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Automatic Mist Sprayer for Oyster Mushroom Cultivation Using Thingspeak IoT Platform and R Analytical Tool

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Abstract

In mushroom greenhouses at IKM Simbang Maros, watering is currently done manually using a hose and scheduled twice daily, without considering the optimal temperature and humidity for mushroom growth. This study aims to develop an automatic watering system for oyster mushroom cultivation using a DHT22 sensor to monitor temperature and humidity. The system is equipped with a NodeMCU ESP32 microcontroller and a mist sprayer, triggered by a relay to activate the water pump. An IoT platform using Thingspeak allows farmers to monitor temperature and humidity data in real-time on their smartphones. In a real case study, the device effectively maintained optimal humidity levels for mushroom growth, with the pump activating when humidity was below 85%. Data from 10 observations showed that the pump was active for 7 times. Data processing using R Studio showed the system's ability to stabilize humidity levels. The proposed system could help farmers optimize mushroom growth and reduce the labor required for manual watering.

Keywords
DHT22, internet of things, oyster mushroom, microcontroller, mist sprayer

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INTRODUCTION

Oyster mushrooms are highly valued for their nutritional content, which includes high protein and low calorie levels, making them a lucrative commodity [1], [2]. In Maros, South Sulawesi, the IKM Simbang industry is actively cultivating oyster mushrooms. However, the current watering process for the mushroom beds is done manually and scheduled, without considering the optimal temperature and humidity levels necessary for mushroom growth. As these factors, specifically temperature between 20-28°C and humidity levels between 80-90%, significantly affect mushroom growth, automating the watering process to maintain these optimal conditions is essential to maximize yield [3].

Previous studies [3]–[5] have shown that the growth of oyster mushrooms is affected by environmental factors such as temperature, humidity, and the moisture level of the growing medium. A new environmental engineering technology has been developed to support oyster mushroom cultivation by increasing watering efficiency and reducing labor costs. This technology uses a solar panel system to power a mist sprayer that utilizes an atomizing nozzle to control the duration and frequency of watering. The system can be controlled manually or automatically and is designed to monitor and adjust temperature, humidity, and moisture levels in the growing medium. The use of solar panels as the main power source has been found to reduce labor costs and increase watering efficiency by up to 80%. However, this system does not incorporate IoT technology for real-time monitoring and data analysis.

Additionally, In agriculture, the use of the Thingspeak [6]–[8] and Blynk IoT platforms [9]–[11] to monitor various conditions has become increasingly popular. The benefit of IoT in agriculture is that it can provide farmers with real-time data about their crops, soil conditions, weather patterns, and other environmental factors. This data can be used to optimize crop yields, reduce waste, and improve overall farm efficiency [12]–[14].

A previous research [15] has shown that temperature and humidity are crucial factors in the successful cultivation of oyster mushrooms, with conventional watering systems being impractical and inefficient. To address this issue, the current study utilized a Research and Development approach to develop an automatic mushroom sprinkler with temperature and humidity control. The design includes a blower component, piezoelectric, ATMega 16 microcontroller, and a DHT11 temperature sensor, as well as IoT features. The results of the implementation of this tool in the cultivation area showed a 34.51% increase in the productivity of oyster mushrooms. However, this study did not utilize the Thingspeak platform for IoT integration as is done in the current paper.

This study presents the development of an automatic mist sprayer for oyster mushroom cultivation using the Thingspeak IoT platform to monitor humidity and temperature data online in real-time. The integration of IoT technology and the Thingspeak platform is necessary to enable real-time monitoring of the environmental conditions, which allows for quick adjustments to be made and ensures that the mushrooms are always growing under optimal conditions. A real case study on the cultivation of mushrooms at IKM Simbang Maros was conducted to test the device's efficacy and collect data. The collected data was processed using R analytical tools, which allowed for in-depth analysis of the temperature and humidity trends over time and helped identify any patterns or anomalies that could affect the growth of the oyster mushrooms. The aim of this study is to demonstrate the benefits of automating the watering process to optimize oyster mushroom growth while reducing the need for manual labor.

