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A Fertilizer Monitoring System for Fertigation Using IoT Platform

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Abstract

The Internet of Things (IoT) technology has revolutionized various sectors, including agriculture. By integrating IoT, sensors, and fertigation techniques, an intelligent system can be created, where the system will automate the fertigation process and adapt it dynamically based on environmental factors and plant needs. However, the uncontrol concentration value of fertilizer in fertigation planting systems becomes an issue. Thus, it is proposed to develop an automated fertilizer control for fertigation monitoring systems. This system controls the fertilizer and water supply using NodeMCU ESP32 microcontroller. A chilli paper plantation was used as a test plant where its temperature and moisture were monitored using NodeMCU ESP32 and Blynk application. The information received will be analyzed and uploaded to the Blynk platform. The result shows that the NodeMCU ESP32 is able to control the fertilizer and water supply, meanwhile, the user can monitor the temperature, moisture and water through the IoT platform that was displayed on Blynk application.

1. Introduction

Fertigation is the application of fertilizers through irrigation systems and is the most advanced and efficient practice of fertilization. A drip system is the most adopted and effective way of fertigation for efficient use of fertilizer and irrigation water. Fertigation remarkably improves fertilizer and water use efficiency with higher crop yield and quality [1]. In Malaysia, a manual method is used to control the fertilizers which is the farmer measures the fertilizer into a bottle by waiting for the fertilizer drip and time is taken to estimate for crop fertilize. Fertilizers were mixed in separate tanks and this method consumes time and energy. Furthermore, the farmer needs to take a reading of the fertilizer concentration and pH value to maintain the quality of the plant [2].

The innovation and past studies in the fertigation automated system are focused on monitoring and mixing the fertilizer [3]. Overall studies found that most studies cannot control the fertilizers given for suitable soil which can affect the plant cycle. For example, all crops need a suitable amount of fertilizer and follow the schedule.

The system mostly needs to control and maintain the concentration and level of fertilizer given for the fertigation system with the use of cocopeat soil. Thus, the A Fertilizer Monitoring System for Fertigation using an IoT Platform is proposed to overcome this problem.

2. Methodology

The outcome of this proposed system is to get the reading of the moisture sensor, amount of fertilizer and water level. The temperature, humidity, soil moisture and amount of fertilizer will be monitored and the real-time data displayed on the Blynk Platform.

Fig.1 shows the circuit sketch diagram of how the microcontroller works. When the microcontroller is powered up, the monitoring input, temperature sensors and humidity sensors will start to read the soil conditions and send the data to the microcontroller to be processed. The status of soil conditions will be uploaded and displayed to the IoT platform, Blynk App.

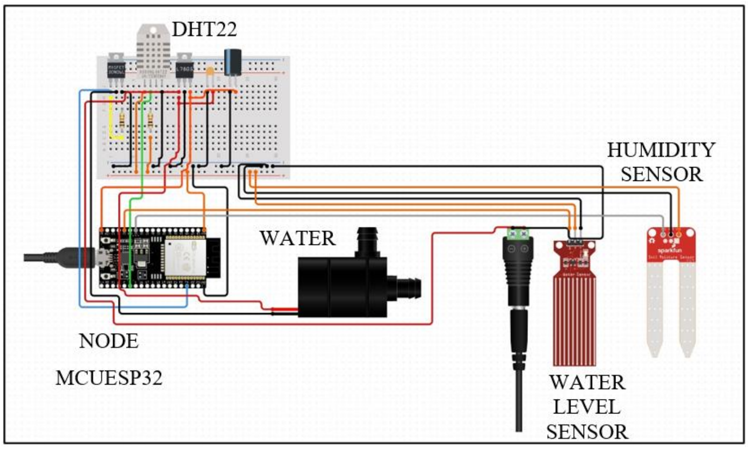


Fig. 1 *Circuit Sketch Diagram of A Fertilizer Monitoring System for Fertigation using IoT Platform.*

Fig. 2 illustrates the block diagram of the system. Once the user selects the plant cycle on the user devices, the data will be sent to the microcontroller (NodeMCU ESP32). Then, the fertilizer level sensor controls the fertilizer pump to fertilize the soil. The displayed output will be shown in the IoT platform which can be accessed by any smart device. The application of using the NodeMCU ESP32 microcontrollers is better that the Arduino IDE, CX-Programmer, PLC and Arduino Controller is due to it's processing power, which is, the NodeMCU ESP32 could provide more computational power compared to the Arduino due to it's dual-core microcontrollers with a clock speed of up to 240MHz. Moreover, when it comes to the connectivity, ESP32 comes with built-in WI-FI and Bluetooth, making it much easier to connect with IoT applications, specifically Blynk Apps compared to other microcontrollers.

