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Technological Innovation: IoT-based Smart Greenhouse for Optimizing Red Garlic Growth

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Abstract: Red garlic become a reliable commodity in Jember society. Red garlic farmers often face some emerging problems such as the influence of extreme weather on the growth of red garlic crops. The success of growing garlic depends on several factors including maintenance temperature, soil humidity, nutrition and use of medicines. (fungicide). One of the technological developments that can be used in agriculture is the development of greenhouses as a monitoring and control system to control the growth of garlic crops. The presence of this innovation is expected to help carry out automatic spraying, irrigation, medication activities using an Internet of Things-based application system. Components used in this system are Arduino and ESP32 microcontroller, Dht22 sensor as temperature controller, Yl-69 soil moisture sensor, and soil pH sensor to monitor soil fertilizer elements. The device can monitor soil humidity, temperature, medication, and soil pH through the Blynk app. From the results of this study, plants grown in greenhouses have a 100% presentation rate with 30 seeds and are growing fertile. This is better than planting on caterpillars and polybags with a growth rate of 84% and 90% or only 25 seed and 27 seed remains.

Keywords: Red Garlic; Soil Moisture Sensor; Soil PH Sensor; Internet of Things

INTRODUCTION

Current weather conditions in Indonesia are sometimes very hot and usually rainy. Due to the drastic climate change this year, farmers' income has decreased because the crops that grow are not as desired and not a few have experienced crop failure. Indonesia is a country with various geographical factors, such as high and lowlands, abundant sun exposure, and almost evenly distributed rainfall every year in some areas, contributing to biodiversity. Existing soil types allow the development of cultivation of various types of plants native to the tropics, as well as commodities that have been introduced from subtropical regions that have successfully adapted to tropical climatic conditions[1]. This erratic climate change causes crop failure in various crops, one of which is the shallot plant. Shallots are one of Indonesia's leading vegetables that have high economic value and have been the focus of farmers' businesses for many years. Shallots are included in the group of important agricultural products that act as inflation controllers, along with chili and garlic, according to the Ministry of Agriculture's strategic plan. The advantages of shallots include many benefits, both as a seasoning and as medicine. In addition, the vitamins C, B6 and B9 found in shallots contribute to the absorption of iron and help in the formation of red blood cells, thus also improving health.,

The increase in population per year makes the need for shallots become more, this results in shallot production also increasing. Until now, shallot production has not reached the maximum level, and this is reflected in the variety of cultivation methods and locations where shallots are grown[2]. Based on information from the Agriculture Office of East Lombok Regency, shallot cultivation requires more than 12 hours of sunshine each day. This plant is suitable for cultivation in the lowlands with an altitude between 0 to 900 meters above sea level. The ideal temperature for shallot plant development is in the range of 20 to 32 [3]. And also the soil ph or acidity level is around 5.6 – 7 [1].

Plant maintenance is still mostly done manually with human labor, and there are often errors in the process such as improper schedules and inappropriate doses that make growth less effective. In addition, human negligence factors such as laziness and forgetfulness Maintenance becomes irregular due to other activities or busyness that makes the maintenance schedule disrupted. In addition, because the owner is not at the location, maintenance is hampered and cannot be carried out intensively and periodically, causing maintenance to be neglected. In connection with the existing problems, a special system is needed to carry out plant maintenance that can work online as a growth control and monitoring system.

Previous research has designed a monitoring and control system for irrigation and watering conducted by Syariful Asmaul Fauziah [4]. Hasanudin University, The title of this research is "Design of Information System Monitoring and Control of Red Onion Plants Based on the Internet of Things". The designed system will monitor several variables, including soil moisture, air temperature and humidity, and the height of the water reservoir. In this study, it controls watering, air conditioning, and heating. From previous researchers, researchers are interested in developing a similar tool which in this study is entitled "Design of an Iot-Based Smart Green House Prototype to Control the Growth of Shallot Plants" with sensors and microcontrollers to monitor and control the growth of shallots.