METHOD

This study was conducted at the Electronics Laboratory and in the mushroom cultivation area of IKM Simbang Maros as a real-case study. The research design used in this study was experimental research, consisting of two stages: the design and manufacture of the automatic watering system and the testing and analysis of the system.

Observation and Literature Study

To support the understanding of the desired device's operation, direct observation surveys were conducted in the surrounding environment. Additionally, a literature review was conducted on optimal oyster mushroom cultivation processes and automation technology that can be applied.

Design Techniques

The working algorithm design of the device is presented in Figure 1. The process starts with the initialization stage, where the microcontroller is active and connected to the internet server. The DHT22 sensor detects temperature and humidity and displays the data every 2 seconds on the LCD, while updating the data every 15 seconds on the Thingspeak IoT platform. The pump will be activated if the humidity value is below the predetermined threshold of 85%, which has been found to be the optimal humidity level for oyster mushroom growth based on previous research. Temperature monitoring is also conducted during the process, but it is not used as a parameter for controlling the mist sprayer.

Figure 2 presents the block diagram of the automatic mist sprayer system for oyster mushroom cultivation. The system consists of an ESP32 microcontroller to process input and output components, a DHT22 sensor to read temperature and humidity data, an LCD and Thingspeak application on a smartphone to display data readings, and a relay to control the water pump. The water pump is turned on when the humidity level falls below the set threshold value of 85% and turned off when the humidity level reaches the optimal value for oyster mushroom growth.

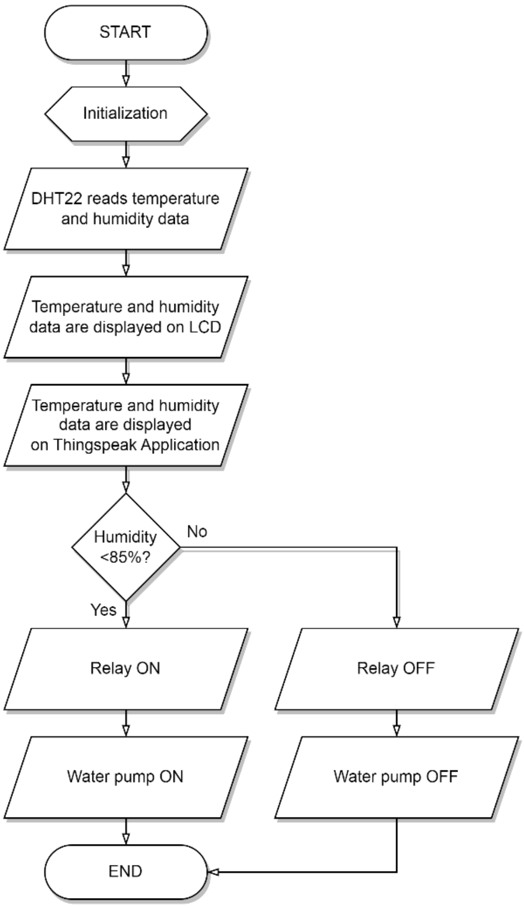

Figure 1. Algorithm program flowchart

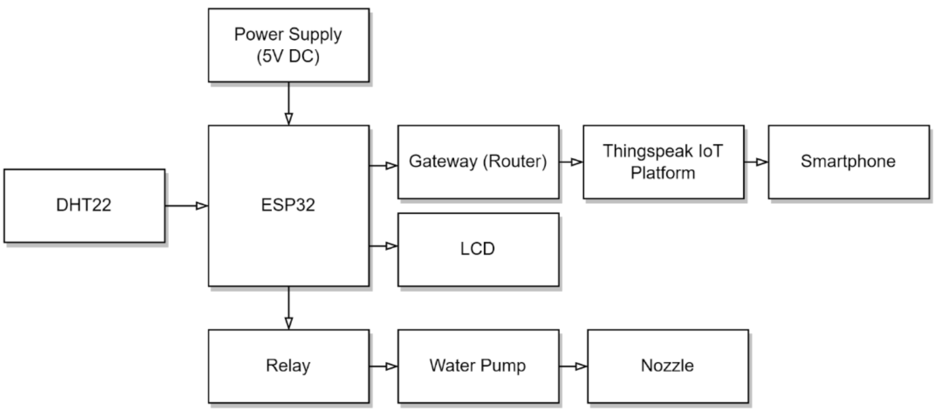

Figure 2. Block diagram of the automatic mist sprayer system

Data Analysis

This research involved tests and analyses, including testing the DHT22 sensor with a standard measuring tool, testing the performance of the automatic pump based on humidity conditions, and analyzing the data collected from Thingspeak using R Studio.

