Progress in Engineering Application and Technology Vol. 3 No. 2 (2022) 1015-1022

PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Development Of Soil Nutrients Monitoring Using Smart Grid System

Mohammed Ali Asban[1], Suhana Mohamed Sultan[2]*, Rahmat Talib[3]

[1]Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, Malaysia

[2]Universiti Teknologi Malaysia, Johor Bahru, 81310, Malaysia.

[3]Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, Malaysia.

*Corresponding Author : suhanasultan@utm.my

DOI: https://doi.org/10.30880/peat.2022.03.02.101
Received 27 January 2022; Accepted 20 July 2022; Available online 10 December 2022

Abstract: Agriculture is considered the basis of life for humans as it is the main source of food. Food security has become a vital global concern in recent years due to the increase in pollution, climate change, and high demand due to the increase in population. Moreover, there are some challenges in agriculture that farmers face recently such as water utilization, crops monitoring, and soil fertilization. In this paper, a grid system is developed using IoT technology to monitor the soil moisture level, pH value, and nutrient parameters remotely. The result shows that the pH value, soil moisture, and nutrients measured from the respective sensors provide reliable data to users. The average moisture level of 70% is achieved and a 6.4 pH value is obtained for the crop soil. The collected data is visualized via the smartphone application for real-time monitoring. This proposed IoT system can improve the quality of soil resources and reduce the extra use of water and fertilizers.

Keywords: Smart farming, Soil pH, Soil NPK, IoT, Microcontroller.

1. Introduction

Agriculture is the main foundation of human development. Humans have been practising farming as a way to secure life's basic needs. Vegetable crops are considered an essential segment of human food. The aim to secure food and increase its productivity has become hard nowadays due to some recent issues like climate change, pollution, water crisis, and high demand for food supply. The resources of irrigation, such as water and energy were not efficiently utilized by the past irrigation systems, since there is no accurate measurement to identify the time and location of where irrigation is needed caused the wastage of water and energy. Consequently, the yield of the crop will drop as well.

The current study focuses on the irrigation system which controls the soil moisture, soil nutrients, and pH parameters. However, there is a lack of systematic studies focusing on these soil parameters and the optimized locations of these sensors.

Corresponding author: suhanasultan@utm.my

Various methods of implementation have been carried out in the field of precision farming to ensure plants grow healthily. Also, a different watering system has been designed to control the irrigation of the crops. To improve the farming sector, studies first started to apply the ICT (Information and Communication Technology) technique. This technique was practical on some levels, but it is not very efficient in the long term. So currently the studies start to explore IoT (Internet of Things) as a solution for agriculture and food demand. Agriculture needs to constantly monitor the soil moisture, temperature, soil nutrients, and fertilizer to ensure a healthy crop can be produced [1].

The work conducted by N. Gondchawar and R. Kawitka [2] proposes a system to control the soil humidity, light, and temperature using sensors and a smart remote irrigation system. The research in P. Rajalakshmi and S. D. Mahalakshmi's paper [3] also proposes an automated system using humidity and moisture sensors, which collects environmental parameters such as temperature, humidity, and, moisture. This is done using wireless through the device NRF24L01 module that is placed on the field. The use of remote monitoring of the soil humidity, nutrients, and pH resources was implemented using moisture, pH, and colour sensor [4]. This system used a built-in Wi-Fi communication module to send the data to the user's smartphone. The work done in [5], also used a monitoring system for soil humidity, temperature, and light, using sensors and sending the data to the user's Laptop or smartphone. However, this study using a laptop was limited by self-irrigation and did not include the nutrients and pH parameters that are essential for vegetable growth.

The contribution of this paper is the implementation of the grid system where each grid section is sufficient in terms of monitoring and decision making. In addition, the system includes the pH and nutrients parameters sensors which are vital to monitor the usage of soil fertilizer and monitor plant growth.