METHOD

In the design of this tool is divided into several parts namely:

1. Hardware design consisting of
   - Design and assembly of electronic components used
   - Creation of prototype design of green house.
2. Software design which consists of
   - Software design on microcontroller as processing all input that comes from the sensor
   - Planning and design of blynk application as a tool of control and monitoring via mobile phone or website

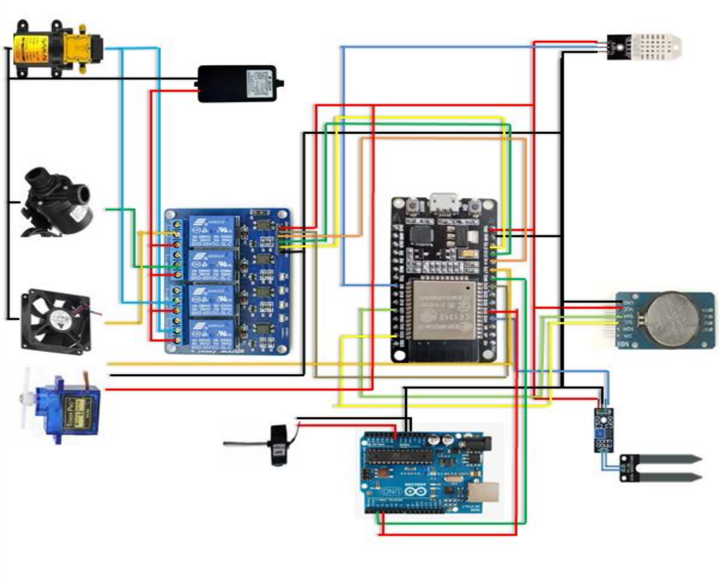


Figure 1. Hardware Design

on figure 1 is the design design of the hardware used in this study. The hardware used for the design of this monitoring and control system is

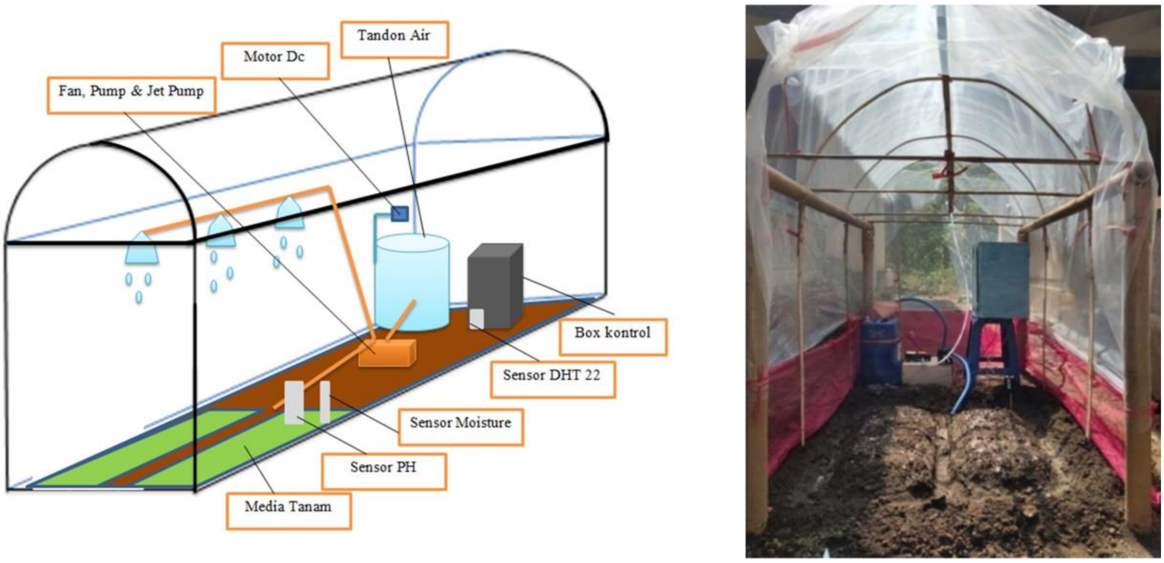
1. Arduino Uno[5] and ESP 32[6] as microcontrollers to process data both data sender and data receiver
2. DHT22 sensors[7] , Soil moisture, PH sensors as sensors to detect temperature, humidity and soil acidity.
3. RTC DS3231[8] as scheduling of outputs
4. Servo Sg-90 as water medicator on
5. Water pump and Fan Dc as the output of this device system.