RESULT AND DISCUSSION

Hardware and Software Design

Figure 3 presents a wiring diagram generated by the Fritzing application, which illustrates the components involved in the system, namely a NodeMCU microcontroller, a DHT22 sensor, a relay, and a 16x2 I2C LCD. Figure 4 shows the automatic mist sprayer system for oyster mushroom cultivation, which operates based on the program uploaded to the microcontroller. The ESP32 processes the input received from the DHT22 sensor and the 12 Volt adapter, which serves as the power source, and produces a 5V output to activate the components according to the program. This involves triggering the relay to activate the water pump and using the I2C LCD to display the temperature and humidity conditions.

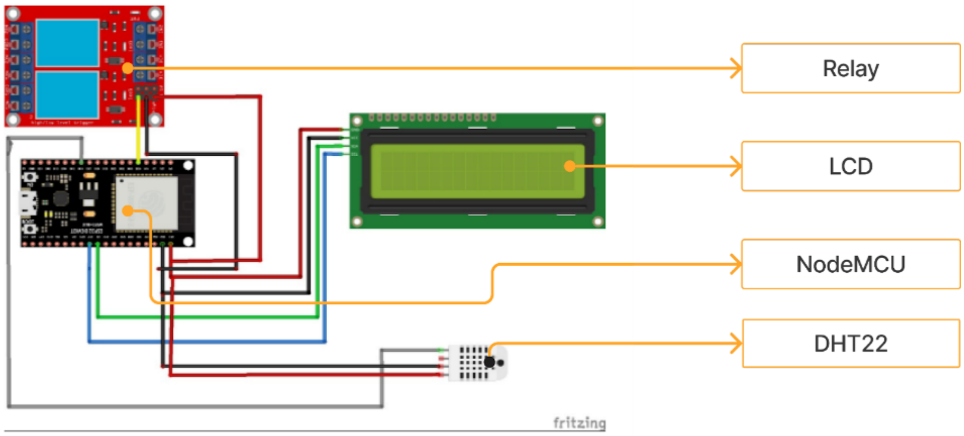

Figure 3. Wiring diagram of the automatic mist sprayer

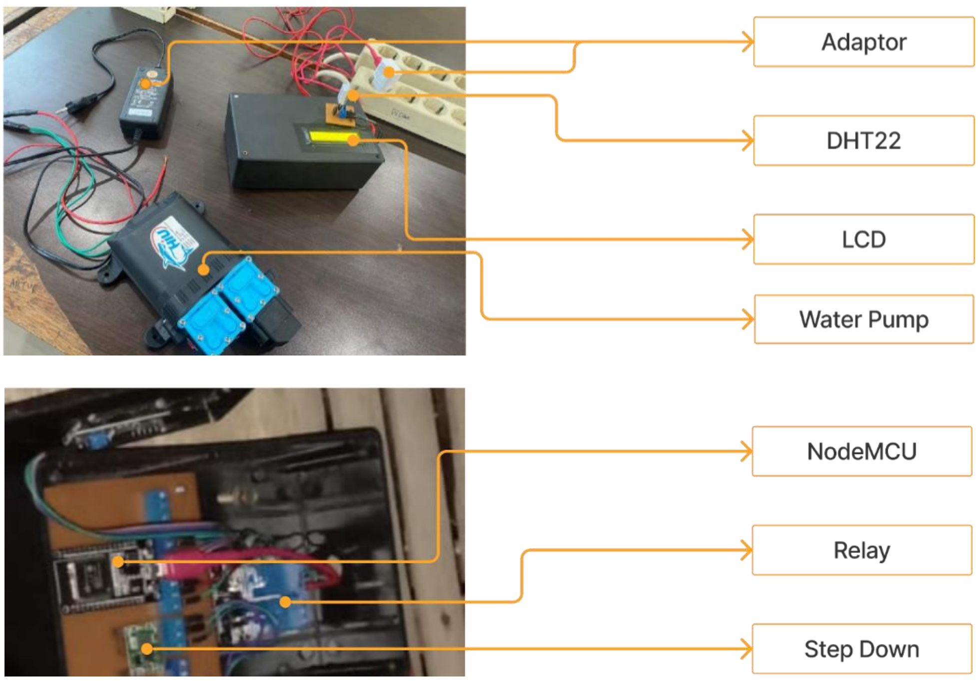

Figure 4. Components of the automatic mist sprayer

Figure 5 displays the installation of the developed device for oyster mushroom cultivation in IKM Simbang Maros. Meanwhile, Figure 6 shows the real-time monitoring of temperature and humidity data during the mushroom cultivation process. The data was collected using the device developed in this study and transmitted to the Thingspeak IoT platform. The figure displays the online visualization of the data, providing an instant overview of the current temperature and humidity levels in the cultivation area. This information can be used to ensure that the environmental conditions remain optimal for oyster mushroom growth.

