farm sites. However, the rusticity of Philippine corn sector takes also a part in difference productivity because of lack adoption of new technologies [5].

Philippines' most common way on determining N-P-K availability in soil is testing the soil in the laboratory under the management of Department of Agriculture (DA). The said laboratory test result is guaranteed after one week. In addition, a soil analyzer named Soil Test Kit (STK) is also an alternative method that has been used by other

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private companies. It is a colorimetric-based analyzer that used chemicals to identify the N-P-K status of the soil [6].

As technology evolved, it was discovered that there was another method on identifying the availability of primary macronutrient. Optical Transducer is a detection sensor which can identify the presence of N-P-K in the soil. It consists of three LEDs as a light source and a photodiode as a light detector [7].

In third developing countries, mobile phone usage plays a vital role for enhancement of farmers business towards agriculture. The farmers were one of the big communities in developing countries where they have not facilities in their area for increase their product and income. Mobile phone was increasing among farmers but still there is gap available among business, customers, farmers, and income. There is need of enhancement different project about mobile phone technologies where farmers could get easy an access to latest information about seed, weather and market [8].

Future mobile applications (apps) should provide accurate and validated content for daily farming. Agricultural app contents should be validated and certified by pertinent public bodies, offering quality services to farmers. Agricultural app has a lot of potential to grow, taking into account that it can combine different technologies, such as sensors and drones [9].

Soil was a major source of nutrients by plants for growth. The three main nutrients are Nitrogen (N), Phosphorus (P), and Potassium (K). Together they make up the trio known as N-P-K [10].Since, corn required high availability of Nitrogen (N), phosphorus (P), and Potassium (K) to create high quality output. Farmer must ensure a proper nutrient management by the means of soil analysis.

In other aspects, soil testing was an important diagnostic tool for determining the nutrient needs of plants for environmental assessments. In determining fertilization needs, advance crop-production used soil testing [11].
Several technologies exist in soil nutrients identification. Previous researchers have developed N-P-K detection devices from various methods, including optical, electrochemical, acoustic, electrical and electromagnetic, and mechanical [12].

In conductivity measurement technique, two or three electrodes of same material were immersed in soil samples. Materials used can be steel, silver, platinum, graphite or copper. As per concentration of N-P-K soil, conductivity of electrode change conductivity is converted into electrical signal further electronic control system [13].

Fiber optic sensors were developed to detect the deficiency of the nutrients Nitrogen

(N), Phosphorus (P) or Potassium (K) in the soil. The sensor is fabricated which has concentric arrangement of source and receiving fibers. It was based on the colorimetric principle where absorption of light by a solution results in variation in the output of the sensor. Aqueous solutions of the soil samples are prepared for testing and then calibrated using proper signal conditioning circuit and microcontroller [14].

A study about soil spectroscopy which uses LED as light source and spectrometer to measure the light spectrum after passing through a sample was conducted. The primary nutrients of the soil namely Nitrogen, Phosphorous and Potassium are verified using the standard soil test kit method. The tested soil was illuminated by visible and near-infrared wavelength range to measure the absorption peak to choose the suitable LED. The selected LED is then illuminating the solution and lights will be reflected depending on the absorbance coefficient of the soil. The reflected light is received by paired optical fiber cable and send to the spectrometer to determine the intensity of transmitted light. With this, it was possible to find the matching wavelength of the LED and the particular nutrient of the soil [15].

Among all the methods presented above, the proponents opted the use of optical transducer. Optical transducers are cost-effective because LEDs can be replaced easily. In this study, the proponents used mobile application for the farmer, which was not considered in the previous study. In addition, the previous study has not tested the device against widely accepted methods in soil testing such as the use of soil test kit and laboratory tests. This is where mobile phone applications nowadays can be a helpful tool in testing soil nutrients. The concept of getting accurate test results, in a short period and time, as well at a lesser cost is plausible.

2.0 METHODOLOGY

2.1Soil Sampling

The Department of Agriculture provided detailed steps for gathering composite soil sample. The said sample taken from the subjected area gone through several processes to achieve its correct requirements. This process helped to reduce the chances of errors during testing and avoid bias sampling.

