DESIGN A MONITORING SYSTEM FOR TEMPERATURE, HUMIDITY AND SOIL PH IN IOT-BASED ONION CULTIVATION

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Abstract

Shallots are one of the most important food ingredients. When planting onions, it is necessary to pay attention to soil conditions such as pH, temperature and humidity. This system is built using soil pH sensors and DHT11 sensors to detect air temperature and humidity, then the Arduino microcontroller will process the data into output in the form of a water pump and an android application used as a control and monitoring of sensor readings by utilizing the Internet of Technology Things (IoT) for local residents, especially farmers who need it to monitor the health of onion fields in order to provide proper care and proper water pump. With the existence of IoT, it is expected to help and improve supervision and control of onion cultivation so that it can increase the productivity of shallots.

Keywords: *Monitoring system, temperature, humidity, soil pH, onion, Internet of things.*

INTRODUCTION

Shallots (Allium ascalonicum L.) are a very important food ingredient, but can also be used as an additional spice in everyday cooking by household consumers. The use of shallots is not only limited to the culinary field, but also has long been used in traditional medicine and its value is recognized by the public at large. Today, the growth of the food industry has increased the high domestic demand for shallots. .(Sigit Rizky Pratama dan Dian Nova Kusuma Hardani, 2021)

Factors that affect the growth and productivity of shallots include soil type, soil pH, temperature, air humidity, water supply, sunlight, treatment, fertilizer application and control of pests, weeds and diseases in plants. Shallot plants require maximum sunlight (at least 70% irradiation), air temperature 25-32°C, and humidity ratio 50-70% (Haryanto and Saraswati, 2019). Shallot plants can form bulbs in areas where the average air temperature is 22 ° C, but the yield of bulbs is not as good as plants planted in hotter areas Shallots will produce larger bulbs if planted in areas exposed to solar irradiation for more than 12 hours. Below 22°C onion plants will not tuber. Therefore, onion plants are more suitable to grow in lowlands with a sunny climate. Shallots require crumb-textured soil, medium to clay, with the right irrigation system, and sufficient organic matter (Kurnianingsih and Sefrila, 2019). Alluvial soil or its combination with Glei-Humus soil or Latosol soil is the most suitable type of soil planted with shallots. The appropriate soil pH value range for onion plants is 5.6 – 7.5 pH. The acid-base nature of the soil will affect the presence of chemical elements in the soil. If the soil is acidic with a pH below 5.6, the presence of Al elements in the soil increases so that the plant will dwarf. Conversely, if the soil is too alkaline (pH above 6.5), the soil will be dominated by Mn elements which cause the quality and size of onion bulbs to be low. (Rome, Wildian, and Firmawati, 2018).

In planting shallots, of course, it is not enough to pay attention to the growing place of the plant to be planted, but it is necessary to pay attention to soil conditions because the soil is the main source of nutrients for plants and the place of a number of important changes in the plant growth cycle. One example is the monitoring and control system of onion cultivation. This system is used to increase agricultural yields especially at soil pH, moisture as well as surrounding temperatures suitable for onion plants. (Firmansyah, 2014).

Therefore, researchers are interested in developing the research with the title "**DESIGN A MONITORING SYSTEM FOR TEMPERATURE, HUMIDITY AND SOIL PH IN IOT-BASED ONION CULTIVATION**". If the soil pH reading >6.5 &< 7.0 is good soil for planting shallots, while if the

soil pH reading is >4.4 &<6.5, then the soil is not good for planting shallots should be given nutrients and if the sensor reading is >7.0 then the soil is not good for planting shallots should be given nutrients.

