SENSOR-BASED SOIL TESTER FOR CROP ROTATION EVALUATION

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Abstract - This research project aimed to develop a portable device that will aid convenience and cheaper cost for the common farmers as an alternative way to test field soil in order for them to evaluate the nutrients present in the soil, identify and select which crop best fits the soil condition for maximized productivity and profitability. The prototype also aimed to be compact, portable, easy-to-use and automatically assess and generates results in minutes bringing the soil testing stations to the farmers. It also utilizes cheap, common and readily available technology and materials such as Arduino Microcontroller, Raspberry Pi, DC Motors, Peristaltic Liquid Pump, LCD Touch Screen, pH Sensor Spear Kit and Color Sensor for colorimetric reading. The research project is based on Soil Tester Kit (STK) process commonly used in the Philippines wherein the STK is integrated into a device to provide quicker and more convenient way of assessing soil condition by displaying the nitrogen, phosphorus, potassium qualitative value and pH quantitative value. It also evaluates which crops best fits the current soil condition depending on other known variables such as crop season, land or farm area, farmer's budget for growing crops and assessed soil nutrients. The prototype would also be able to generate how much fertilizer to be applied and forecast how much will be the estimated possible profit given that the crops are grown in normal environment conditions.

Keywords - Colorimetry, Crop Rotation, Color Sensor, Soil Tester

I. INTRODUCTION

In Philippines, crop rotation is a common practice of planting different types of crops every end of the period to help the soil recover and replenish its nutrients. The common and most important nutrient that lies in the soils are Nitrogen (N), Phosphorus (P) and Potassium (K) commonly known as NPK. In traditional farming, crop rotation is done by the farmers using the traditional routine of crops series with respect to the seasoned crops. However, some of these practices are more often tend to be inaccurate as the soil is not formally assessed with its condition and content.

As referred to the description and explanation of Mr. Donald Bickelhaupt an Instructional Support Specialist, Department of Forest and Natural Resources Management, states that, Soil Potential Hydrogen (pH) level is the indication of the acidity or alkalinity of soil . The pH scale range from 0 to 14 with pH 7 is the neutral point. The soil pH decreases which makes the soil acidic when the amount of hydrogen ion is increased in soil. On the other hand, soil becomes alkaline when the pH increases due to the decreased of hydrogen ion. (Bickelhaupt)

The Nitrogen, Phosphorous and Potassium (NPK) content in the soil are needed by all plants to grow. The NPK level of the soil are considered to have a big factor in the proper development and healthy crop growth, an improper NPK level for crops will most likely result into low growth development. With the development of the Sensor-Based Soil Tester for Crop Rotation Evaluation device, it will help determine the pH and NPK level of the soil. Furthermore, it will evaluate further based on the expanded variables which is generally considered in identifying proper crop rotation.

The Sensor-Based Soil Tester for Crop Rotation Evaluation device will modernize the traditional means of crop selection and planting in Philippines to a more efficient and dynamic ways of crop rotation at a cheaper cost and maximized profitability. The local farmers will be readily informed of the nutrients present in their field soil instead of going to a specified area of soil laboratory for chemical analysis. Through this device, the farmers may be able to monitor the level of pH and NPK levels as needed with ease of getting the results in matter of minutes instead of waiting for the soil laboratory result for two weeks. Being informed with the NPK and pH levels of the soil can aid the farmer decide on which appropriate crops is well suited for the soil and the proper amount of fertilizer should be applied.

II. STATEMENT OF THE PROBLEM

The NPK level of the soil is the major concern when it comes to crop rotation. Lack of information about soil nutrients will result into improper crop rotation, waste of resources and time, and loss of profit. The research project goal is to provide solution for the following problems:

1. Lack of information of nutrients present in the soil

Proper information about soil nutrients can affect to the growth quality of crops. Each kind of crop has a proper range of soil nutrients needed. Determining the pH and NPK level of soil gives the farmer the idea for choosing the crop to be planted and its suitable amount of fertilizer needed.

2. Improper crop selection
Choosing the right crop from the present nutrients in the soil is important for the full growth of the plants; improper plant selection for crop rotation can deteriorate the balance of the soil nutrients.