The electrical specifications of the components used are shown in table 1 below. In Figure 2 below is the prototype design of the green house used in this study.

Table 1. Electrical Specifications of Components

No	Parameter	Keterangan
1	Arduino	7- 12 Volt
2	Modul RTC	3 – 5 volt
3	ESP 32	3.3 Volt
4	Soil Moisture Sensor	5 Volt
5	DHT22	5 Volt
6	Soil PH Sensor	5 Volt
7	Motor Servo	5 Volt
8	Jet Pump	12 Volt
9	Water Pump	12 Volt
10	Kipas DC	12Volt
11	Power Supply	220 Volt

The design of the green house was done by making a greenhouse-like planting medium with a half-circular shape on the roof and a square-shaped length on the bottom. Transparent plastic covered the entire top and bottom are painted as air ventilation.



(a) (b)

Figure 2. (a) Side View Tool Design, (b) Front View Tool Design

On the software design is the creation of software requires a flowchart of the program to be created described in the figure 3.

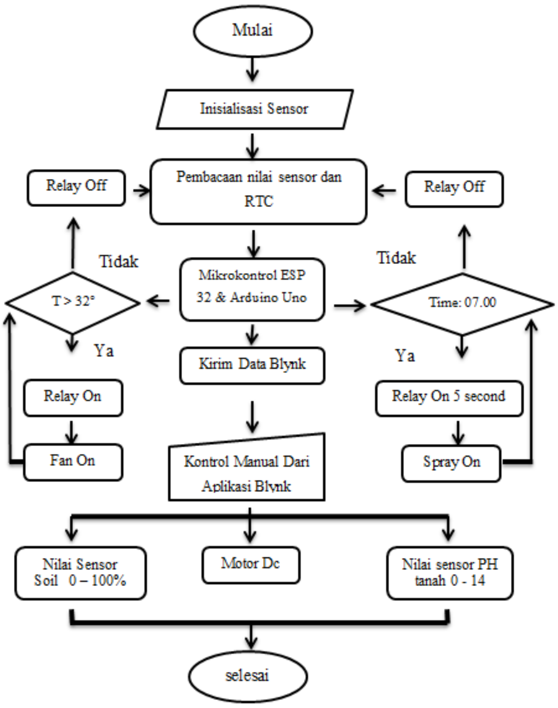
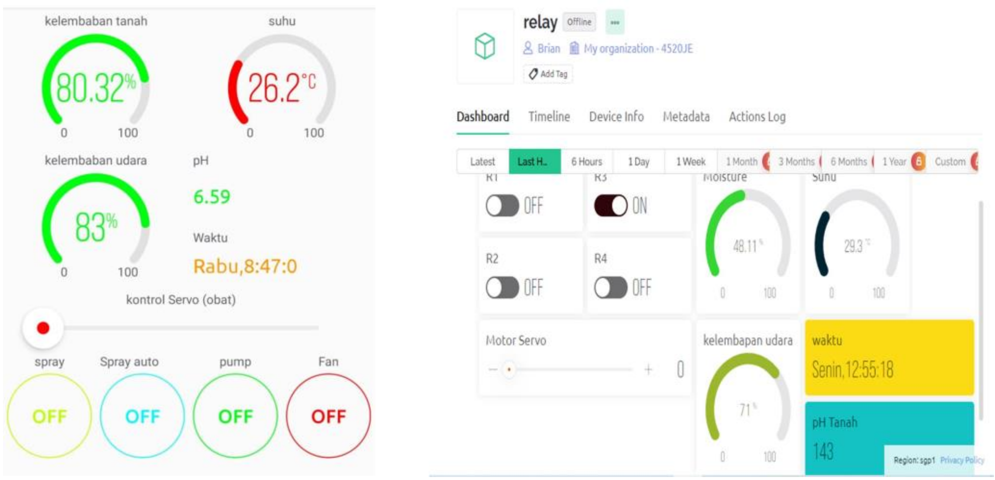