LITERATURE REVIEW

A. Literature Study

Peneliti tentang sistem pemantauan suhu, kelembapan, dan pH tanah pada budidaya bawang merah berbasis IoT. With several studies that have been done by several researchers. Here are some summaries of literature studies used to determine the extent to which the research has been carried out:

—In the study (Sigit Rizky Pratama dan Dian Nova Kusuma Hardani, 2021)"Design of a Soil Humidity and Temperature Monitoring System for Shallot Plants in Brebes Regency", This tool is used to measure and normalize soil humidity and temperature for onion crops. Soil moisture measurement using soil moisture sensors, soil temperature measurement using DS18B20 sensors. This system uses Arduino Nano as the prime mover. The way this tool works is when the soil moisture sensor detects moisture below 50%, the microcontroller will activate the water pump, when the sensor measures soil moisture above 70%, the microcontroller will give the water pump off command. All information on turning the water pump on and off will be displayed on the LCD. The results showed that if the humidity read by the soil moisture sensor is below 50%, the water pump will turn on, and if the measurement data has reached 70%, the water pump will stop. The type of soil that is suitable for onion plants is alluvial soil that is not easy to dry so that the soil moisture value is more stable.

—On research (Dekita Nuswantara, 2016), "Design of Automatic Temperature, Humidity and Water Circulation Control Monitoring System in Arduino Uno-Based Hydroponic Orchid Plants". The control subsystem used is Arduino UNO. Arduino microcontroller serves to read input signals from humidity temperature sensors, pH sensors and ultrasonic water level sensors. The object of research using orchid plants *Dendrobium* age 5 months. The temperature, humidity and pH values of nutrients inputted to Arduino are adjusted to the standardization of temperature, humidity and nutrition of orchids aged 5 months, namely temperatures of 23 ° - 29 ° C, humidity 60 - 80% and pH 5 - 6. The actuator will activate if the temperature, humidity and pH values of nutrients are outside the limits of the inputted values.

B. Theoretical Basis

- Soil pH

  Soil as the outermost layer of the earth's surface has a role as a place for the growth and development of plants, a medium for the establishment of roots, and as a provider of water and air needs. Chemically, soil plays a role in providing nuntrition and nutrients, both in the form of organic and inorganic compounds. Simple chemical elements present in the soil are Al, Mg, Ca, Cu, Zn, Fe, S, P, N, P, K, etc. The biological function of soil is as a habitat for microorganisms that play a role in the formation of nutrients, nutrients and other soil additives (Kurnianingsih, and Sefrila, 2019)

  On agricultural land, of course, it is necessary to adjust the pH of the soil so that plants can grow well. If the soil pH in agricultural land does not match the soil pH of the plants to be planted, an effort is needed to improve the soil pH value to reach the ideal pH. In acidic soils, efforts to raise pH can be done by liming, usually added lime (CaO) (Hanafiah, 2014).

- Temperature and Humidity

  Temperature is a state of heat or cold, a temperature that can be seen based on a predetermined scale. Degrees Celsius (ºC) is one of the units applied to measure temperature, in several other countries including the UK using the unit of degrees Fahrenheit (ºF). Fahrenheit Temperature Conversion to degrees Celsius: F = 32 x (9/5) ºC. Humidity is related to the amount of water vapor content found in the air. Humidity is the ratio between the mass of water vapor in the air and the unit of air mass, which is expressed in a unit called grams / m3. The value of the relative humidity range is between 0-100%, where 0% is dry air, while 100% is saturated air.

- Bawang Merah

Shallots (Allium cepa var. Ascalonicum) is a spice originating from Pakistan, Iran, and the mountains to the north, which then spread to other parts of the world both tropical and subtropical. Shallots are plants that have long been known as flavoring dishes (Rismunandar, 1986). Apart from being a spice for red onion food also has health properties including increasing appetite, as an antioxidant, preventing narrowing of blood vessels, and the extract can be used to cure flu symptoms and shortness of breath. (Pajow, Purbopuspito and Sinolungan, no date).