Composite test sample that tested on Department of Agriculture laboratory and proponent's device undergo on the same process, through SWM method where composite of ten separated soil sample was taken from subjected area. After gathering, the said sample will undergo Quartering Method to reduced sample mass.

2.2 System Design

The researcher designs a system that composed of hardware, software, and mobile application including its data flow and the process flow to enhance the design of the said system, the actual setup of device on soil sample is included.

As shown in Figure 2 below, to identify the nutrients from the soil, the system partitioned in two modules represented by a broken line. The leftmost module is the device stage where the data is initialized. The proponents designed the device in a way that it would read the soil sample through the three LEDs and photodiode sensor. There is a start button attached on the device which is intended to start the reading using NodeMCU ESP8266 12-e.

After initialization, it would be displayed to the LCD and dispatched to the database where the data is being stored. The rightmost module is the mobile application where it would be used to fetch the data from the database. It had two buttons, first is the “VIEW DATA” where the current reading from database is displayed. Second is the “PREVIOUS READING” which displays the nutrient value so as date and time from the previous readings.

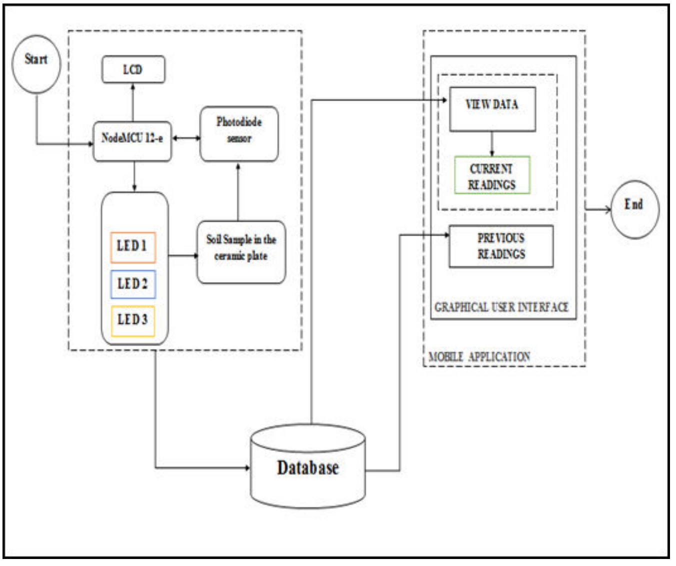

Figure 2: System Design

2.3 Hardware Design

This section illustrates the dimensions and measurements used for building up the structural design of the prototype which contains the measurements used for the main device, table, placement for the photodiode and LEDs, and the dimensions of the plates used.

Figure 3 (left) shows the isometric dimensions illustrating the width, height and

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measurement for each compartment of the table. Plates on top of the table were used as the holder of soil samples. Figure 3 (right) shows the dimension used for the main device that will be placed at the top of each plates on the table. The first compartment is for NodeMCU ESP8266 12-e and power while the second compartment is for LEDs and photodiode.

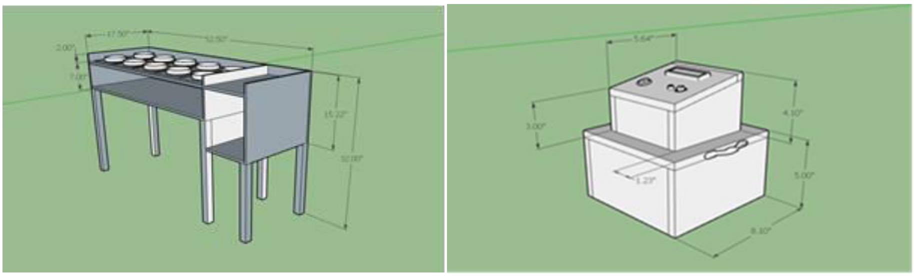

Figure 3: Isometric View of NPKlyzer

Figure 4 shows the block diagram of the hardware device powered by a 5V power supply. The optical transducer serves as data acquisition component that composed integration of light transmission (Light Emitting Diode) and light detection system (photodiode). The LEDs are utilized as the light source where the soil interacts by absorbing the light which evaluated using photodiode that has the capability of converting the reflected light from the soil into current. After emission of light, voltage will read. After that classify the readings as X, Y, and Z. Categorize voltage according to threshold values. The said readings were sent to the NodeMCU ESP8266 12-e microcontroller and analyzed the data readings from the optical transducer converting into N-P-K values. The output will then be displayed in the LCD and the farmer can also access the output through the mobile application via Wi-Fi connectivity.

