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Design of a Smart Farming Monitoring System Leveraging Internet of Things Technology: Application of the NPKTHCPH -S Sensor

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Abstract

Shallot plants are currently widely cultivated, but cultivation is still done manually to control soil conditions. For this reason, with a monitoring system using the NPKTHCPH-S sensor, which can show seven parameters of soil conditions using only one sensor, it is hoped that it will make it easier to see the appropriate soil content and required shallot plants according to the criteria for good shallot plant growth, so that plant growth shallots become more optimal and avoid crop failure. The smart farming monitoring system prototype uses the NPKTHCPH-S sensor, which was developed using the Blynk application by implementing several components such as the NPKTHCPH-S sensor, ESP32, Relay 3.3, RS485-TTL Converter. The NPKTHCPH-S sensor is a reader of soil water content, electrical conductivity, temperature, nitrogen, phosphorus, potassium, and pH in shallot soil. The results obtained from the NPKTHCPH-S sensor test were the most significant seen at 2 pm found a temperature value of 35.6oC with a humidity of 50.7%. And at 11 pm it was found that the temperature was 28.4oC with a humidity of 58.6%. The values for N, P, K, and Conductivity were constant for 9 hours of testing, namely for N was 170mg/kg, for P was 439mg/k, for K was 434mg/k, and conductivity was 1000uS/cm.

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Keywords— *Smart Faming, NPKTHCPH-S Sensor, ESP32, Shallot Plants*

1. INTRODUCTION

This Indonesia is known as a country with strong economic strength, which is supported by the agricultural sector. One of the technological developments observed in the agricultural sector is the use of the concept of smart farming. The Ministry of Agriculture (Kementan) continues to emphasize the importance of implementing smart agriculture to increase the productivity and quality of the agricultural sector while facing future challenges. [1][2][3][4]. Shallot (Allium ascalonicum L.) is a horticultural crop that has high economic value and is an agricultural commodity that plays an important role in Indonesia [5][6][7]. Dominant shallots grow in the lowlands with a dry climate, warm temperatures, and sunny weather [8][9][10][11]. At present, many farmers plant shallots, but cultivation is still done manually to control humidity or soil conditions, whereas for shallots, soil moisture really needs to be considered because it will have an impact on crop yields [12][13][14]. Farmers also still carry out traditional irrigation systems, thereby reducing their effectiveness [15][16][17].

From these problems, an innovative system was created to be able to detect parameters in the soil and to be able to adjust the irrigation system for shallot plants to make it more efficient. This system uses the NKTHCPH-S sensor, which functions to read soil water content, electrical conductivity, temperature, nitrogen, phosphorus, potassium, and pH. where the sensor will be processed through the ESP32 microcontroller system[18][19][20], which is then sent to the Blynk application. Furthermore, the Blynk application will display data from parameters that can be read by the NPKTHCPH-S sensor on onion plants. With this tool and system, it is hoped that it can monitor and provide information regarding whether or not onion plants need water with the NPKTHHCPH-S sensor and also PVC water flow, which functions to control irrigation sources according to their needs. When the onion plants are in a water shortage condition, the system will control the mini water pump to fill it, and when the water condition is full, the system will control the mini water pump to be inactive.

2. RESEARCH METHODOLOGY

2.1 Block Diagram System

The block diagram explains the system workflow regarding the Internet of Things-Based Smart Farming Monitoring System. Figure 1 is a block diagram system that consists of three parts: the input section, the process section, and the output section.