C. Hardware Used

- NodeMCU ESP8266

NodeMCU ESP8266 is a type of ESP8266 microcontroller that has WiFi. Allows to easily create IoT projects (*Internet of Things)* and connect their devices to the internet wirelessly. Board *NodeMCU* ESP8266 features onboard WiFi, 16 GPIO pins, one analog input pin, and a micro USB port for programming and power. The chip itself is ESP8266 a low-power 32-bit microcontroller with integrated WiFi capabilities. It can operate up to 80 MHz and has 4MB flash memory for program storage

- Soil pH sensor

Soil pH sensor is a sensor that functions to detect the level of soil acidity or alkaline. This sensor has a soil pH measurement range from a scale of 3.5 - 8. This sensor can be assembled directly with Arduino analog pins or other microcontroller analog pins, without the need for additional amplifier modules.

- Sensor DHT11

Temperature and humidity are two different but interrelated parameters. In some temperature and humidity measurements are carried out using separate sensors, but to facilitate the measurement has now been produced sensors that are able to measure these two parameters, one of which is the DHT11 sensor (Syam, 2013).

- Fan

Fans are used to generate wind. Common functions are for air conditioning, air fresheners, ventilation (exhaust fan), dryers (generally using heat-producing components).

- Relay

A relay is a device that works based on electromagnetics to move a number of arranged contactors or an electronic switch that can be controlled from other electronic circuits by utilizing electrical power as an energy source. The contactor will be closed (on) or open (off) due to the effect of magnetic induction produced by the coil (inductor) when an electric current is applied. Unlike the switch, the movement of the contactor (on or off) is done manually without the need for electric current.

- Air Pump

A pump is a machine / device used to raise fluid from a low surface to a higher surface or move Fluid from a place of low pressure to a place of higher pressure. The pump operates on the principle of making a pressure difference between the inlet parts (*suction*) with an exit (*discharge*).

D. Software Used

- Software Mikrokontroller Arduino Uno

Arduino software used are drivers and IDE, although there are still some other software that is very useful during the development of Arduino. Integrated Development Environment (IDE), a special program for a computer to be able to create a design or sketch program for an Arduino board.

- Arduino IDE Software

IDE stands for Integrated Development Environment. IDE is a program used to create programs on Arduino Uno. Programs written using Arduino Software (IDE) are referred to as sketches. Sketches are written in a text editor and stored in a file with the extension.ino.

- Internet of Things

The Internet of Things, also known by the acronym **IoT**, is a concept that aims to expand the benefits of continuously connected internet connectivity. As for capabilities such as data sharing, remote control, and so on, including objects in the real world.

- Android

Android is an operating system for Linux-based mobile devices that includes the operating system, middleware and applications. Android provides an open platform for developers to create their own apps for use by a variety of mobile devices.

- MIT App Inventor 2 App

App Inventor for Android is an app that is basically provided by Google and is now maintained by the Massachusetts Institute of Technology (MIT). App Inventor uses the Kawa Language Framework and Kawa's dialect developed by Per Bothner. Both applications are used as compilers and translate Visual Block Programming.