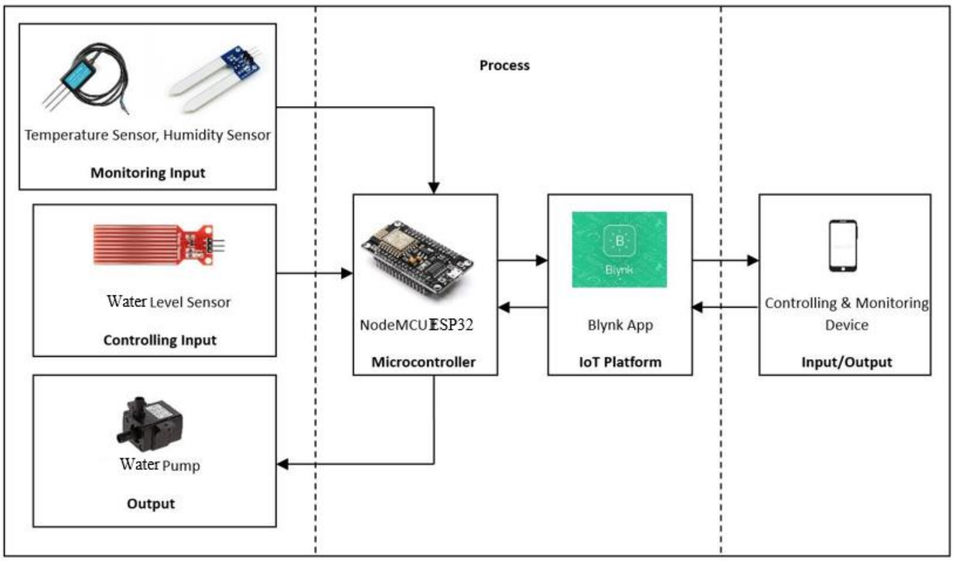


Fig. 2 *Block Diagram of A Fertilizer Monitoring System for Fertigation using IoT Platform.*

Meanwhile, for the application of the sensors, which is DHT22 humidity sensors were used instead of other sensors, as mentioned in Table 2.6 : The comparison of sensors, is due to it's high accurancy which, the DHT22 provide precise temperature and humidity measurement with an accurancy of +/- 0.5°C for temperature and +/-

2% for humidity, with a wide operating range, that operates from -40˚C to 80˚C, making it suitable for various environments, and the outputs data were in a digital format, that make it easy to integrate with microcontollers and other devices. Other than this factors, comparing the other sensors, specifically in the measurements of humidity, Resistive Soil Humidity Sensor are known to its limited accurancy and are not suitable for long-term use. Next, the Capacitive Soil Humidity Sensors are not suitable to be use is due to it's disadvantages that the sensors may be affected by soil salinity and requires regular calibration. Lastly, for Water Level Sensor, Temperature Sensors LM35, and Ultrasonic Sensor are not suitable for measuring humidity or temperature, duie to it's unsuitable systems to measure both the humidity or temperature.