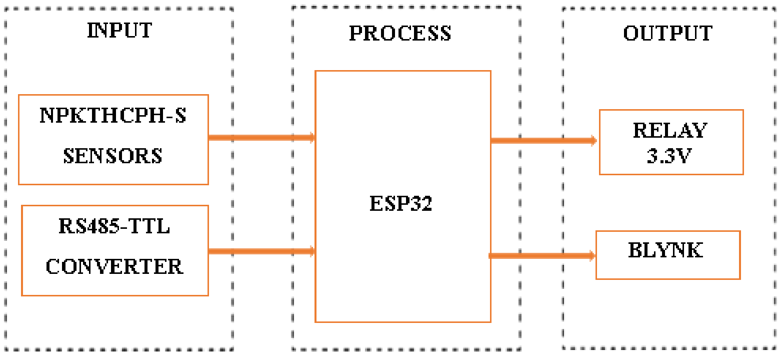


Figure 1. Block Diagram System

On the input side, it consists of an NPKTHCPH-S sensor with parameters (Temperature, Humidity, EC, pH, Nitrogen, Phosphorus, and potassium) and an RS485-TTL converter, which will be processed by the ESP32 as a microcontroller. The ESP32 will read data from the NPKTHCPH-S sensor equipped with wireless access (the internet). The ESP32 side and the Blynk application will communicate with each other to send and receive information. On the output side, the data obtained from the ESP32 will be displayed on the Blynk application, which gives readings on seven parameters.

2.2 Flowchart System

The flowchart explains the flow of the entire system process that will be made in a tool design. Figure 2 is a flowchart diagram from the Final Project using several algorithms to regulate the work of the system.

First, the power is turned on to turn on the monitoring system device. The ESP32 works to read the soil content of the NPKTHCPH-S sensor and prints soil water content, electrical conductivity, temperature, nitrogen, phosphorus, potassium, and pH. Then each piece of data received by the ESP32 from the NPKTHCPH-sensor S will be sent through the internet network in real time and displayed on the Blynk application on the smartphone.

1. Start, is the starting condition for conducting initial monitoring of the NPKTHPH-S sensor.
2. Hardware initialization, is the process of automatically controlling the condition of the NPKTHCPH-S sensors and ESP32 used.
3. ESP32 works to read the soil content of the NPKTHCPH-S sensor, which prints soil water content, electrical conductivity, temperature, nitrogen, phosphorus, potassium, and pH in shallot plants, which are then forwarded to the Blynk application via the internet network to display data in real time