- Area kerja MIT App Inventor 2

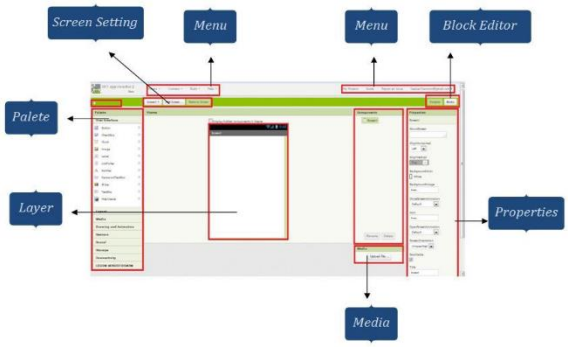


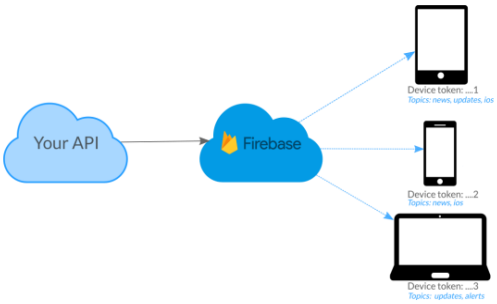
Figure 2.1 APP Inventor 2 Work Area

- Wi-Fi

Wi-Fi stands for Wireless Fidelity which uses the IEEE 802.11x standard, which is a wireless technology that is able to provide internet access with large bandwidth, reaching 11 Mbps (for the 802.11b standard). Hotspot is a location equipped with a Wi-Fi device so that it can be used by people who are in that location to access the internet using a notebook that already has a WiFi card.

- Firebase

Firebase is a service from Google that is used to make it easier for application developers to develop applications. With Firebase, app developers can focus on developing apps without having to put in a lot of effort.



Firebase Figure 2.2

RESEARCH METHODOLOGY

A. Stages of Research

This chapter will describe the research steps that will be carried out in the Design and Build of a Soil Temperature, Humidity and pH Monitoring System in IoT-Based Shallot Cultivation.

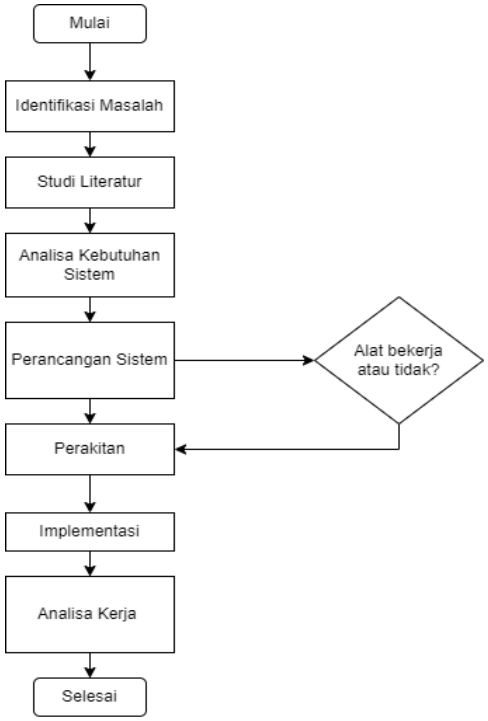


Figure 3.1 Research Flow

B. System Planning Analysis

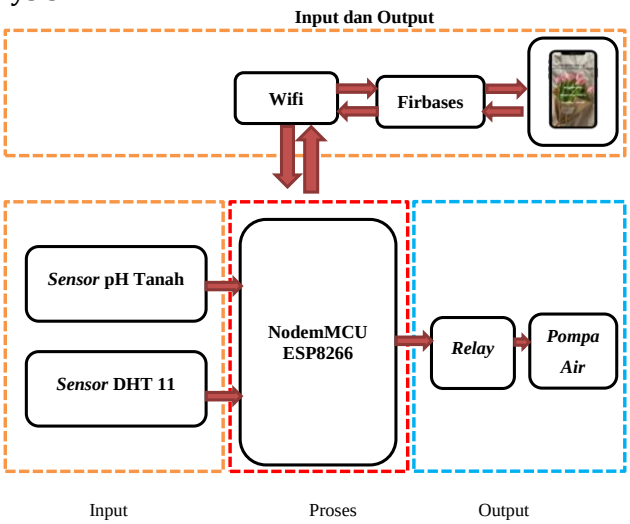


Figure 3.2 Block System Diagram

The system in this study is divided into three parts, including an input system consisting of a soil pH sensor and a DHT 11 sensor. The microkntroller used is a *minimum board system NodeMCU* ESP8266. The output system in the form of a water pump and Android application is used as a control and monitoring of sensor readings. Here is an explanation of the block diagram:

1. The soil pH sensor serves as a measure of the value of the soil in onion plants.
2. The DHT 11 sensor is used as a temperature and humidity reader.
3. The microcontroller system in this design uses the *NodeMCU minimum system board ESP8266*.
4. The relay functions as the ON and OFF water pump applied to the system.
5. The application functions as a minitoring of soil pH sensor readings, DHT 11 sensors and water pump controls.