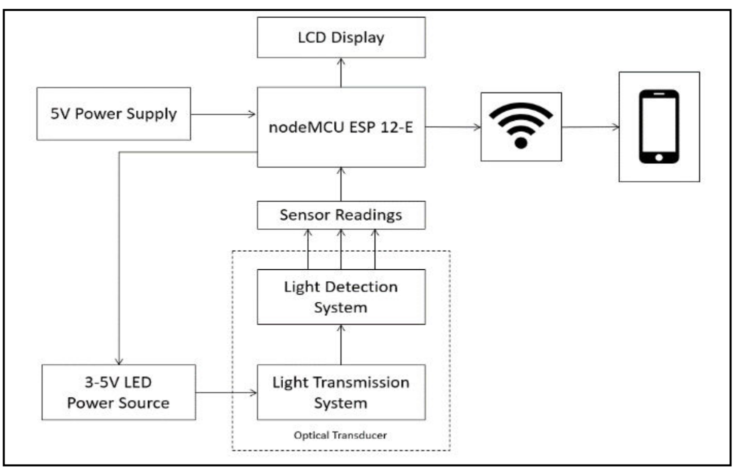

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Figure 4: Block Diagram of the Hardware Device

2.4 Mobile Application

In developing the mobile application, the researcher used Ionic framework platform in constructing the application which is compatible for marshmallow up to recent version of android devices.

The GUI has two buttons the "VIEW DATA" and "PREVIOUS READING". The view data button is used to view the current reading and previous reading is to show the last reading of the device.Firebase is a real-time database where it reflects data immediately by performing a sync across all the platforms, the data gathered from the main device.Figure 5 shows the mobile applications-user interface. The mobile application had a two user interface button. Upon opening the application there is view data button and previous button.

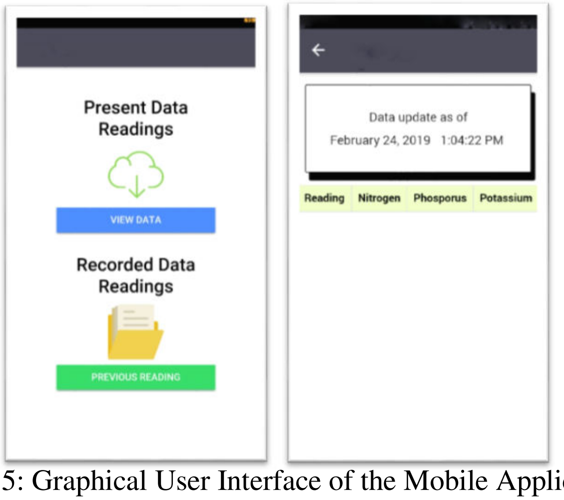

Figure 5: Graphical User Interface of the Mobile Application

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3.0 RESULTS AND DISCUSSION

The researchers created a device named N-P-K-lyzer that capable of identifying the status of three macro-nutrients present in the soil, the N-P-K. The said device converted voltage into nutrient value status in order for the end-users to easily interpret the output. The device was programmed in a way that any user can easily adopt to its functions, and simple instructions were displayed in the LCD to serve as guide.

The N-P-K-lyzer undergoes several testings in order to calibrate the threshold values for determining the status of the soil. Table 1 shows the calibrated voltage threshold values for low, medium and high values for nitrogen, phosphorus and potassium for NPKlyzer and low only for laboratory result respectively. These threshold values were determined based on the absorption rate of each nutrient during testing. The table also serves as a basis for the device to read the nutrients present in the soil.