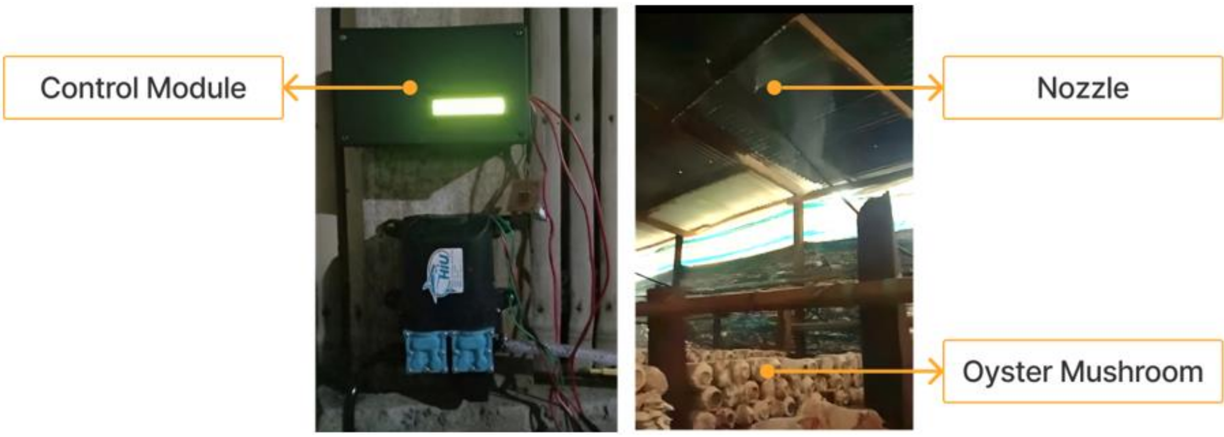

Figure 5. Installation of the device in mushroom cultivation

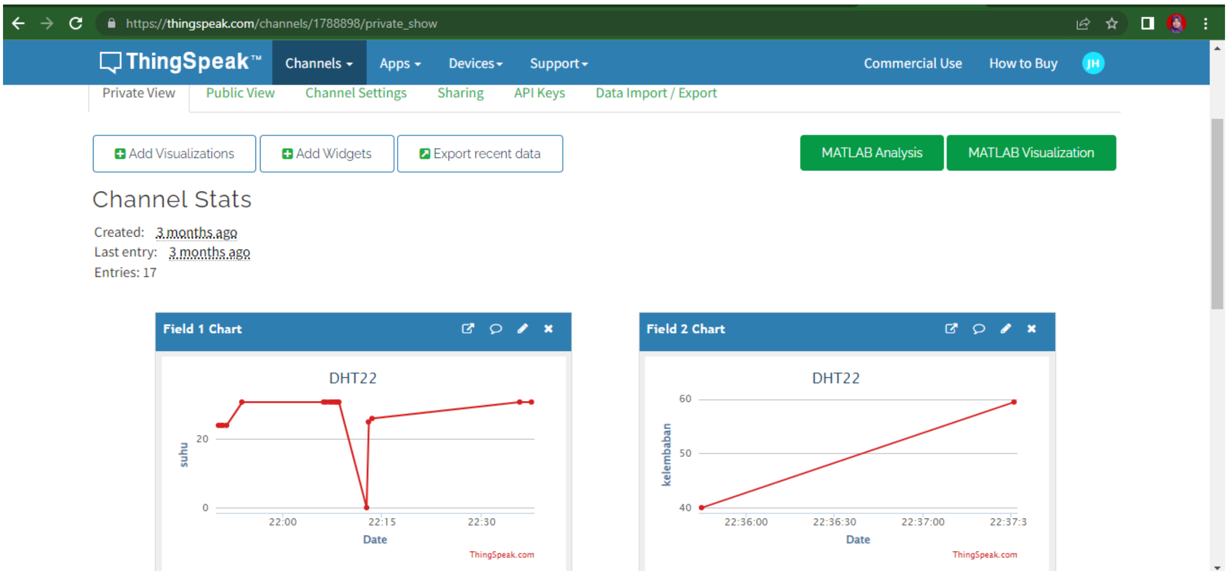

Figure 6. Temperature and humidity real-time monitoring using Thingspeak

Testing and Analysis

Table 1 presents the temperature measurement results of the oyster mushroom beds using the DHT22 sensor validated against the standard STC-3028 measurement tool. The average measurement error for temperature was found to be 2.08%, indicating an average accuracy rate of 97.92%. Similarly, Table 2 shows the humidity measurement results using the DHT22 sensor with validation against the standard STC-3028 measurement tool, with an average measurement error of 0.41% and an average accuracy rate of 99.59%. These results demonstrate the reliability of the DHT22 sensor in accurately measuring temperature and humidity levels in the oyster mushroom beds.

Furthermore, the data presented in Table 3 shows the performance of the automatic water misting system at the IKM Jamur Simbang Maros. The misting system was found to activate only when the humidity level in the mushroom bed was below 85%, while it was inactive when the