C. Hardware Design

Design is a very important part of making a tool because by designing in advance with the right components will reduce excess purchase of components and tool work as desired. To avoid

damage to components, it is also necessary to understand the characteristics of these components. Here's the hardware deployment system flow:

- Soil pH network

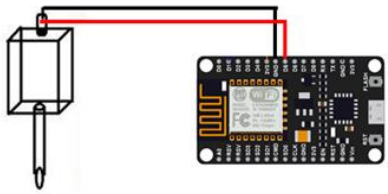


Figure 3.3 Soil pH network

In the soil pH circuit, only a few feet are connected to the nodemcu digital pin so that the process results on the nodemcu can read the soil pH value. The explanation of the use of nodemcu PIN and soil pH is that Pin D5 nodemcu goes to pin out *soil pH* and GND goes to GND nodemcu and 3.3 V.

- DHT11 Sensor Network

In the DHT 11 Sensor circuit, only a few feet are connected to the nodemcu digital pin so that the process results on nodemcu can read the temperature and humidity values of the pins used, namely out to enter the D1 nodemcu pin while the vcc goes to 3 volts nodemcu and GND to the nodemcu GND pin.

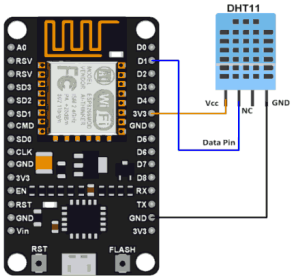


Figure 3.4 DHT 11 Sensor Network

- Relay Series

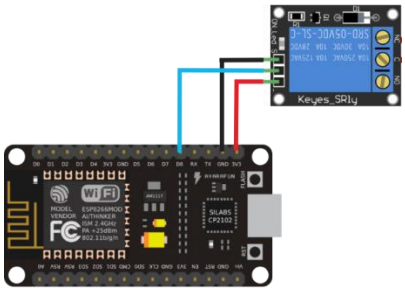
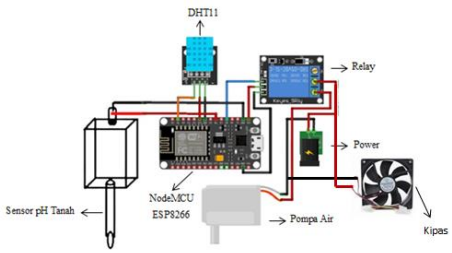


Figure 3.5 Relay circuit

The relay *driver* circuit is used as a voltage controller on *the nutrient pump*. The relay is used as a breaker and connects one of the cables on the *water pump* can stop according to the command of the nodemcu which receives the input signal from the blynk application. In the Relay circuit, there are Ground pins and VCCs as voltage sources and input pins to the Microcontroller are 1 because the Relay used is a 1-channel relay.

- The entire range of tools



Picture 3.6 Overall Tool Network

The working system of the circuit above, namely from the input of the Soil pH sensor and *DHT 11 sensor,* both sensors function as measuring the value of Soil PH, Temperature, and Humidity. Meanwhile, for the output on the system, the Relay functions to connect the Water Pump. The way this tool works is that the Soil pH Sensor can find out the pH value of the soil that is feasible or not the soil is planted with an object (shallots).

- Software Design

Initialize the system to declare which pins are used. The process starts with arduino initializing the system. The soil pH sensor will measure the pH value of the soil in the onion field. If the pH sensor > pH 6.0 and pH <7.0 then the pump relay will be Off and if the pH sensor > 2.5 and pH <6.0 then the pump relay will be ON.