Table1:Floating-pointoperationsnecessarytoclassifyasample

NUTRIENTS	**NPKLyzer INTERPRETATION**			**LABORATORY RESULT**
	LOW	MEDIUM	HIGH	LOW
Nitrogen (N)	$x < 2.56$	$2.56 \leq x < 2.84$	$x \geq 2.84$	0-2
Phosphorus (P)	$y < 3.62$	$3.62 \leq y < 3.80$	$y \geq 3.80$	0-2
Potassium (K)	$z < 1.52$	$1.52 \leq z < 1.97$	$z \geq 1.97$	0-113

The proponents prepared corn soil sample to be tested for 10 times and get the average of total testing to determine the soil's present nutrient status.

Table 2: The Comparison of the Results for Nitrogen from NPKlyzer and Laboratory Result

Samples	**NPKLyzer (Nitrogen)**		**Laboratory Result (Nitrogen)**		**Remarks**
	N	**Interpretation**	**N**	**Interpretation**	
1	1.56	LOW	0.098	LOW	SAME
2	2.38	LOW	0.099	LOW	SAME
3	2.10	LOW	0.1005	LOW	SAME
4	2.33	LOW	0.0995	LOW	SAME

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5	1.82	LOW	0.097	LOW	SAME
6	1.96	LOW	0.0985	LOW	SAME
7	1.63	LOW	0.1025	LOW	SAME
8	2.27	LOW	0.1045	LOW	SAME
9	2.23	LOW	0.1	LOW	SAME
10	1.94	LOW	0.0375	LOW	SAME
Average	2.02	LOW	0.0973	LOW	SAME

Table 3: The Comparison of the Results for Phosphorus from NPKlyzer and Laboratory Result

Samples	**NPKLyzer (Phosphorus)**		**Laboratory Result (Phosphorus)**		**Remarks**
	P	**Interpretation**	**P**	**Interpretation**	
1	1.35	LOW	0.63	LOW	SAME
2	2.49	LOW	0.30	LOW	SAME
3	2.09	LOW	0.48	LOW	SAME
4	2.55	LOW	0.30	LOW	SAME
5	2.02	LOW	0.27	LOW	SAME
6	1.73	LOW	0.36	LOW	SAME
7	1.51	LOW	0.46	LOW	SAME
8	2.55	LOW	0.41	LOW	SAME
9	2.42	LOW	0.36	LOW	SAME
10	2.25	LOW	0.68	LOW	SAME
Average	2.10	LOW	0.43	LOW	SAME

Table 4: The Comparison of the Results for Potassium from NPKlyzer and Laboratory Result

Samples	**NPKLyzer (Potassium)**		**Laboratory Result (Potassium)**		**Remarks**
	K	**Interpretation**	**K**	**Interpretation**	
1	0.53	LOW	83	LOW	SAME
2	1.43	LOW	83	LOW	SAME
3	0.98	LOW	87	LOW	SAME
4	1.11	LOW	87	LOW	SAME
5	0.82	LOW	83	LOW	SAME
6	0.57	LOW	83	LOW	SAME
7	0.61	LOW	87	LOW	SAME
8	1.06	LOW	83	LOW	SAME

9	1.41	LOW	87	LOW	SAME
10	0.63	LOW	91	LOW	SAME
Average	0.92	LOW	85.4	LOW	SAME

As shown in the formula below, to get the exact result of reliability of the device, the number of same remarks (comparing NPKlyzer results and laboratory) divided by number of trials times 100. For nitrogen, phosphorus and potassium, the device is 100% reliable since it has the same readings when compared to laboratory tests from Department of Agriculture.

$$\text{reliability} = \frac{\text{number of } \textbf{same} \text{ remarks}}{\text{number of trials}} \quad (1)$$

4.0 CONCLUSION

The proponents were able to retrieve data readings from the N-P-K-lyzer and stored in Firebase with its respective date and time. These data were successfully fetched and displayed its interpreted data using the mobile application. In addition, proponents were able to get the reliability of the N-P-K-lyzer by comparing its interpreted data from the Department of Agriculture Soil Laboratory. The said interpreted data were all at LOW in Nitrogen, LOW in Phosphorous and LOW in Potassium. The proponents would like to recommend to further test other soil samples with medium or high nutrients content to further test the accuracy of the device.

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