2. Materials and Methods

Crop growth yield is based on soil nutrients, moisture, and pH value. Hence, three low-cost sensors are deployed in this study to monitor the grid field (120 cm x 80 cm). Data collected are sent to NodeMCU microcontroller and then to cloud through Wi-Fi or communication.

The paper presents a technique to monitor soil parameters remotely and supported by the irrigation system. The grid has a dimension of 80 cm x 120 cm, depth of (0-20) cm and carries 24 corn plants inside which are covered by the three sensors. **Figure 1** shows the architecture of the system.

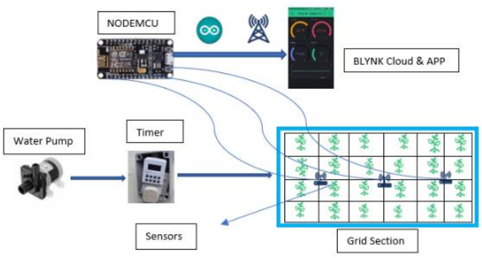


Figure 1. System Architecture.

From the system architecture, the sensors that are used are capacitive soil moisture sensor, colour sensor, and pH sensor, which measure the most relevant environmental conditions required to determine the need for fertilization and irrigation. The watering system of the project uses a water pump, tank, soaker hose, sprinkler, and timer to control drip irrigation of the plant. The irrigation process will start when the soil moisture is below the threshold value. The user will be able to monitor and control the crops via a smartphone application.

2.1 Soil Moisture

Soil moisture is referring to the amount of water in the soil, water content varies from value 0 which is dry soil to the value of saturation that is total moist soil. The amount of moisture is important to grow carrier food nutrients for plant growth, also soil water considers as a nutrient itself for the crops and it also regulates soil temperature [6].

Figure 2 shows a capacitive soil moisture sensor that measures the dielectric contrast between water and soil, where dry soils have a relative permittivity between 2-6 and water has a value of ~80. Based on the exact moisture information of the soil, it can be used to activate the watering of the plant section [6].

Figure 2:**Capacitive soil moisture sensor**

2.2 pH sensor

pH value is a measure of how acidic or basic water is. The value ranges from 0 to 14, with 7 means neutral. pH value less than 7 indicate acidity, whereas a pH greater than 7 means a base content [7].

Soil pH is considered the most informative measurement that indicates and determine soil characteristics. Many crops grow best when the pH value is close to neutral (pH 6 to7.5). Some crops grow healthy in acid or base soils. The pH sensor measures the relative amount of free hydrogen and hydroxyl ions in the water. The soil pH will be measured by the pH sensor as shown in **Figure 3**. The data will be sent to the microcontroller and server for storing[8].

This pH sensor is widely used in water quality monitoring systems. It can be used in different types of places like water tanks or tubes. The sensor has an LED that works as a power indicator, a pH sensor, a BNC connector, and a variable resistor. The sensor read an analogue signal from the content and send it to the microcontroller NodeMCU that has an ADC converter, it read the data and analyze it. The server receives the data from the NodeMCU and sends it back to the application for user monitoring [8].

Figure 3: **pH sensor**

2.3 Colour sensor

For the plant to grow healthy, the amount of nutrients on the soil must be satisfied. Some of the important nutrients are nitrogen (N) phosphorus (P), potassium (K), Sulphur (S), calcium (Ca), and magnesium (Mg).

The colour sensor (TCS3200) detects the presence of NPK, Nitrogen (N), Phosphorus (P), and Potassium (K) content in the soil. The colour sensor works by illuminating soil samples with white light and measuring the intensity of reflected light using the TCS3200 chip built in the sensor, which consists of an 8 x 8 array of photodiodes. These photodiodes absorb the reflected light from the soil sample and then convert it into the current as shown in **Figure 4.** The difference between standard absorption wavelength and the sample absorption wavelength of particular colour gives the amount of presence of nutrients as shown in **Table 1.** The NodeMCU microcontroller helps to maintain the intensity of light that is falling on the soil of the plant. The data then will be sent to the microcontroller and the server. End-user can utilize these data to monitor the required amount of fertilizers to be dispensed into the soil [9].