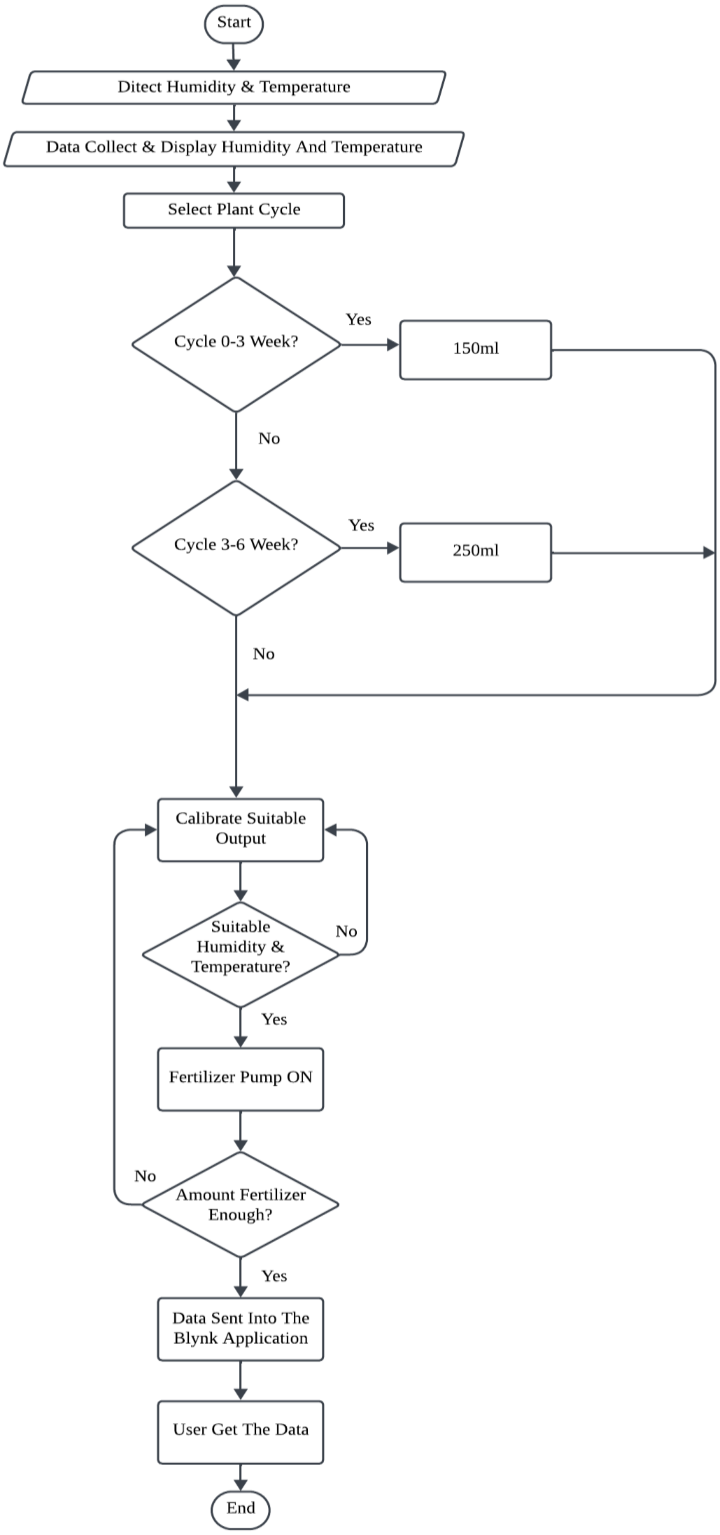


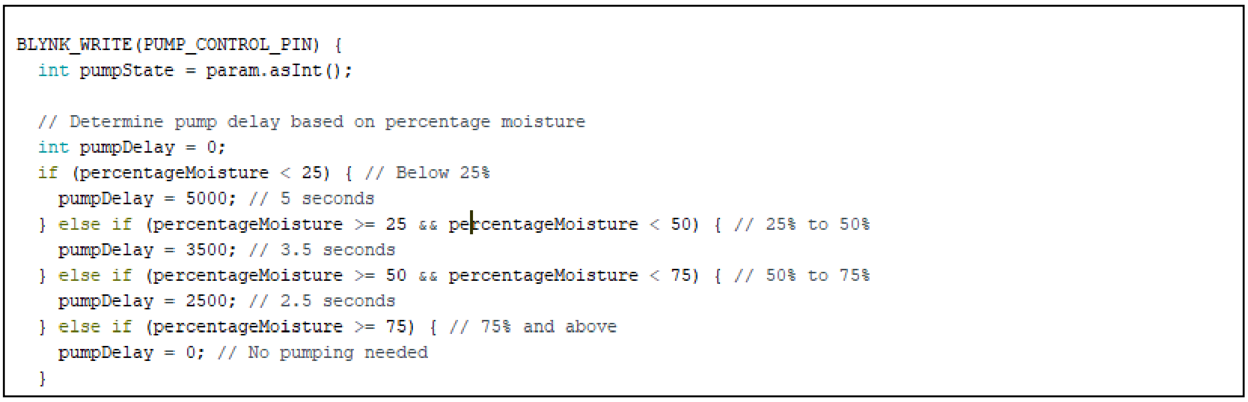
Fig. 3 *Flowchart of A Fertilizer Monitoring System for Fertigation using IoT Platform.*

In summary, the DHT22 Humidity Sensor are better in the Fertigation System due to its high accurancy, wide operating range, digital output and low power consumptions that can provide comprehensive environmental monitoring.