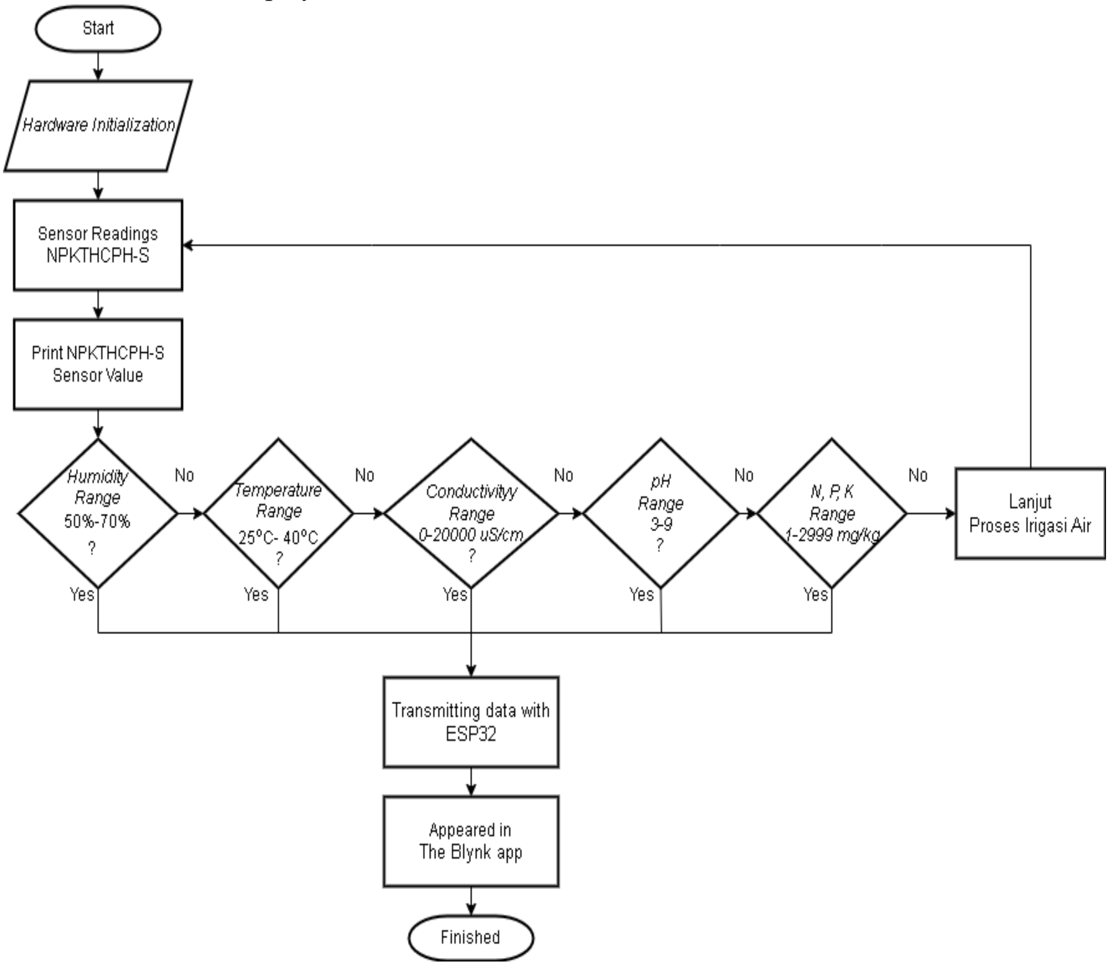


Figure 2. Flowchart System

The figure below will show a program sketch based on a flowchart system. Figure 3 shows the sketch program for reading the NPKTHPH-S sensor. Figure 4 is a sketch program for printing NPKTHCPH-S sensor values. Figure 5 is the Sketch program display for sending data to the Blynk virtual pin code.

```
#define RXD2 16 // ESP32 Serial2 RX2 pin
#define TXD2 17 // ESP32 Serial2 TX2 pin
#define Modbus Serial2 // RS485/Modbus communication using ESP32 Serial2
//Request or read humidity, temperature, conductivity, PH, N, P, and K values via RS485/Modbus
const byte req_fc03_soilParam[8] = { 0x01, 0x03, 0x00, 0x00, 0x00, 0x07, 0x04, 0x08 };
//Response humidity, temperature, conductivity, PH, N, P, and K values via RS485/Modbus
byte resp_fc03_soilParam[19] = { 0 };
//Variables used to store humidity, temperature, conductivity, PH, N, P, and K values
int16_t cond, n, p, k;
//Variables used to store humidity, temperature, conductivity, PH, N, P, and K values
float hum, temp, ph;
unsigned long npkLoopCnt = 0; // control looping task
// Modbus Request/Request Data to NPKTHCPH-S sensor
  if (Modbus.write(req_fc03_soilParam, 8) == 8) {
    Serial.print("Modbus Response: ");
    for (int i = 0; i < 19; i++) {
      // Serial.printf("%02X ", Modbus.read());
      resp_fc03_soilParam[i] = Modbus.read();
      Serial.printf("%02X ", resp_fc03_soilParam[i]);
    }
```

Figure 3. Sketch Program Reading the NPKTHCPH-S Sensor

```
      // store Modbus data to assigned variables code BEGIN
      Serial.println();
      if (npkLoopCnt > 0) {
        addr = resp_fc03_soilParam[0];
        fc = resp_fc03_soilParam[1];
        numofbyte = resp_fc03_soilParam[2];
        hum = 0.1 * convertFrom8To16(resp_fc03_soilParam[3], resp_fc03_soilParam[4]);
        temp = 0.1 * convertFrom8To16(resp_fc03_soilParam[5], resp_fc03_soilParam[6]);
        cond = convertFrom8To16(resp_fc03_soilParam[7], resp_fc03_soilParam[8]);
        ph = 0.1 * convertFrom8To16(resp_fc03_soilParam[9], resp_fc03_soilParam[10]);
        n = convertFrom8To16(resp_fc03_soilParam[11], resp_fc03_soilParam[12]);
        p = convertFrom8To16(resp_fc03_soilParam[13], resp_fc03_soilParam[14]);
        k = convertFrom8To16(resp_fc03_soilParam[15], resp_fc03_soilParam[16]);
        crc = convertFrom8To16(resp_fc03_soilParam[17], resp_fc03_soilParam[18]);
        Serial.printf("Humidity: %.1f %%RH\n", hum);
        Serial.printf("Temperature: %.1f degC\n", temp);
        Serial.printf("Conductivity: %d us/cm\n", cond);
        Serial.printf("PH: %.1f\n", ph);
        Serial.printf("Nitrogen: %d mg/kg\n", n);
        Serial.printf("Phosphorus: %d mg/kg\n", p);
        Serial.printf("Potassium: %d mg/kg\n", k);
        Serial.println();
      }
    }
```