3. Inappropriate application of soil fertilizer
Improper usage of fertilizer in the soil can increase its acidity which is not advisable for plants as its ability to absorb proper and balanced nutrients is disrupted therefore having a poor crop growth. Proper application of organic or non-organic fertilizer is needed to balance the desired pH level of the soil.
With the identified problems, the researchers were able to come up with the design of the Sensor-Based Soil Tester for Crop Rotation Evaluation device which utilizes TCS3200 Color Sensor and a pH Spear Sensor integrated with the Colorimetry Technique and Soil Tester Kit Process as the basic foundation of the idea behind the prototype.

III. OBJECTIVES

General Objective
To create a Sensor-Based Soil Tester for Crop Rotation Evaluation that has ability to measure the NPK and pH level of the soil and provides recommendation for the best suited crops from the result of the tested soil condition.

Specific Objectives
1. To provide an easier and cheaper way of testing the soil for the local farmers.

The common method of soil testing process in the Philippines is done through laboratory tests which is usually processed manually and takes two weeks to get the result. With the proposed method, testing can be done easily through the portable device providing a much cheaper option for the farmers.

2. To provide soil nutrient information for the farmers present in the soil.
Soil nutrients such as nitrogen, phosphorous, and potassium are vital in the healthy crop growth and cultivation. Moreover, these nutrients are specifically important for the farmers to enable them to know the soil condition prior to planting their selected crops.
3. To measure the pH level of the soil.
Determining the acidity or alkalinity level of the soil is essential as this information will provide an indication of soil suitability for planting. It is also the deciding indicator whether the soil needed a certain amount of fertilizer.

4. To provide general information of the crops that is suitable for planting based from the tested soil which also includes the harvesting period, fertilizer expense and possible profit forecasting.
Crop selection suggestion is generated by the system including the harvest period of common crop, amount of fertilizers to be used in the soil, and possible forecasted profit assuming the normal conditions are met without any consideration on the acts of nature.

5. To provide appropriate amount of fertilizer recommendation for selected crop on tested soil condition.
Upon knowing the NPK and pH level of the soil, the system would be able to generate the amount of recommended fertilizer based on the selected crop. These will aid the farmers in selecting the proper fertilizers for their soil rather than just speculating the fertilizers which some farmers normally do.

IV. SCOPE AND DELIMITATIONS

The researchers identified the scope of the study and its capabilities. Also, the delimitation identifies the constraints of the study which are not within the control of the researchers.

Scope
1. The system has the ability to determine the NPK level which is present in soil sample displaying the following output; High, Medium, and Low for Nitrogen (N) and Phosphorus (P), while, Sufficient and Insufficient for Potassium (K).
2. The system uses chemical analysis to exactly analyze the different nutrients present in the soil. The mixing solutions are P, P_1, K, K_1, K_2, and N.
3. The system can measure the acidity or alkalinity of the soil using the pH level sensor.
4. The TCS3200 color sensor is also used to read the output color of chemical analysis.
5. The farmer would be able to select on which crop is best suited for planting based on obtained pH and NPK levels of the soil condition.
6. The system would require the following input from the farmer: Farmer's budget, the land area (in hectare) to be used for the selected crop, Planting Month, and Current market price of the selected crop.
7. The system can display the seeds expenses, the amount of fertilizer recommended, application and forecasted expenses, and forecasted possible profit.

Delimitation
1. The NPK nutrients and pH level of the soil are the only parameters that can be determined by the system.

It cannot identify other nutrients present in the soil sample.
2. The chemical analysis process is restricted at a range of 20 to 30 minutes before generating the proper NPK result levels.
3. The system cannot determine the specific values for Nitrogen, Phosphorus and Potassium. It can only display Low, Medium, High for Nitrogen and Phosphorus, while Insufficient or Sufficient for Potassium.
4. The system does not cover the other variable such as manpower and transportation in the computation of the total expenses.