The system implementation involves configuring and connecting the sensors and microprocessor to the relevant input and output devices, as shown in Fig. 3. This workflow details the process which accurately reads the sensor data and handles any errors during initialization.

3. Results and Discussion

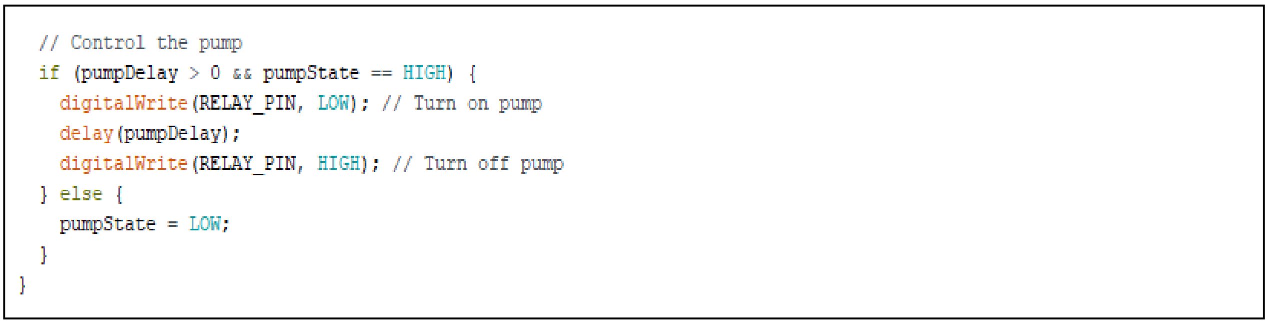
The source code in Fig. 4 shows the generated code by the Arduino IDE platform based on the parameters that have been set up. The main component which is the fertilizer pump will be working based on the reading that the NodeMCU ESP32 received and will send the impulse to the relay from the microcontroller based on the main coding that has been uploaded. Fig. 5, on the other hand, shows the coding to connect the microcontroller input (NodeMCU ESP32 with the Blynk platform) to transmit the output to the respected server. The codes were generated to create cloud variables that have the *Water Pump Control Pin* enabled. The code in this function will run each time the variable is activated from the cloud. To note, most of the code from the *loop( )* does not always operate and only runs as needed.



```
BLYNK_WRITE(PUMP_CONTROL_PIN) {
  int pumpState = param.asInt();

  // Determine pump delay based on percentage moisture
  int pumpDelay = 0;
  if (percentageMoisture < 25) { // Below 25%
    pumpDelay = 5000; // 5 seconds
  } else if (percentageMoisture >= 25 && percentageMoisture < 50) { // 25% to 50%
    pumpDelay = 3500; // 3.5 seconds
  } else if (percentageMoisture >= 50 && percentageMoisture < 75) { // 50% to 75%
    pumpDelay = 2500; // 2.5 seconds
  } else if (percentageMoisture >= 75) { // 75% and above
    pumpDelay = 0; // No pumping needed
  }
```

Fig. 4 *Code snippet for water pump control based on humidity level*



```
  // Control the pump
  if (pumpDelay > 0 && pumpState == HIGH) {
    digitalWrite(RELAY_PIN, LOW); // Turn on pump
    delay(pumpDelay);
    digitalWrite(RELAY_PIN, HIGH); // Turn off pump
  } else {
    pumpState = LOW;
  }
}
```

Fig. 5 *Cloud Variable Function (Button for water pump)*

As shown in Fig 6, the device setup configuration was made in Blynk template settings. In the *Home* overview, the user can choose: the device to use, the type of Wi-Fi network to connect, and create variables that the user can monitor and control. *Widgets* act as an indicator to show the status of fertigation. The information indicates that fertigation information such as humidity, temperature, water tank level, etc. Fig. 7 shows the dashboard interfaces that were built to make it easier for users to access their fertigation monitoring and fertilize schedule.

