International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 11, Issue 3 [May.-June. 2022] PP: 1019-1026

Automatic Fertilizer Management System for Advanced Farming

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Abstract

Agriculture is the backbone of our country in today's environment, which is beset by difficulties. The majority of the time, resources are not utilised effectively, and a significant amount of water is squandered. Precision agriculture techniques for enhancing crop harvest and productivity are becoming more popular by the day. Our approach is intended to provide a solution that is a step ahead in agricultural development. Soil analysis based on IoT to assist farmers in minimising human effort and increasing production. The technique entails inserting a sensor that provides information on soil NPK and moisture content, as well as displaying the data as recommendations in layman's terms to assist local farmers in determining the missing content. The NPK Soil Sensor and Arduino can be used to easily measure the nutrient content of the soil. To estimate how much more nutrient content should be supplied to soil to promote crop fertility, soil content N (nitrogen), P (phosphorus), and K (potassium) must be measured. NPK sensors are used to detect soil fertility. Nitrogen, phosphorus, and potassium are all important components of soil fertiliser. The understanding of soil nutrient concentrations can assist us in determining if soils used to support plant production are nutritionally deficient or abundant. The soil nutrient level can be measured in a variety of ways, including utilising optical sensors or a spectrometer. However, the spectrum analysis approach is inconvenient, and the data are only 60-70 percent accurate. Given the scarcity of data, the accuracy of the products has yet to be fully resolved when comparing the spectrum analysis method to classic wet chemistry procedures. The Soil NPK Sensor is used to monitor nitrogen, phosphorus, and potassium levels in soil. The Soil NPK sensor is a low-cost, quick-response, high-precision, and portable Modbus RS485 sensor. The advantage of this sensor over a standard detection approach is that it provides extremely quick measurements with extremely accurate data.

Date of Submission: 15-06-2022 Date of Acceptance: 30-06-2022

I. INTRODUCTION

Soil is an essential component of successful agriculture since it is the source of the nutrients we require to grow our crops. The basis of productive farming operations is soil health. Before planting any crop, the quality of the soil must be checked for minerals and pH content so that the required nutrients in terms of nitrogen, phosphorus, and potassium can be added to the soil through appropriate natural/chemical fertilisers, for which soil samples must be sent to a laboratory. Farmers must, without a doubt, squander a large amount of cultivable time while waiting for laboratory test findings[1].Farmers can solve these two issues by employing automatic irrigation and soil quality assessment techniques.

The volume of water needed to irrigate the field can be maximised using automatic irrigation and soil quality techniques, and if the soil quality could be analysed in a short time, it would be of tremendous assistance to the farmers in improving the yield. As a result, the goal of this project is to create and execute a novel agricultural technique that will generate more crop per drop of water. Irrigation occurs only when water is needed, and the

soil quality required for the type of crop is also displayed, along with all of the necessary data of vital elements such as Nitrogen, Phosphorus, and Potassium[3].
Furthermore, farmers that use automated equipment can reduce runoff caused by excessive soil irrigation and fertiliser use. To water the field, we can use an automatic drip irrigation system or a sprinkle irrigation system, both of which are easy and precise irrigation methods[1]. It also saves time and eliminates human error when it comes to modifying available soil moisture content and boosting yield. Devices used to control, monitor, or aid in the operation of equipment, machinery, or plants are referred to as embedded systems. Models based on artificial neural networks (ANNs) have been investigated for use in a variety of agricultural machinery applications.
Farmers may use big data to get detailed information on rainfall patterns, water cycles, fertiliser requirements, and more. This allows them to make informed judgments about which crops to sow for maximum profit and when to harvest. Farm yields are improved when the appropriate selections are made. Precision agriculture is an agricultural management approach centred on detecting, measuring, and responding to crop variability both within and between fields. Predictive analytics can be used to make better judgments in the future by gathering real-time data on weather, soil and air quality, crop maturity, and other things[4]. This paper presents a low-power, low-cost, and reliable data collection system for autonomous data generation and gathering in isolated or remote places.

II. EXPERIMENTAL SETUP

The technology primarily entails the connecting of a soil moisture sensor and a soil NPK sensor. The moisture sensor's interfacing consists of two probes: one for detecting the volumetric content of water, and the other for detecting the level of Nitrogen, Phosphorous, and Potassium in the soil, which aids in assessing the soil's fertility.