Figure 3. Flowchart System

In the picture above is the process of the system, with the preparation of microcontrollers, sensors and rtc, then continued with the system connected to the blynk application via an internet connection. Blynk monitors soil sensors, temperature, pH, rtc and also servo motors. On the humidity sensor if the soil is below 45% then it will activate the pum if not the pump remains dead, if the ground is above 75% then if it is pumped on then the pump will be off. For the temperature sensor if temperature is above 32 then it'll activate a fan and if it's below it the fan will not live or die. RTC set the time at 7:00 if the conditions are met then it will turn on the pum jet for 20 seconds outside that time there will be no automatic spraying. The pH sensor only monitors and performs manual actions, as does the servo motor. Pengoffan system is done manually if it is not dioffed then the system will continue to run.



(a) (b)

Figure 4. (a) IOS App View (b) Web App View

The design and design of the Blynk application is shown in Figure 4. The display of this application serves as a monitoring of soil moisture, temperature, air humidity and soil PH values using an app available on both android and laptop connected to the Internet network. Changes to these values will be displayed on the monitor and displayed in real time on the application. In addition to monitoring the application it can also be used as a controller such as servo motor, spraying, irrigation and wind fan dc which is basically something that is done automatically or something that controls manually through the application.

RESULTS AND DISCUSSION

The design and assembly results of the device are tested to see if the device is already functioning as planned.

1. DHT22 sensor testing at the greenhouse

The purpose of this test is to test the performance of the DHT22 sensor as well as to verify whether the sensor is also able to accurately detect the temperature level of the growing medium as a device that controls the temperature by controlling the wind fan to lower the excess temperature on the growing media so that the plant can grow as desired. In addition, the purpose is to find out the truth of the value of the sensor used by comparing it to the measuring device. Data to be stored is data when the plant is at the age of + 10 days. After obtaining the values of the sensor and the measuring instrument it will be searched for error values i.e. with