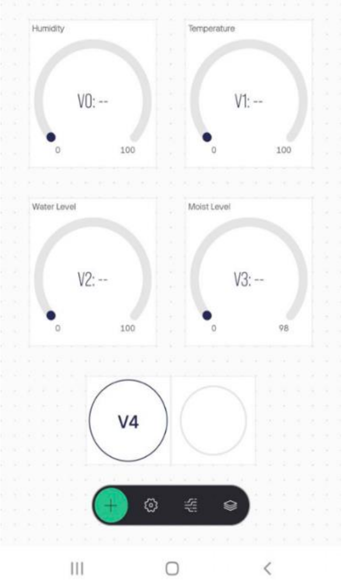


Fig. 6 *Information Widgets*

Fig. 7 *Dashboard interface*

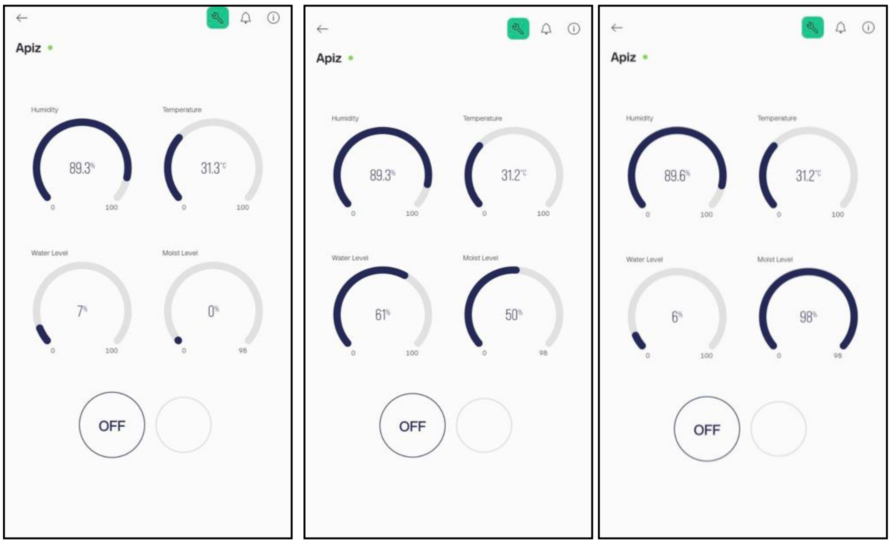


Fig. 8 *Moisture indicator on the dashboard*

Fig. 9 *Observation of water pump based on moisture indicator*

As shown in Fig. 8, the information of moisture in the fertigation cup was detected, thus, the information data sent the sign to the microcontroller to process the data and display the status of the fertigation plant (through percentage of moisture) on the user mobile phone. Fig. 9 was the output from the percentage of moisture that needed the amount *ml* water to moisturise the fertigation, which, an automated fertilizer control for a fertigation monitoring systems are able to monitor the temperature, moisture and water level, and were being read in the IoT platforms, which is Blynk Apps. Fig. 10 shows the output based on more precise data percentage of moisture collected, which the output results are the amount of water pump *millilitre* and the fertilizer indications signal, this signal indicated the functionality and efficiency of the system in monitoring and controlling fertilizer, and indicate how the microcontroller NodeMCU ESP32 operated in control the fertilizer and water supply, by the user, using Blynk Apps.

Moisture (%)	Fertilizer Needed	Water Pump (ml)
0	Full	150
15	Full	150
25	Full	150
48	Half	100
50	Half	100
65	Half	100
75	No Fertilizer Required	0
84	No Fertilizer Required	0
98	No Fertilizer Required	0