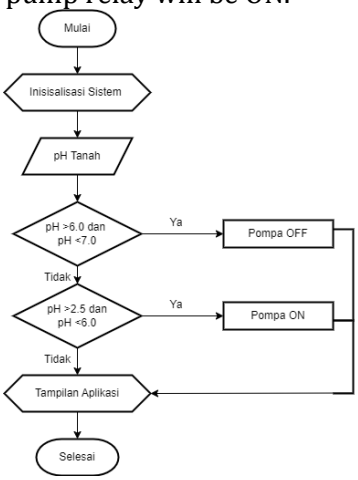


Figure 3.7 Soil pH System Flowchart

D. Implementation

The planting media material is made from a combination of soil and rice husk charcoal as much as 1: 1. This design uses two soil pH sensors, each of which is placed in the middle between onion plants. DHT *11 sensor is* used to measure air temperature and humidity, this sensor is placed on the middle edge. In the acid-base solution control section, two 6L capacity boxes are used, each of which contains acid and base solutions, and is equipped with a mini water pump and is directly connected to the watering pipe. The alkaline solution is made from a mixture of water with liquid dolomite, while the acid solution is made from the solution of ketapang leaves. The microcontroller box contains a series of system wiring which includes a series of sensors with Arduino, *NodeMCU* ESP8266 and Relay Modules.

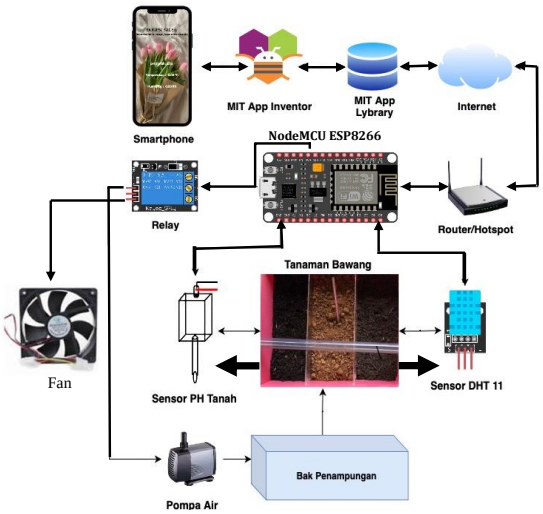


Figure 3.8 System Implementation

E. System Testing

After the *hardware* and *software* design is complete, what is done is *running* the program, testing each series whether it is as desired or not. Tests are performed on parts such as response testing, system *range* and overall circuit on this system.

- Soil pH Sensor Test Design
- DHT 11 Sensor *Test Design*
- Relay Testing Design
- Application Test Design
- Overall System Testing

F. Work Analysis

For work analysis, it is carried out together when conducting tool trials that aim to find out the work of the tool. In addition, what will be analyzed is distance, internal response to input in the Design and Build of a Soil Temperature, Humidity and pH Monitoring System in IoT-Based Shallot Cultivation. Based on the results of system testing that has been obtained will be analyzed to ensure that the system that has been made is in accordance with expectations.

RESULTS AND DISCUSSION

This chapter contains the results of trials and analysis of the system. The test begins by making sure each component (*application*, DHT *sensor and* soil *pH sensor*) *whether the tool that has been made in good condition can work properly according to the program that has been made, then checking that each path connected to the component used has been connected, where the circuit is adjusted to the schematic drawing.*

A. Physical Form of Tools

Trials are carried out to ensure the resulting circuit is able to work as expected. Then first the testing step is carried out and directly observe the circuit and components. The results of this measurement can be known whether the circuit has worked properly or not, so that if there are errors and shortcomings will be detected. Figure 4.1 below is a picture of the physical form of the tool that has been created.

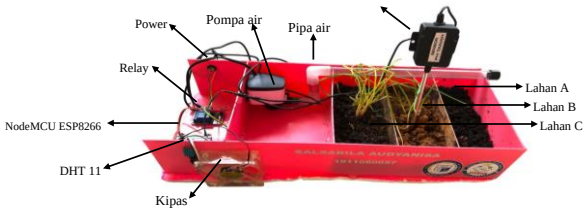


Figure 4.1 Physical Form of the Tool

From the results of the assembly, researchers can find out the working system of the tool has worked in accordance with the program that has been made, namely. It is known if the pH sensor > pH 5.5 and pH <7.0 then the pump relay will be Off and if the pH sensor > 3.5 and pH <5.5 then the pump relay will be ON.