Table 1: The wavelength range of NPK soil and LED [10]

Nutrients	Absorption Wavelength(nm)	Colour	Standard Wavelength(nm)
Nitrogen(N)	445-485	Blue	450-495
Phosphorus(P)	505-565	Green	495-570
Potassium(K)	625-685	Red	653-700

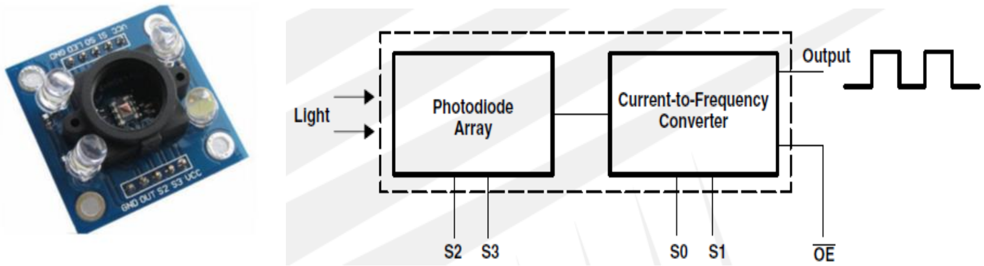


Figure 4: Colour Sensor block diagram

The data collected by the three sensors is transmitted to the server by the microcontroller NodeMCU. The data is then sent back to the smartphone installed with the Blynk application interface. This application is for monitoring, analysis, and for the user to take action.

2.3 Experiment setup

The irrigation system has been set up, by connecting sprinkler, pump, adaptor, and the soaker hose, to provide the watering to the plant. The hardware implementation is carried out by connecting the three sensors to the microcontroller as shown in **Figure 5** and **Figure 6** respectively**.**

Figure 5. Irrigation system

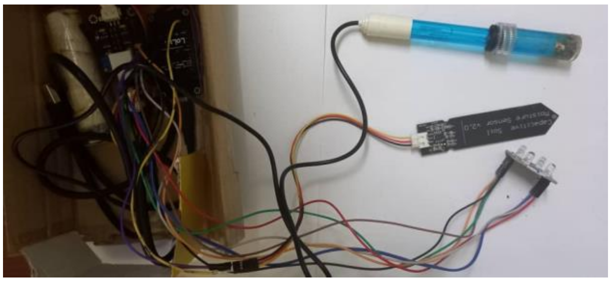


Figure 6:Hardware Connection

3. Results and Discussion

The corn plant pH level, soil moisture, and nutrients parameters are tested and monitored for three weeks to ensure the plant resources are satisfied and growing healthily. The data is collected from the soil in the grid section at different areas to get an accurate measurement. **Figure 7** shows the locations where the sensors are placed to measure target soil's parameters.

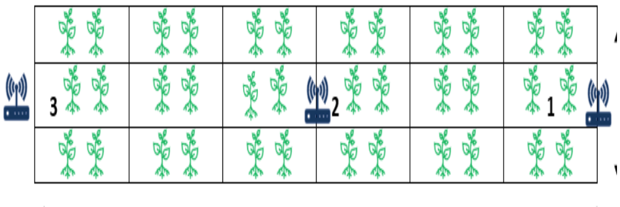


Figure 7:The data was collected from the soil grid section at three different locations.

3.1 Soil Moisture monitoring

The moisture level of the soils are measured and the threshold value is set to 45%. If the water level is below this threshold value, the soil will be considered dry.

The result showed that the plant moisture level is within the range for the corn plant to grow healthy, where moisture range from 66% to 76 %. A mean moisture level of 70% was achieved. **Figure 8** shows the chart of soil moisture levels for 3 weeks.