INTERFACING OF SOIL MOISTURE SENSOR

Two probes are utilised to measure the volumetric content of water in the soil moisture sensor. The two probes allow current to flow through the soil, and the resistance value is used to calculate the moisture content. When there is more water in the soil, the soil conducts more electrical, resulting in less resistance.
As a result, the moisture content will be increased. Because dry soil conducts electricity poorly, when there is less water, the soil conducts less electricity, resulting in increased resistance. As a result, the moisture content will be decreased. There are two ways to attach this sensor: analogue and digital. First, we will connect it in Analog mode and then we will use it in Digital mode.
The specification of the soil moisture sensor is given below:
Input Voltage :3.3 – 5V
Output Voltage :0 – 4.2V
Input Current :35mA
Output Signal :Both Analog and Digital

CONNECTIONS

To use the soil moisture sensor FC-28 in digital mode, we'll link the sensor's digital output to the Arduino's digital pin. A potentiometer is included in the Sensor module, which is used to set the threshold value. The sensor output value is then compared to this threshold value using the LM393 comparator on the sensor module. The comparator of the LM393 compares the sensor output value to the threshold value and then outputs the result through the digital pin.
When the sensor value will be greater than the threshold value, then the digital pin will give us 5V and the LED on the sensor will light up and when the sensor value will be less than this threshold value, then the digital pin will give us 0V and the light will go down.

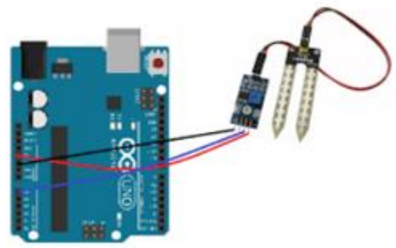

Fig 1. Soil Moisture Connection Diagram

INTERFACING OF SOIL NPK SENSOR

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The soil NPK sensor can be used to measure nitrogen, phosphorus, and potassium levels in the soil. It aids in identifying the soil's fertility, allowing for a more methodical assessment of the soil's state. The sensor can be buried for a long period in the soil. It has an 8-high-quality probe with rust resistance, electrolytic resistance, salt and alkali corrosion resistance to assure the probe part's long-term functioning. As a result, it can be used in any type of soil. Alkaline soil, acid soil, substrate soil, seedling bed soil, and coconut bran soil may all be detected with this device. There is no chemical reagent required for the sensor.
It may be used with any microcontroller because of its high measurement accuracy, fast reaction speed, and interchangeability. Because the sensor has a Modbus Communication interface, it cannot be used directly with the microcontroller. As a result, you'll need a Modbus Module, such as an RS485/MAX485 module, to link the sensor to the microcontroller. The sensor runs on 9-24V and consumes very little power. When it comes to the sensor's precision, it's accurate to within 2%. The measurement resolution for nitrogen, phosphorous, and potassium is up to 1 mg/kg.

CONNECTIONS

The Interface Module enables us to use RS-485 differential signalling for reliable long-distance serial communications up to 1200 metres or in electrically loud conditions, and is widely used in industrial settings. It can support data speeds of up to 2.5MBit/sec, however as distance increases, the maximum data rate that can be sustained decreases. As far as the microcontroller is concerned, the data starts out as a conventional TTL level serial, while the RS-485 module converts the electrical impulses between TTL and the differential signalling utilised by RS-485. RS-485 has the advantage of supporting numerous devices (up to 32) on the same wire, a feature known as'multi-drop.'

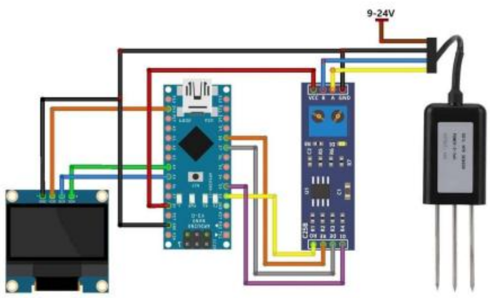


Fig 2. Soil NPK sensor Connection Diagram

SPECIFICATION OF RS485

- Use MAX485 Interface chip
- Uses differential signalling for noise immunity

- Distances up to 1200 meters
- Speeds up to 2.5Mbit/Sec
- Multi-drop supports up to 32 devices on same bus
- Red power LED
- 5V operation

Let's use the MAX485 Modbus Module to connect the Soil NPK Sensor to the Arduino Uno Board. Using Software Serial, connect the R0 and DI pins of the Modbus to D2 and D3 Arduino. Similarly, we must permit DE & RE at a high level. Connect the DE and RE pins to the D7 and D8 pins on the Arduino. The NPK Sensor is made up of four wires. VCC is the brown one, and it requires a 9V-24V power supply. The GND pin is a black-colored pin. As a result, attach it to Arduino's GND. The B pin of the MAX485 is linked to the B pin of the wire, and the A pin of the wire is connected to the A pin of the MAX485.I2C is used in the SSD1306 OLED Display. Connect the OLED Display's VCC and GND pins to the Arduino's 3.3V and GND. Connect its SDA and SCL pins to Arduino's A4 and A5 pins, respectively.