Figure 4. Sketch Program Printing NPKTHCPH-S sensor values

```
      // send/write data to Blynk virtual pin code BEGIN //
      Blynk.virtualWrite(V0, hum);
      Blynk.virtualWrite(V1, temp);
      Blynk.virtualWrite(V2, cond);
      Blynk.virtualWrite(V3, ph);
      Blynk.virtualWrite(V4, n);
      Blynk.virtualWrite(V5, p);
      Blynk.virtualWrite(V6, k);
      Blynk.virtualWrite(V7, mlPerMinute);
      Blynk.virtualWrite(V8, pumpStatus[pumpState]);
      // send/write data to Blynk virtual pin code END //
```

Figure 5. Sketch Program Sending Data To Blynk

2.3 Mechanical Design

In the mechanical design, namely, designing a prototype of the Internet of Things-Based Smart Farming Monitoring System tool with a size of 60cm by 30cm by 15cm. Inside the box are all the components used, such as the NPKTHCPH-S sensor, RS485-TTL Converter, ESP32, 3.3 volt relay module, YF-S401 pvc water flow, mini water pump, and water. For power supply using a 5 volt and 9 volt power supply adapter. Shallot plants are placed on the front of the box. Figure 6 is the mechanical design of the prototype.

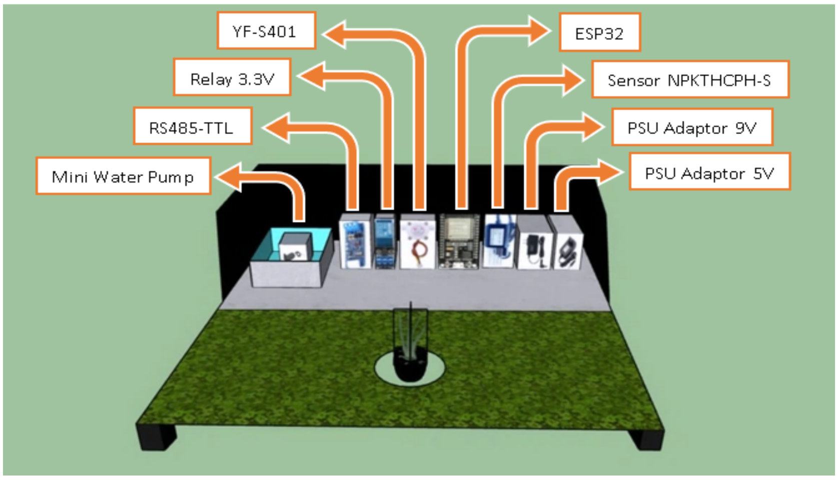


Figure 6. Design Prototype

2.4 Electrical Design

Electrical design is a series of block diagrams that support each other. 9 volts is used for the ESP32 and NPKTHCPH-S Sensor. ESP32 as a microcontroller that is connected to WiFi to receive and also process data that will later be displayed by the Blynk application. There is an NPKTHCPH-S sensor that functions to read seven parameters in the soil, namely humidity, temperature, conductivity, pH, nitrogen, phosphorus, and potassium parameters.