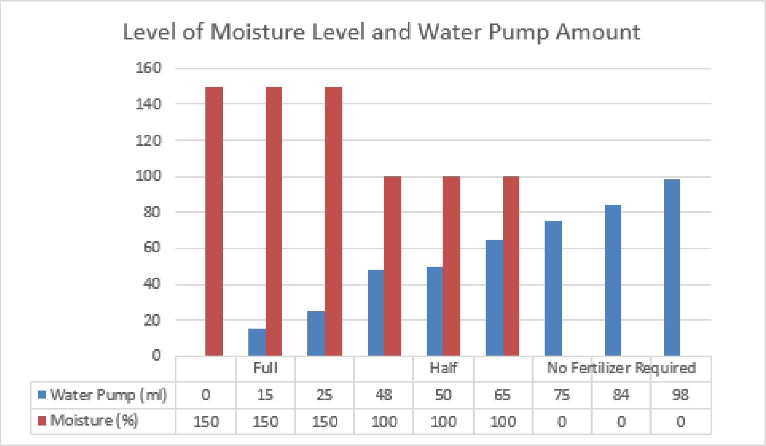
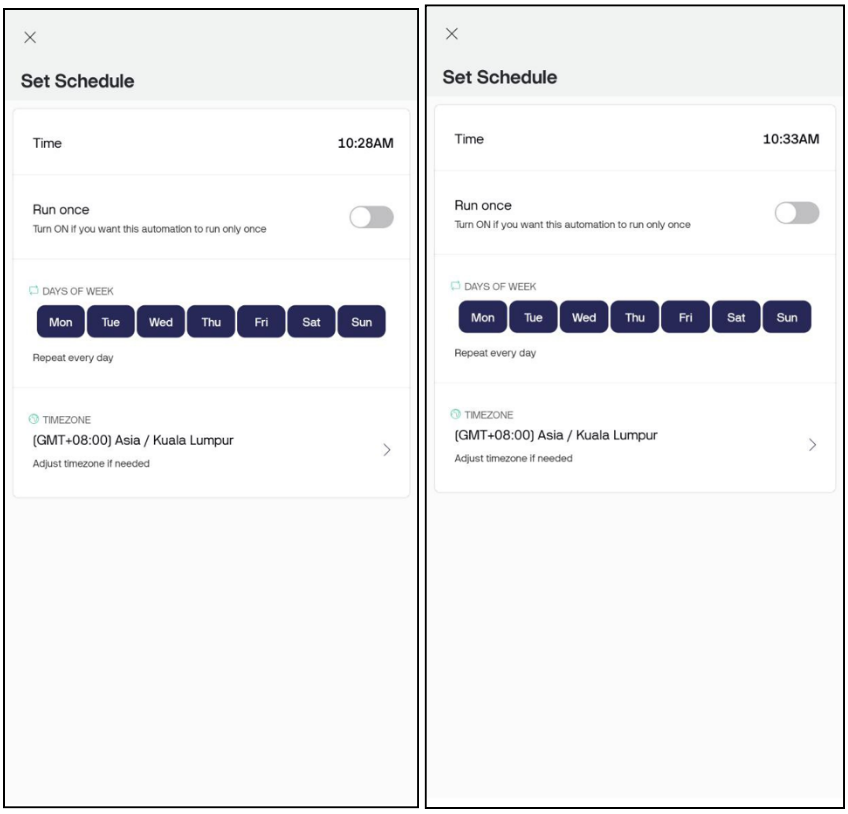


Fig. 10 *Level of Moisture Level and Water Pump Amount*

Fig. 11 shows the time situation that was manually set up by the users, which, will trigger the microcontroller to collect data of moisture in the fertigation cup and display the moisture level on the dashboard, as shown in Fig 12. Fig. 13 shows the output based on more precise data of time setup collected, which the output results are the moisture level percentage and water pump. The completed circuit connection is shown in Fig. 14.