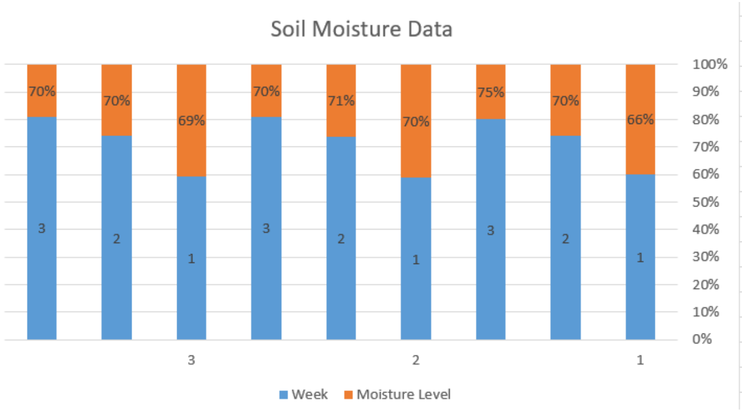


Figure 8: Soil Moisture Data

3.2 Soil pH monitoring

The pH sensor test is carried out to get the soil pH value. The test was done by getting a sample of pure water as well as water mixed with the plant soil to measure the pH difference. **Figure 9** shows the measurement of pH values in pure water and soil with water for 3 weeks. The pH values for pure water are around 6.8 which is close to the ideal value of 7.0. The pH value for the corn soil is around 6.4 which is considered within the range for the plant to grow healthy.

.

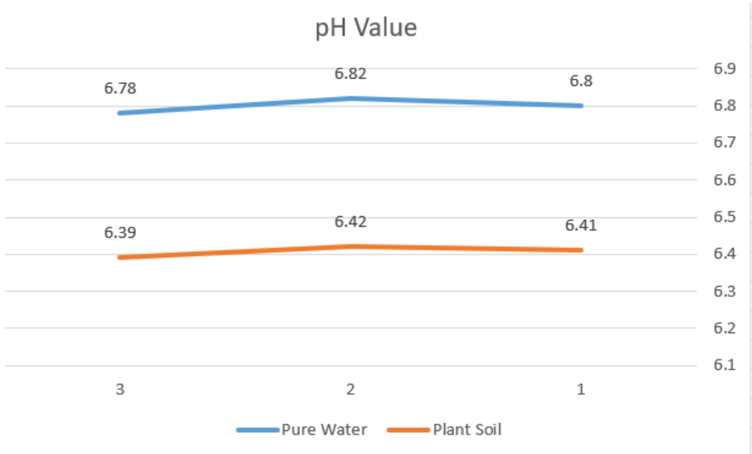


Figure 9: pH value of pure water and plant soil measured for 3 weeks

.

3.3 Soil nutrients monitoring

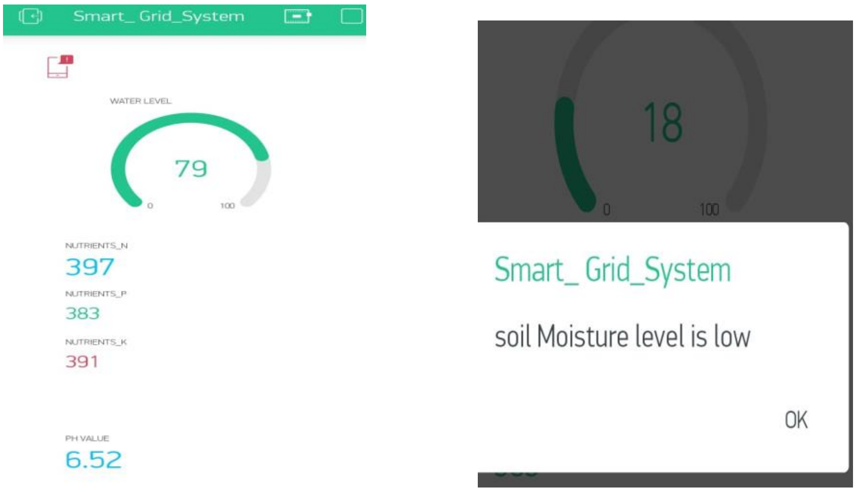
The data received from the colour sensor was used to measure the amount of nutrients in the soil. **Table 2** shows the Nitrogen(N) absorption wavelength of the amount of 397 nm, Phosphorus(P) 383 nm, and Potassium (K) with 391 nm. All the values are considered below level compared to the standard absorption wavelength for the NPK.