B. Testing Soil pH Sensors in Shallot Fields

Testing of soil pH sensors is carried out so that researchers can find out whether the program can work well. In testing soil pH sensors, researchers used three fields, namely land A, land B, and land C.

Table 4.1 Soil pH Sensor Measurement in Shallot Field

Lahan Bawang Merah	Waktu (Detik)	Hasil Pembacaan (pH Awal)	Hasil Pemberian Nutrisi+Air (pH tanah)	Sensor suhu dan kelembaban	
				Suhu °C	Kelembaban %
Lahan A	1	3,4	6	30 °C	50%
	5	3,5	6	30 °C	50%
	10	3,6	6	30 °C	50%
	15	3,5	6	30 °C	50%
	20	3,5	6	30 °C	50%
Lahan B	1	5,4	5,4	28°C	70%
	5	5.5	5,5	28°C	70%
	10	5,6	5,6	29°C	70%
	15	5,5	5,5	28°C	70%
	20	5,5	5,5	28°C	70%
Lahan C	1	2,8	5,7	32°C	45%
	5	2,8	6	32°C	40%
	10	2,9	6	32°C	40%
	15	2,8	6	32°C	45%
	20	2,8	6	32°C	45%

C. Soil pH Sensor Testing

Testing of soil pH sensors is carried out so that researchers can find out the average value of experiments with trials on land A, land B, and land C.

Table 4.2 Soil pH Sensor Measurements

Test drive to	Shallot Land	Preliminary PH Readings
1	Lahan A	3,4
2		3,5
3		3,6
4		3,5
5		3,5
Average rating		**3,5**
1	Lahan B	5,4
2		5.5
3		5,6
4		5,5
5		5,5
Average rating		**5,5**
1	Lahan C	2,8
2		2,8
3		2,9
4		2,8
5		2,8
Average rating		**2,82**

Based on table 4.2, it can be seen that the results of trials on land A, land B, and land C with 5 experiments with an average value of 3.5 on land A while on trials on land B get **an average value of 5.5 and in trials with land C an average value of** 2.82 is known **.**

D. DHT 11 Sensor Testing

Table 4.3. DHT 11 Sensor Temperature Test Results

Pengukuran yang ke	Suhu (°C)	Termometer (°C)	Selisih	*Error*
1	24.	25	0.2	0.8%
2	23.	24	0.4	1.6%
3	25.	24	0.3	1.2%
4	23.	24	0.2	0.8%
5	26.	26	0.1	0.3%
Rata-rata				**0,94%**

The temperature comparison obtained using a thermometer and a DHT 11 sensor is tested in Table 4.3.

$$Error(\%) = \frac{(Selisih\ Nilai\ Pembacaan)}{Nilai\ Termometer\ Digital} x100\%$$

Based on the formula above, the calculation results obtained are as follows:

$$Error(\%) = \frac{(0.2)}{25} x100\%$$
$$Error(\%) = 0.008\ x\ 100$$
$$Error(\%) = 0.8\ \%$$

The data from the DHT 11 sensor test in table 4.3 is a comparison of the temperature reading of the DHT 11 sensor with the thermometer which obtained an average error of 0.94%.