Set Schedule

Time 10:28AM

Run once
Turn ON if you want this automation to run only once

DAYS OF WEEK
Mon Tue Wed Thu Fri Sat Sun
Repeat every day

TIMEZONE
(GMT+08:00) Asia / Kuala Lumpur
Adjust timezone if needed

Set Schedule

Time 10:33AM

Run once
Turn ON if you want this automation to run only once

DAYS OF WEEK
Mon Tue Wed Thu Fri Sat Sun
Repeat every day

TIMEZONE
(GMT+08:00) Asia / Kuala Lumpur
Adjust timezone if needed

Fig. 11 *Observation of Time Setup*

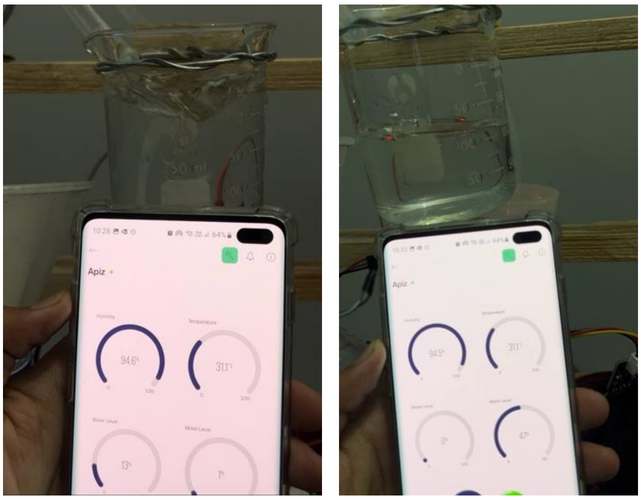


Fig. 12 *Moisture indicator on the dashboard based on the observation of time*

Time	Moisture Level (%)	Water Pump (ml)
10.28 am	0	150
10.30 am	20	150
10.31 am	25	150
10.33 am	48	100
2.38 pm	57	100
3.00 pm	65	100
3.01 pm	75	0
3.02 pm	85	0
3.05 pm	98	0
6.50 pm	35	100
9.30 pm	23	150

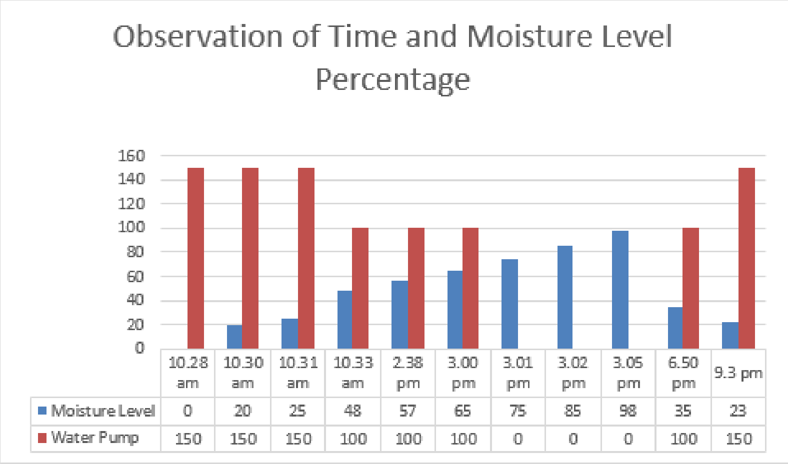


Fig. 13 *Observation of Time and Moisture Level Percentage*

Fig. 14 *Completed Circuit Connection*

4.0 Conclusion

In conclusion, to achieve the project's objective, the sketching and calculation of all essential parts were done based on the project's primary function. A Fertilizer Monitoring System for Fertigation using IoT Platform was assembled by using several essential components. The combination of the Prototype of A Fertilizer Monitoring System for Fertigation using IoT Platform has helped the project to achieve the first objective. Blynk App has been used as a medium between users and devices. Blynk App provides a simple interface and easy steps for users to connect the devices to the cloud server. The benefit has helped to achieve the second and third objective which are to use the Blynk App as a medium and the use of electronic devices on projects such as monitoring fertigation and capacitive soil moisture sensors to control fertilize the fertigation and also virtual components to interact with each other in the IoT system. After the project was successfully developed, various verification was performed. This is to determine whether the system can achieve the third objective, which is to verify the functionality of the project in monitoring and control fertilize of fertigation through the IoT system. After several trials, this system was able to control fertilize amount by using a soil moisture sensor as a control element through IoT Cloud Remote. Thus, the third objective was successfully achieved. In this module, the types of crops are solely on Chilli peppers due to it's advantages of easy to grows, and take less hustle. But, for future, it's better to create scalable solutions that can easily customized for different types of crops and farm sizes to make it more accessible to a boarder range of farmers to make it affordable by providing the smal-scale farmers to access of the advanced agricultural technologies.

Acknowledgment

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Conflict of Interest

The errors and limitations during the trials are connectivity problems, which came from the WI-FI or Bluetooth connectivity that disrupt the communication between the NodeMCU ESP32, and the Blynk App, leading the data loss or delays. Other than that, the malfunctioning components especially the water level sensor and the 12V water pump, that affecting the system's performances.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Muhammad Hafiz Bin Ishak, Tasiransurini Binti Ab Rahman;* ***data collection:*** *Muhammad Hafiz Bin Ishak;* ***analysis and interpretation of results:*** *Muhammad Hafiz Bin Ishak;* ***draft manuscript preparation:*** *Muhammad Hafiz Bin Ishak, Tasiransurini Binti Ab Rahman. All authors reviewed the results and approved the final version of the manuscript.*

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