V. DIAGRAM AND FLOWCHART

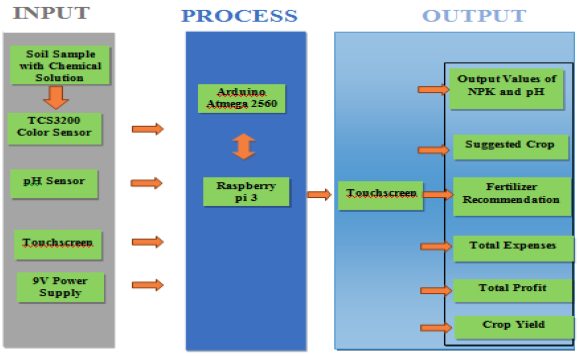


Figure 1. Input Process Output Diagram

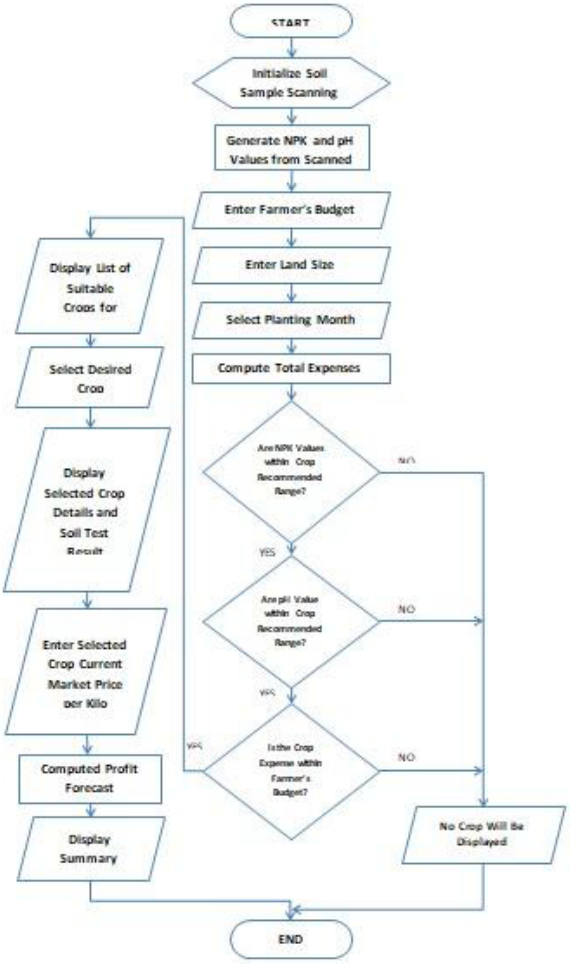


Figure 2. Process Flow Chart

SUMMARY

The traditional method of crop rotation in the Philippines follows the traditional routine of crop series or planting different types of crops in the same area. Through the years, farmers would go to a soil laboratory in order for them to determine on which crops they will plant based on the result of the chemical test done manually. This study aimed to help the farmers monitor the NPK and pH level of the soil in their field. Furthermore, the system would be able to suggest on which would be the best suitable crop to plant given the assessed soil condition and added variables such as land area, planting month, amount of expenses for seeds and fertilizers, and farmers' allocated budget are all considered to aid the decision making process in maximizing the probability of getting high profitability.

For the result of the Post-Study Usability Survey of the System from the respondents, the system was generally evaluated with a positive response from the farmers pertaining to its easiness to learn in using the device which garnered an average of 1.90 from the scale of 1 to 5 on which 1 would be the Strongly Agree statement. However, the device also obtained a downside in terms of the speed in recovery whenever an error is encountered upon using it as a basis from the result of the respondents which scored an average of 3.62.

As a result for the System Usability Scale Survey, the system got an average of 1.73 for the item which indicates that the respondents are very confident in using the system.

CONCLUSION

The project titled "Sensor-Based Soil Tester for Crop Rotation Evaluation" is proven to be optimal in measuring NPK and pH level of every soil specimen. Moreover, the system helped the user to identify which crop is best suited for planting given the assessed soil condition, it also aids the farmer to identify the amount of fertilizer needed, and shows the estimated expenses in planting crops as well as displaying the forecasted possible profit that can be produced from the harvested crop given the maintained soil condition and disregarding the extremities of the acts of nature.

Based from the results of the conducted evaluation from the farmers and other respondents, the researchers may conclude that the system or device was easy and convenient to use and overall they are satisfied in using the system. Nevertheless, the device also lacked in some aspects such as its speed in error recovery which would require technical knowledge of the system or device to troubleshoot.

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