Error=(DHT-Device Measurement Results)/(DHT Measuring Result) x 100

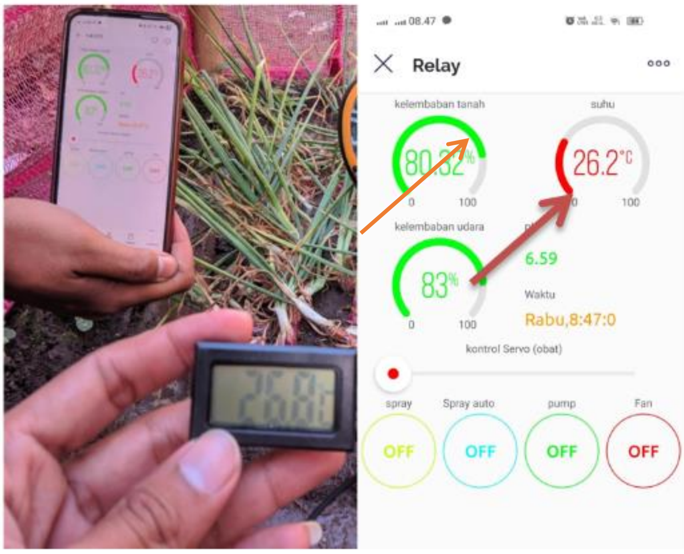


Figure 5 DHT22 Sensor Test Results with Digital Thermo in Greenhouse

Table 2 DHT22 Temperature Data

Tanggal Pengujian	Usia Tanaman	Suhu Dht	Pengukur Temperatur	Eror %	Kondisi Fan Dc
13 Juni	13	34,1°	34°	0,2%	0FF
14 Juni	14	32,3°	33°	2%	0N
15 Juni	15	31,6°	32°	1,2%	0FF
16 Juni	16	29,4°	30°	2%	0FF
17 Juni	17	34°	34°	0%	0N
18 Juni	18	33,1°	33°	0,3%	0N
19 Juni	19	31,3°	32°	2%	0FF
20 Juni	20	33°	33°	0%	0N
21 Juni	21	31,8°	32°	0,6%	0FF
22 Juni	22	32,4°	33°	1,8%	0N
23 Juni	23	30,6°	30°	1,9%	0FF
24 Juni	24	33,2°	33°	0,6%	0N
25 Juni	25	31°	31°	0%	0FF
26 Juni	26	32,2°	33°	2%	0N
Rata Rata Eror %		1,3%			

It can be seen from the sunny day that the temperature remained stable for about two weeks. The above temperature indicates the greenhouse's state from around 11 a.m. to 1 p.m., taking the clockwise radiation from the sun's highest radiation occurring at this hour. The highest temperature reached by the DHT22 sensor is 34.1° while the temperature meter is 34° so the measurement error is 0.2% and the lowest temperature is 29.4° whereas the temperature sensor is 30° and the error value is 2%. When the temperature is below 32° the garlic plant receives sufficient temperature so it needs to perform automatic processing of the Fan Dc. And when the temperature above 32° then the microcontroller will perform the automatic control of the fan Dc until the temperature returns to the position <32°. From the data it is concluded that the control of fan dc automatically succeeds with the result of an error of about 1.8% of the comparison.

2. Soil Moisture Sensor Testing

This test was carried out to evaluate the performance of soil moisture sensors with a focus on the accuracy of detection of the soil humidity level. In planted media with soil media. The higher the moisture level of the soil, the higher the level of water in the ground, or the high level of humidity, the lowest the level or the dry level of soil. Here's soil humidity data:

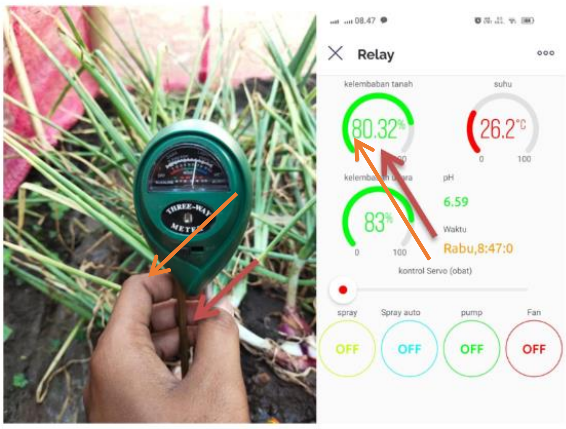


Figure.6 Soil Moisture sensor test results with moisture test device

Table 3 Data Soil Moisture

Tanggal Pengujian	Usia Tanaman	Tingkat Kelembaban Awal	Kondisi Pompa manual	Kondisi Kelembaban pada alat ukur	Tingkat Kelembaban setelah kontrol
13 Juni	13	45%	ON	Dry+	83%
14 Juni	14	79%	OFF	Wet+	-
15 Juni	15	69%	OFF	Wet+	-
16 Juni	16	68%	OFF	Wet+	-
17 Juni	17	55%	OFF	Dry	-
18 Juni	18	48%	OFF	Dry	-
19 Juni	19	45%	ON	Dry+	82%
20 Juni	20	80%	OFF	Wet+	-
21 Juni	21	68%	OFF	Wet+	-
22 Juni	22	64%	OFF	Wet	-
23 Juni	23	56%	OFF	Dry	-
24 Juni	24	51%	OFF	Dry	-
25 Juni	25	48%	ON	Dry	87%
26 Juni	26	86%	OFF	Wet+	-

3. Testing of the whole tool against the growth of plants

This test was carried out with the aim of finding out if there was any interrelated influence between the data obtained from each sensor on plant growth.