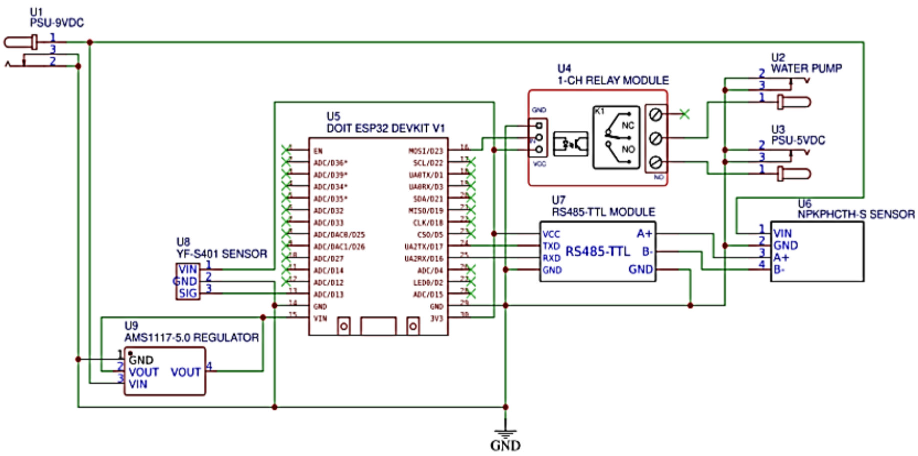


Figure 7. Schematic Diagram

Figure 7 the design an internet of things-based smart farming monitoring system. The ESP32 uses four pins, namely D13, D23, D17, and D16.

- The ESP32 gets voltage from a 9-volt adapter power supply.
- The NPKTHCPH-S sensor has four connections, namely the yellow cable to RS485 A+, the blue cable to RS485 B-, the brown cable to the 9-volt power supply adapter, and the black cable to ground.
- Pins D17 and D16 are Tx and Rx, which are in charge of sending and receiving data to be read by the NPKTHCPH-S sensor.
- Pin D13 is connected to the water flow sensor signal leg (YF-S401), and for the Vin leg, it is connected to a 3.3V relay.

- Pin D23 is connected to a 3.3V relay, where the NO pin is connected to the 5V adapter power supply and the COM pin to the mini water pump terminal.

3. RESULTS AND DISCUSSION

3.1 NPKTHCPH-S Sensor Validation Test

Sensor validation testing is a test to see whether the NKTHCPH-S sensor is functioning or not. Testing by looking at the Tx and Rx values using the "Config Tool" application. If the Tx and Rx values are read, then the sensor is working, and if only one of them is read, then the sensor has a problem. The following are the steps carried out in the sensor validation test :

1. Connecting sensors to PC
2. Read the value for "Slave ID"
3. Setting parameters

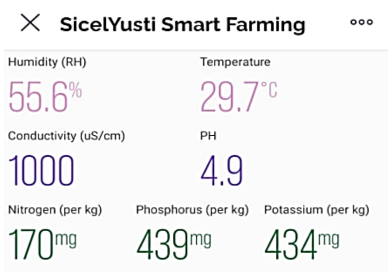
In the sensor validation test that has been carried out, it can be seen that the Tx and Rx values are read in each test. Because of this test, it can be concluded that the NPKTHCPH-S sensor can function properly.

3.2 NPKTHCPH-S Sensor Testing on Shallot Plants

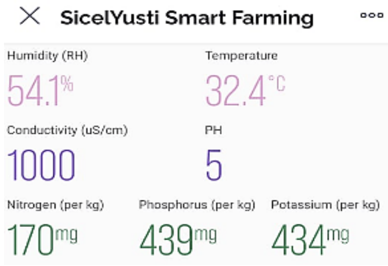
Testing of the NPKTHCPH-S sensor was carried out for 5 minutes once every 9 hours (from 11.00 to 23.00). Table 1 shows the test results that have been divided from the 110 data points obtained.