Table 2: NPK content into the soil

Nutrients	Absorption Wavelength(nm)	Condition
Nitrogen(N)	397	Low
Phosphorus(P)	383	Low
Potassium(K)	391	Low

3.4 User interface

The mobile application is built using the Blynk application. The data is collected by the sensors and received by the microcontroller. These data are sent to the Blynk server via Wi-Fi communication. Finally, the data is transmitted back to the application platform for visualization. **Figure 10** shows the real-time data monitoring for the moisture, pH, and nutrient levels of the soil content which the user can observe. If any of the values are below the threshold values set, the user will receive a notification on the application.



(a) (b)

Figure 10: (a) Application interface of real-time monitoring, (b) The app notification

4. Conclusion

The system using a grid system was designed and tested in various conditions. The system has the potential to monitor a large-scale land more effectively and can be implemented for another type of vegetable. The soil moisture sensor, pH sensor and colour sensor have been tested in the corn plant soil. The crops were monitored for 3 weeks and the measured data showed a valuable result, which can help to improve the overall plant yield. The data received from the sensors displayed into the Blynk application to provide real basis status about the soil conditions. The proposed system directs the users to monitor their crops remotely and make a decision correctly. This will attract more people to practice farming and contribute to solve the agriculture and food problems. In future work, the system performance could be improved by including other parameters such as temperature and light.

Acknowledgement

This research was made possible by funding from Universiti Teknologi Malaysia, faculty of engineering, school of electrical engineering.

References

[1] T. Bernatin, V. K. Sonti, and S. A. Nisha, "Smart Farming with Fertilizer Dispenser and Predictive Analysis," *Journal of Pharmaceutical Sciences and Research*, vol. 11, no. 8, pp. 2956-2958, 2019.

[2] N. Gondchawar and R. Kawitkar, "IoT based smart agriculture," *International Journal of advanced research in Computer and Communication Engineering*, vol. 5, no. 6, pp. 838-842, 2016.

[3] P. Rajalakshmi and S. D. Mahalakshmi, "IOT based crop-field monitoring and irrigation automation," in *2016 10th International Conference on Intelligent Systems and Control (ISCO)*, 2016: IEEE, pp. 1-6.

[4] S. Anand and A. Sweatha, "Monitoring of Soil Nutrients Using Iot for Optimizing the Use of Fertilizers," *Int. J. of Science, Eng. and Technology Res*, vol. 8, no. 4, pp. 105-107, 2019.

[5] J. Doshi, T. Patel, and S. kumar Bharti, "Smart Farming using IoT, a solution for optimally monitoring farming conditions," *Procedia Computer Science*, vol. 160, pp. 746-751, 2019.

[6] J. Hrisko, "Capacitive Soil Moisture Sensor Theory, Calibration, and Testing," *no*, vol. 2, pp. 1-12, 2020.

[7] D. Neina, "The role of soil pH in plant nutrition and soil remediation," *Applied and Environmental Soil Science*, vol. 2019, 2019.

[8] S. Kumar and R. Thakur, "Soil pH Sensing Techniques and Technologies," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 4, no. 5, pp. 1-3, 2015.

[9] E. Wierzbicka, "Novel methods of nitrate and nitrite determination-a review," *Journal of Elementology*, vol. 25, no. 1, 2020.

[10] M. Masrie, M. S. A. Rosman, R. Sam, and Z. Janin, "Detection of nitrogen, phosphorus, and potassium (NPK) nutrients of soil using optical transducer," in *2017 IEEE 4th international conference on smart instrumentation, measurement and application (ICSIMA)*, 2017: IEEE, pp. 1-4.