Table 4.4 Moisture Test Results

Pengukuran yang ke	Kelembaban %/RH	Higrometer Digital %/RH	Selisih	*Error*
1	87%/ RH	88%/RH	1%	1.1%
2	72% /RH	73%/ RH	1%	1.3%
3	78%/ RH	77%/ RH	1%	1.2%
4	69%/ RH	69%/ RH	0%	0%
5	90%/ RH	89%/ RH	1%	1.1%
Rata-rata *error* (%)				**0,78%**

Comparison The humidity levels obtained using a digital hygrometer and DHT 11 sensor are tested in Table 4.4.

$$Error(\%) = \frac{(Selisih\ Nilai\ Pembacaan)}{Nilai\ Higrometer\ Digital} x100\%$$

Based on the formula above, the calculation results obtained are as follows:

$$Error(\%) = \frac{(1)}{88} x100\%$$
$$Error(\%) = 0.113\ x\ 100$$
$$Error(\%) = 1.13\ \%$$

The data from the DHT 11 sensor test in table 4.4 is a comparison of the temperature reading of the DHT 11 sensor with the thermometer which obtained an average error of 0.78%.

E. Test Results on Application Display

Application testing aims to ensure that there are no errors in the application program used as monitoring of temperature, humidity, and soil pH. The results of the test can be seen in Figure 4.2.

Figure 4.2 Test Results on Application View

F. Overall System Testing

Testing the system as a whole is carried out to test the performance of the Design, system testing is carried out so that researchers can find out whether the system that has been made can work well.

Table 4.5 Overall System Test Results

Lahan Bawang Merah	Waktu (Detik)	Hasil Pembacaan (pH Awal)	Sensor suhu dan kelembaban		Kondisi Pompa (ON/OFF) (pemberian Nutrisi+Air)	Hasil Pemberian Nutrisi+Air (pH Tanah)
			Suhu °C	Kelembaban %		
Lahan A	1	3,4	30 °C	50%	ON	6
	5	3,5	30 °C	50%	ON	6
	10	3,6	30 °C	50%	ON	6
	15	3,5	30 °C	50%	ON	6
	20	3,5	30 °C	50%	ON	6
Lahan B	1	5,4	28°C	70%	OFF	5,4
	5	5.5	28°C	70%	OFF	5.5
	10	5,6	29°C	70%	OFF	5,6
	15	5,5	28°C	70%	OFF	5,5
	20	5,5	28°C	70%	OFF	5,5
Lahan C	1	2,8	32°C	45%	ON	5,7
	5	2,8	32°C	40%	ON	6
	10	2,9	32°C	40%	ON	6
	15	2,8	32°C	45%	ON	6
	20	2,8	32°C	45%	ON	6

Based on table 4.5. Based on the results of the overall system trial, it can be known that in land test A the soil pH sensor reading is 3.4, then the pump ON after being given soil pH nutrients becomes 6. While in the field B trial, the soil pH sensor reading was 5.4, then the pump OFF after being given the same soil pH reading nutrients. and in field C test the soil pH sensor reading was 2.8, then the pump ON after nutrient given soil pH reading became 5.7.

CONCLUSION AND ADVICE

A. Conclusion

Based on the testing and analysis of the system that has been carried out, it can be concluded as follows:

- The monitoring system of temperature, humidity and soil pH in onion cultivation uses DHT11 sensors and soil pH sensors that measure temperature, air humidity by utilizing Technology (IoT) as a means for local residents, especially farmers who need to monitor the health of shallot fields to provide proper care.

- Water pumps provide benefits for farmers to be able to find out the test results of the temperature, humidity and soil pH monitoring system if the pH sensor >6.0 and pH <7.0 then the pump relay will be OFF and if the pH sensor >3.5 and pH <6.0 then the pump relay will be ON.
- The implementation of this system can improve monitoring and control of onion cultivation so that agricultural products, especially in soil pH, temperature and humidity get appropriate results for onion plants.

B. Suggestion

The suggestions proposed regarding the design of a monitoring system for temperature, humidity and soil pH in IoT-based onion cultivation for further research are:

- Future research can improve the response readings from DHT11 sensors and soil pH sensors.
- Future research could incorporate electrical parts systems that can use backup power or batteries in the event of a power loss. Further research is suggested to be able to add mass scheduling of harvests.

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