III. HARDWARE AND SOFTWARE ARCHITECTURE

All visible and structural components of a system are included in the hardware components. The Arduino UNO ATmega328 and the RS485 Modbus module are the main hardware components in this project. The Modbus module is primarily used for serial communication and data transmission. The sensors are used to monitor soil moisture and nutrient concentration, respectively. The software components that were used in the development and programming of the Android application.

HARDWARE COMPONENTS

- Arduino ATmega328
- RS485 Modbus Module
- Soil Moisture Sensor
- Soil NPK Sensor
- OLED Display
- HC-05 Bluetooth Module

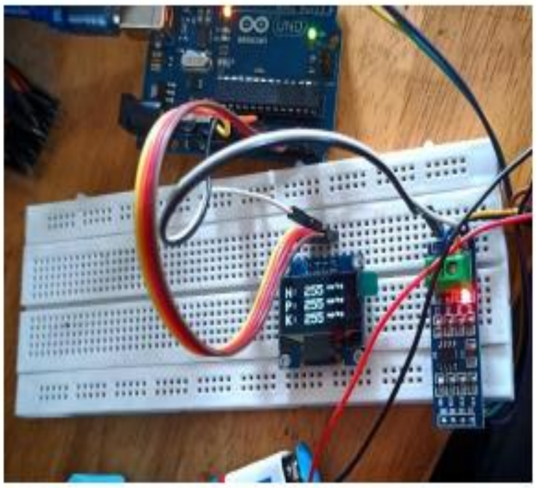


Fig 3(a).Hardware connection of Soil Moisture sensor

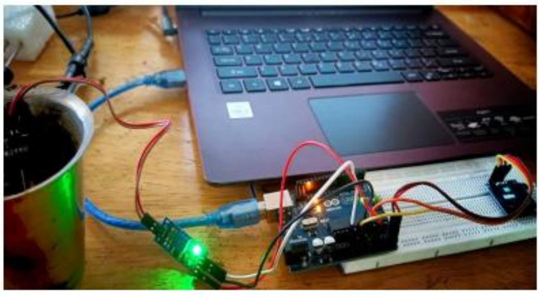


Fig 3(b).Hardware connection of soil NPK Sensor

SOFTWARE COMPONENTS

ANDROID STUDIO

Based on IntelliJ IDEA, Android Studio is the official Integrated Development Environment (IDE) for Android app development. Android Studio adds on IntelliJ's excellent code editor and developer tools by providing even more capabilities to help you build Android apps faster. It uses a Gradle-based build system that is quite versatile. For app testing, it has a fast and feature-rich emulator. We can create for all Android devices using Android Studio's centralised environment.

Fig 4.Sign-In page of Android App

KOTLIN

Kotlin is a type-inferred, cross-platform, statically typed general-purpose programming language. Although Kotlin is designed to work seamlessly with Java, and the JVM version of the standard library relies on the Java Class Library, type inference allows for more concise syntax. Kotlin is primarily designed for the JVM, however it can also compile to JavaScript. Our programme has a signup page that asks for a username and password before moving on to another page that shows a range of crops in various colours. The colours are assigned based on the blue-tooth module's values and a standard value comparison.

ARDUINO IDE

The Arduino IDE is an open-source programme for writing and uploading code to Arduino boards. The IDE programme is compatible with a variety of operating systems, including Windows, Mac OS X, and Linux. C and C++ are supported programming languages. IDE stands for Integrated Development Environment in this case. In our project, we use the Arduino platform to programme the Arduino UNO, which is used to detect soil NPK and moisture content, as well as to display the results on the OLED display that we built into our system. The various soil nutrient readings may be shown on an OLED display, which is very convenient and also in a comprehensible format (in mg/kg) for farmers that use our system. This practise has greatly aided farmers in the field of advanced farming, resulting in increased crop yields. The data of the soil NPK is fetched by the microcontroller and all three respective values of the soil are discriminated and presented in the OLED screen when the three probes of the sensor are immersed in the soil to be tested.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

We have successfully built a device that can detect the amount of nutrients and moisture in the soil and then show this information together with recommendations for local farmers in layman's terms. The ultimate product is a device that assists local farmers in enhancing crop harvest and, as a result, increasing output. At different phases of its growth, the crop requires varying amounts of nutrients, and the sensor provides recommendations to the farmers, who can view the information on a screen.