humidity was 85% or above. Out of the 10 observations, the pump was active for 7 times and inactive for 3 times. These results indicate that the misting system was effective in maintaining the ideal humidity level for oyster mushroom cultivation, thus increasing the productivity of the cultivation process.

Table 1. Temperature sensor test result

No	Time	Temperature DHT22 (˚C)	Temperature STC-3028(˚C)	Error (%)	Accuracy(%)
1	00:14	30,0	29,3	2,39	97,61
2	00:15	31,0	30,4	1,97	98,03
3	00:16	29,5	28,9	2,08	97,92
4	00:17	31,1	30,6	1,63	98,37
5	00:18	31,5	30,8	2,27	97,73
6	00:19	30,8	30,3	1,65	98,35
7	00:20	31,1	30,5	1,97	98,03
8	00:21	31,1	30,4	2,30	97,70
9	00:22	30,7	30,0	2,33	97,67
10	00:23	32,8	32,1	2,18	97,82
Average				2,08	97,92

Table 2. Humidity sensor test result

No	Time	Humidity DHT22 (%)	Humidity STC-3028 (%)	Error (%)	Accuracy(%)
1	00:14	91,1	91,4	0,33	99,67
2	00:15	84,1	84,7	0,71	99,29
3	00:16	87,0	87,4	0,46	99,54
4	00:17	84,1	84,5	0,47	99,53
5	00:18	82,4	82,7	0,36	99,64
6	00:19	82,0	82,5	0,61	99,39
7	00:20	81,7	81,7	0,00	100,00
8	00:21	80,7	80,9	0,25	99,75
9	00:22	87,2	87,8	0,68	99,32
10	00:23	77,8	78,0	0,26	99,74
Average				0,41	99,59