Table 1. NPKTHCPH-S Sensor Testing

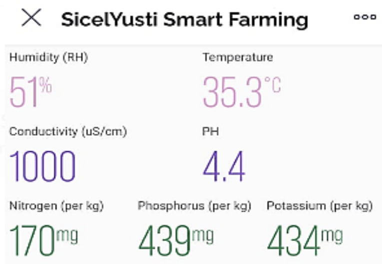
Time	Humidity(%)	Temperature(ºC)	Conductivity (uS/cm)	H			
					(mg/kg)		
11 am	55.6	29.7	1000	.9	70	39	34
Proof of Blynk Application Data							



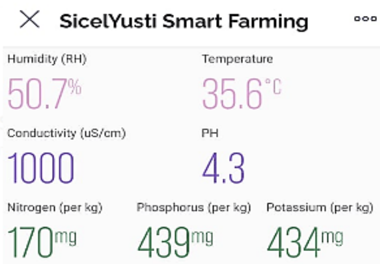
Time	Humidity(%)	Temperat ure (ºC)	Conducti vity (uS/cm)	H			
					(mg/kg)		
12 pm	54.1	32.4	1000	5	70	39	34
Proof of Blynk Application Data							



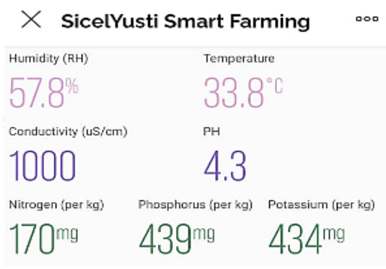
Time	Humidity (%)	Temperature(°C)	Conductivity (uS/cm)	H		(mg/kg)	
1 pm	51	35.3	1000	4	70	39	34
Proof of Blynk Application Data							



Time	Humidity (%)	Temperature (°C)	Conductivity (uS/cm)	H		(mg/kg)	
2 pm	50.7	35.6	1000	3	70	39	34
Proof of Blynk Application Data							

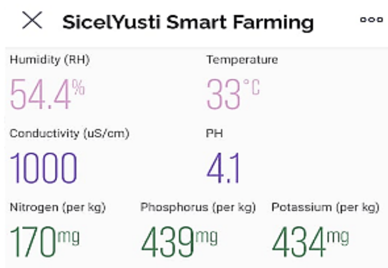


Time	Humidity(%)	Temperature(°C)	Conductivity (uS/cm)	H		(mg/kg)	
3 pm	57.8	33.8	1000	3	70	39	34
Proof of Blynk Application Data							



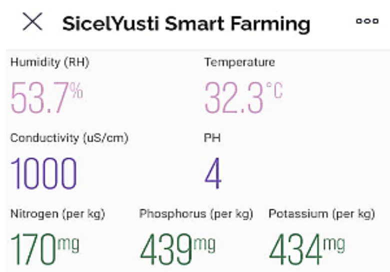
Time	Humidity(%)	Temperature(°C)	Conductivity (uS/cm)	H			
					(mg/kg)		
4 pm	54.4	33	1000	.1	70	39	34

Proof of Blynk Application Data



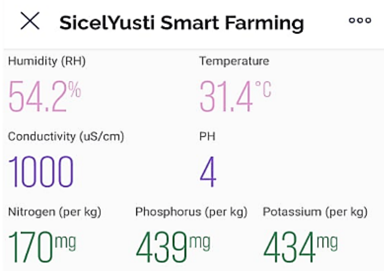
Time	Humidity(%)	Temperature(°C)	Conductivity (uS/cm)	H			
					(mg/kg)		
5 pm	53.7	32.3	1000	4	70	39	34

Proof of Blynk Application Data



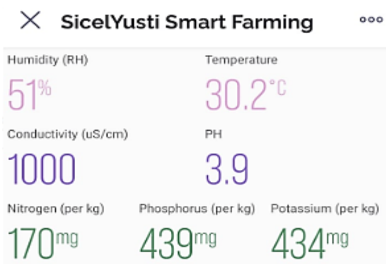
Time	Humidity(%)	Temperature(°C)	Conductivity (uS/cm)	H			
					(mg/kg)		
6 pm	54.2	31.4	1000	4	70	39	34