The values of NPK which is taken from the tested soil is given to the application via the Bluetooth module. Based on the agricultural survey conducted, the standard values of NPK which for different varieties of crops is already coded and comparison of values are done and recommendations already given in the form of data.

PLANTATION	N	P	K
BANANA	190	85	225
TAPIOCA	100	40	75
COCONUT	500	240	900
PEPPER	100	40	100
RUBBER	75	60	60

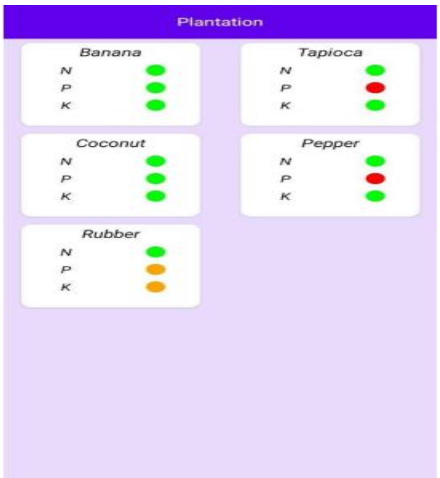
Table 1. Standard values of N, P and K

Different samples were taken to the lab for nutritional value testing, and the findings were obtained as low, medium and high Laboratories only provide hazy results.

SAMPLE	N	P	K
1	MEDIUM	LOW	MEDIUM
2	MEDIUM	LOW	LOW
3	MEDIUM	MEDIUM	LOW
4	MEDIUM	LOW	MEDIUM

Table 2. Nutrient values for different samples

Based on the standard value comparison from the agricultural survey report, the NPK values of the tested soil are collected via the Bluetooth module and recommendations for the same has been made available to the farmers through our mobile application. The figure shown below is the UI of our application developed showing different crop varieties suitable for the tested soil along with which the recommendations are displayed



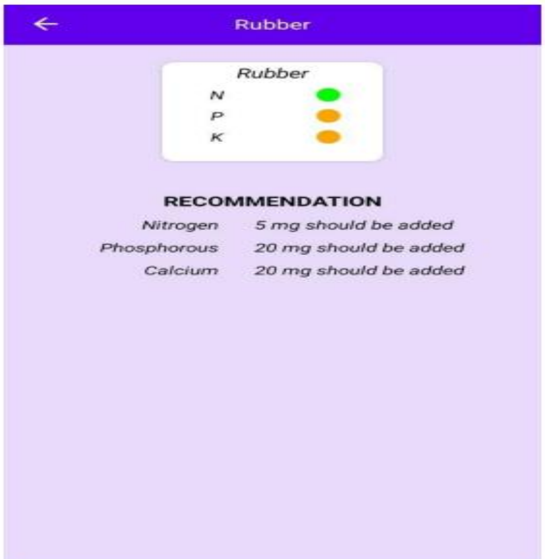


Fig 5. User Interface of Android Application

The final output which includes the soil NPK sensor and Soil Moisture sensor where the information of the soil nutrient data is displayed in the Serial monitor as well as in the OLED display.

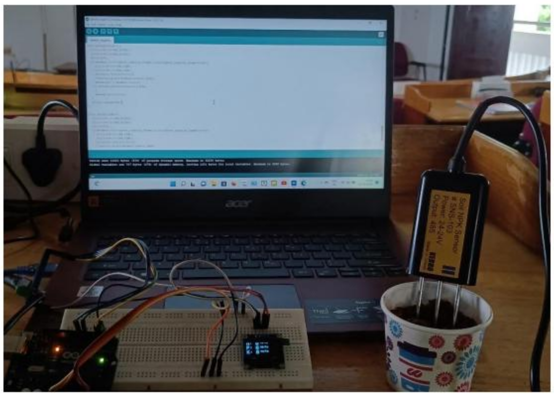


Fig 6. Sensor displaying the Nutrient contents

V. CONCLUSION

In the present scenario, agricultural sector and farmers are facing different challenges and obstacles regarding soil fertility and nutrients measurement. The end product we developed resolves the above mentioned challenges and thereby acts as a solution in the field of advanced farming. The device developed can detect the presence of nutrients and moisture content in the soil and then display this information along with recommendation in layman's terms for local farmers. Precision agriculture management practices and Advanced farming techniques can significantly reduce the amount of nutrient and other crop inputs used while boosting yields. Farmers thus obtain a return on their investment by saving water, pesticide and fertilizer costs.

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