Table 3. Performance test result

Test	Temperature DHT22 (°C)	Humidity DHT22 (%)	Pump Status	Control Validation
1	30,0	91,1	OFF	Yes
2	31,0	84,1	ON	Yes
3	29,5	87,0	OFF	Yes
4	31,1	84,1	ON	Yes
5	31,5	82,4	ON	Yes
6	30,8	82,0	ON	Yes
7	31,1	81,7	ON	Yes
8	31,1	80,7	ON	Yes
9	30,7	87,2	OFF	Yes
10	32,8	77,8	ON	Yes

Real-time monitoring and data collection of temperature and humidity using the IoT Thingspeak platform was conducted for one week, from September 18 to 24, with data updates recorded every 15 seconds. Subsequently, the data was analyzed using R studio to collect and observe long-term data to assess the stability of temperature and humidity levels over an extended period. The collected data were analyzed to evaluate the consistency and stability of these environmental factors in the oyster mushroom cultivation area.

Figure 7, Figure 8, and Figure 9 present the collected data of temperature, humidity, and pump status during a 50-minute observation period on September 22, 2022, from 00:07 to 00:57 WITA, at the IKM Jamur Simbang. These figures offer valuable insights into the correlation between the spray system, humidity levels, and temperature conditions, providing a comprehensive view of the cultivation environment.

Upon analyzing the data, it is evident that during specific minutes, such as 15, 18, 19, 20, 22, 23, 24, 25, 26, 48, and 49, the humidity levels in the mushroom bed dropped below the predefined threshold of 85%. As a result, the pump was triggered to activate and spray the mushroom bed, ensuring adequate moisture levels for optimal growth.

Additionally, it is worth noting that although the focus of the study primarily revolves around humidity control, an incidental observation regarding temperature can be made. During the periods when the spray system was active, a slight decrease in temperature was observed. This can be attributed to the cooling effect of the water mist, even though the temperature did not reach the ideal conditions for oyster mushroom growth. This correlation between the spray system, humidity levels, and the subsequent temperature decrease highlights the multifaceted effects of the misting process on the mushroom bed's environmental conditions.