Table 4 Total Data on Plant Growth

Tanggal Pengujian	Suhu	Kelembaban Tanah	PH Tanah	Pertumbuhan Tanaman
13 Juni	34,1°	45%	7,12	100%
14 Juni	32,3°	79%	7,05	100%
15 Juni	31,6°	69%	7,01	100%
16 Juni	29,4°	68%	6,98	100%
17 Juni	34,0°	55%	6,97	100%
18 Juni	33,1°	48%	6,91	100%
19 Juni	31,3°	45%	6,89	100%
20 Juni	33,0°	80%	6,85	100%
21 Juni	31,8°	68%	6,76	100%
22 Juni	32,4°	64%	6,71	100%
23 Juni	30,6°	56%	6,68	100%
24 Juni	33,2°	51%	6,65	100%
25 Juni	31,0°	48%	6,58	100%
26 Juni	32,2°	86%	7,26	100%

From the table above it can be seen that relatively high temperatures can cause soil humidity levels to fall very quickly because heat can reduce water levels falling rapidly. From day to day the soil acidity level or Ph of soil is degraded, this is due to the fact that the plants always absorb the nutrients in soil that makes the ground experience a decrease in Ph. The effect of setting the parameter parameter above proves that the control of temperature, humidity, and also Ph makes the growth of garlic crops in the greenhouse very good and obtains satisfactory results.

4. Comparison of growth rates of plants using greenhouses with manual and polybag beds

Table 5 Comparison of each planted medium

	Greenhouse	Bedengan	Polybag
Jumlah Benih	30 biji	30 biji	30 biji
Pertumbuhan Tanaman Hari ke 26	100%	84%	90%

From the data of the study it is known that the use of greenhouses has a growth rate of plants that belong to a very good category because the plants growing on the greenhouse have a perfect lev-elpresentation with 30 seeds and grow fertile all 30 of these seeds, whereas in the grassland and polybang respectively have the number of seeds that grow is 84% and 90% or only 25 seeds remaining and 27 seeds. This phenomenon is caused by the greenhouse's ability to absorb a quantity of heat from exposure to sunlight and water vapour, which serves to keep the ambient temperature warm and maintain the humidity level within a greenhouse.

CONCLUSION

Based on the results of research and data collection under the title Technological Innovation: IoT-based Smart Greenhouse for Optimizing Red Garlic Growth", the publisher has the following re-search conclusions:

1. The design of the device is done through three stages consisting of input, process and output. On the input there are soilmoisture sensors YL-69, DHT22, RTC, Servo, and Soil PH sensors that function to monitor the state of the planting media or greenhouse. Then it will be processed with the microcontroller arduino uno R3 and ESP32 which will be displayed and sent to the blynk iot application to perform output controls as desired, then the output will turn on.
2. When the DHT and RTC sensors read the values corresponding to the specified command, then esp 32 and the Arduino will process and move the Fan dc for temperature and the Jet Pump for RTC.
3. 3.The device can monitor air temperature, water humidity, pH sensors and also do scheduling so you don't have to be confused with manual monitoring every day.
4. Each sensor has an error of accuracy of each measurement. Dht sensors have an average error of about 1.3% and ground PH sensors are 0.45%. The small error on each sensor can be understood that every sensor can measure data quite accurately.
5. The relatively high temperature causes the humidity level to drop rapidly. It is because of the water that can evaporate the water in the soil quickly, while the pH of the earth from day to day decreases due to the plants absorb the nutrients in the ground.
6. Based on data obtained from greenhouse differences, with polybag it is known that the use of this greenhouse is very effective because it can control the environment so that it is not affected by the season

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