Proof of Blynk Application Data



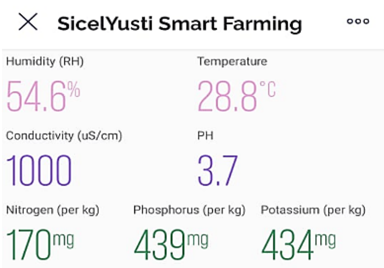
Time	Humidity(%)	Temperature(°C)	Conductivity (uS/cm)	H			(mg/kg)
7 pm	51	30.2	1000	9	70	39	34

Proof of Blynk Application Data



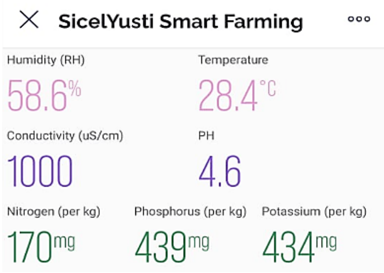
Time	Humidity(%)	Temperature(°C)	Conductivity (uS/cm)	H			(mg/kg)
10 pm	54.6	28.8	1000	7	70	39	34

Proof of Blynk Application Data



Time	Humidity(%)	Temperature(°C)	Conductivity (uS/cm)	H			(mg/kg)
11 pm	58.6	28.4	1000	6	70	39	34

Proof of Blynk Application Data



Data Analysis

Based on the results of the NPKTHCPH-S sensor testing that has been carried out, it can be analyzed : The most significant data points are at 2 pm and 11 pm. Where, at 2 pm, the temperature is 35.6 oC with a humidity of 50.7%. And at 11 pm for a temperature of 28.4 oC with a humidity of 58.6%. This shows that the temperature affects the humidity value of the shallot soil. This is because the values obtained show that when the air temperature is hot, the soil moisture decreases, and vice versa when the air temperature is cold, the soil moisture increases. According to the Department of Food Security, Food Crops, and Horticulture, good soil moisture for cultivating shallots is 50%–70%. So, with this sensor, we can find out whether the soil in shallot plants has enough moisture or not so that the humidity is maintained in a stable range for shallot cultivation.

The average value for the pH of the shallot plants tested was 4.3. According to the Office of Food Security, Food Crops, and Horticulture, the criteria for shallot cultivation are soil pH ranging from 5.6–6.5. The soil used in the shallots tested is organic soil, but the soil conditions in the shallots are still acidic. According to the Agriculture and Food Service, the cause of the soil reacting sourly or having a low pH is due to a lack of the elements calcium (CaO) and magnesium (MgO). Organic soils tend to have high acidity. Thus, this acidic soil needs to be neutralized because this acidic soil will reduce the level of productivity of the planted shallots. How to neutralize it by adding nutrients to the soil of the shallot plant.

From the N, P, K, and soil conductivity data of the shallot plants tested, it was found that the data was stable after 9 hours of using the tool. This is because nutrients are not given to shallot plants, so the values obtained are constant, namely, N is 170mg/kg, P is 439mg/k, K is 434mg/k, and conductivity is 1000 uS/cm

4. CONCLUSION

The Based on the design and test results of the tool, it can be concluded that:

1. The monitoring system has succeeded in designing a prototype soil content measuring system in which the designed tool can read data from the NKTHCPH-S sensor, which displays the parameter values of humidity, temperature, conductivity, pH, nitrogen, phosphorus, and potassium in onion soil. Monitoring is carried out using the Blynk application on a smartphone.
2. The most significant test results were at 2 pm and 11 pm. Where, at 2 pm, it was found that the temperature was 35.6 oC with a humidity of 50.7%. And at 11 pm, it was found that the temperature was 28.4 oC with a humidity of 58.6%. This shows that the temperature affects the humidity of the shallot plant soil because if the temperature increases, the soil moisture decreases, and when the temperature decreases, the soil moisture increases.
3. From the test results, it was also found that the values of N, P, K, and constant Conductivity during the 9 hours of testing were: N was 170mg/kg, P was 439mg/k, K was 434mg/k, and conductivity was 1000 uS/cm.

4. With this tool, it is possible to determine the appropriate soil content and the needs of shallot plants according to their growth criteria.

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