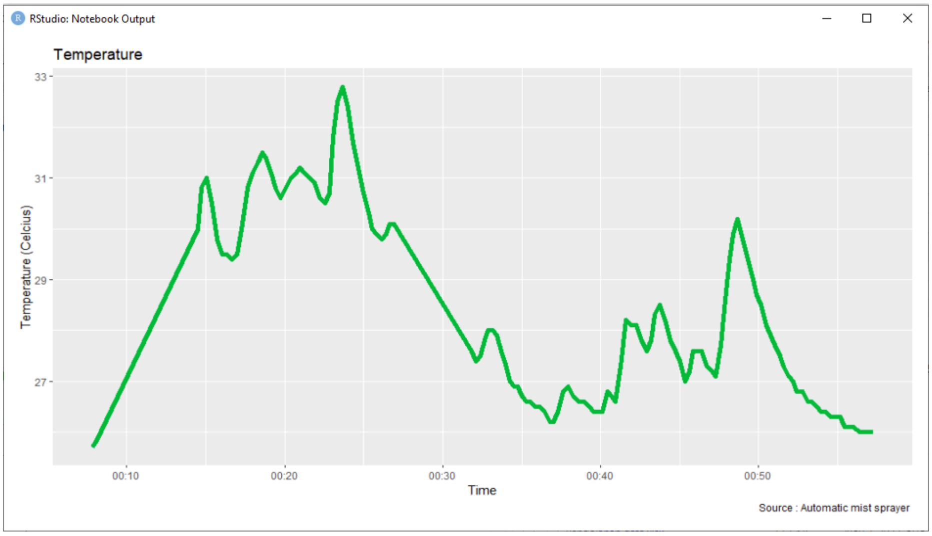

Figure 7. Temperature data using R Studio

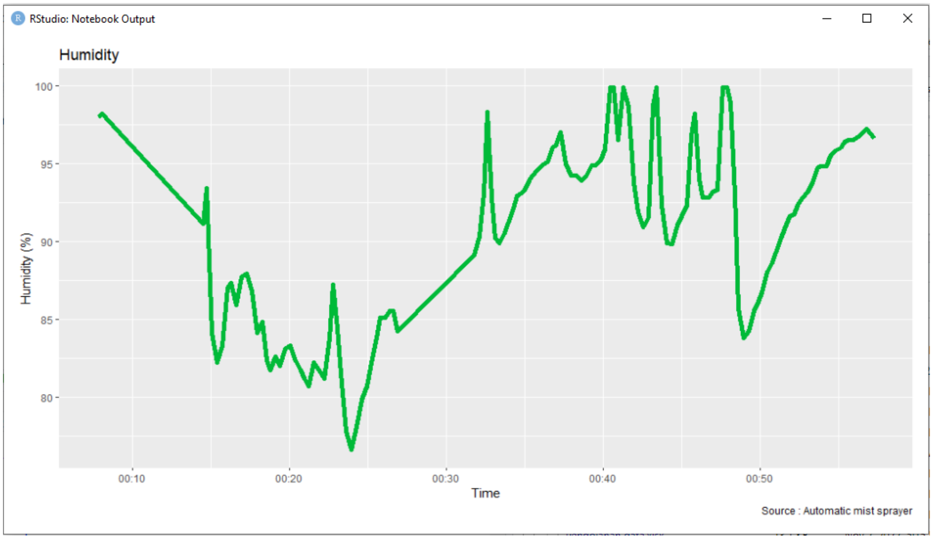

Figure 8. Humidity data using R Studio

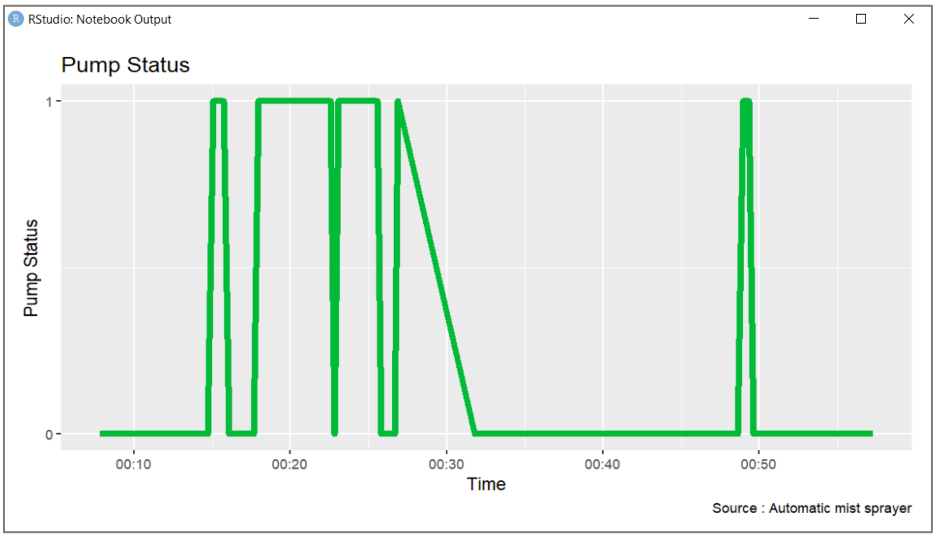

Figure 9. Pump status data using R Studio

CONCLUSION

The study has successfully designed and developed an automatic mist sprayer for oyster mushroom cultivation using the Thingspeak IoT platform. Real-case testing of the device in oyster mushroom cultivation at IKM Simbang Maros showed that the device functioned well, where automatic watering occurred if the humidity value fell below 85%, and the pump remained inactive when humidity in the mushroom greenhouse reached 85% or more. The pump was active for 7 out of 10 observations, while it was off for the remaining 3. The data collected and analyzed through Thingspeak using R Studio showed that the device was able to stabilize the optimal humidity level required for oyster mushroom growth, as evident from the data graph history of humidity data. The results suggest that the developed device has the potential to increase productivity and ease the process of oyster mushroom cultivation.

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