Research and Innovation in Technical and Vocational Education and Training Vol. 2 No. 2 (2022) 012-021
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RITVET

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/ritvet
e-ISSN: 2785-8138

Green Technology Monitoring System for Oyster Mushrooms

Siti Sri Noraini Ta'ahal [1], **Alias Masek**[1*], **Yusmarwati Yusof**[1]

[1] Faculty of Technical and Vocational Education,
University Tun Hussein Onn Malaysia, Parit Raja, 86400, BATU PAHAT

*Corresponding Author Designation

DOI: https://doi.org/10.30880/ritvet.2022.02.02.002
Received 12 August 2020; Accepted 30 August 2022; Available online 30 September 2022

Abstract: The use of IoT technology in modern agriculture is growing rapidly, especially in the agricultural sector. The agricultural sector, including oyster mushroom plantation, faces the problem of supplying sources. Among the problems is increasing of electricity bills when they want to apply technology system in oyster mushroom house because several things that need to be controlled related to ambient which is humidity and temperature in the mushroom house. The project was to design automatic Green Technology Monitoring System to control an ambient temperature of oyster mushroom house and develop a mushroom house power supply system using photovoltaic (PV) solar energy. It is also to test the functionality of an automatic temperature control system using the photovoltaic (PV) solar energy. This Oyster Mushroom Care Monitoring Green Technology System uses a DHT22 sensor to detect humidity and ambient temperature in the mushroom house and an ultrasonic sensor to detect the water tank level. The system operates when the DHT22 sensor detects a temperature above 30˚C or a humidity of less than 70%, then a 12V DC water pump act to water the mushroom chunk. Programming uses an Arduino with the C language, uses the NodeMCU ESP8266 as a microcontroller and sends temperature, humidity and water tank level data to the Blynk application. For the supply source using 25W solar panel, 12V 7.0Ah battery, 10A solar controller and 12V inverter to accommodate the system that uses power of 3.75Wh. Overall, this system is able to operate with solar energy supply well and facilitate the work of monitoring condition in the mushroom house.

Keywords: Oyster Mushroom, Green Technology, Solar Energy, Blynk Application, Wi-Fi Module NodeMCU ESP8266, DHT22 Sensor, Ultrasonic Sensor

1. Introduction

One of the contributors to the income of farmers in Malaysia as well as contributing to the improvement of the agricultural sector in Malaysia is the farming of grey oyster mushrooms. The farming of oyster mushrooms is able to provide high profits because it has a high demand not only in the local market but also around the world. The use of technologies such as Internet of Things (IoT) in

*Corresponding author: aliasmasek@uthm.edu.my

modern agriculture and the use of green technology is growing rapidly used mainly in the agricultural sector. The use of technology has been widely implemented in the modern agricultural sector such as the use of drones in the plantation sector, intelligent caged cattle breeding systems and modern machine-based oil palm cultivation. The use of technology can automatically increase the quality of products and can be sold at a high price as well as make the farming process more systematic which in turn can contribute a worthwhile income to farmers. Application of green technology by using solar energy as an energy source also seen to be able to make farming more efficient as well as to reduce the cost of electricity bills for farmers, especially for the long term.

The grey oyster mushroom is one of the Pleurotus species that has a relatively high temperature and can be grown in the lowlands (Rosnina, 2016; Bria, et. al., 2016). Therefore, the farming of this grey oyster mushroom does not require plant in hilly areas. Humidity mushroom house control factors where humid and cold temperatures are controlled are among the important elements for the farming of grey oyster mushrooms. To control the humidity of the mushroom house, most operators build mushroom houses with wood and nets and cement floors so that the system can be well ventilated to carry out the mushroom growth process well without any insects and diseases. This is because a good and clean mushroom house handling can prevent pest attacks. The basic requirements for mushroom growth are ambient temperature of less than 30˚C, relative humidity, carbon dioxide (CO_2), light and good airflow in the mushroom house.

1.1 Problem statements

Due to the high demand of grey oyster mushrooms in Malaysia (Rosnina, 2016), the production of mushrooms is increasing while maintaining the quality of the mushrooms has also been emphasized. However, the care of oyster mushrooms in Malaysia still uses the old methods in the agricultural sector, especially to control the environment that is suitable for the farming of the mushrooms to grow and good size of oyster mushrooms. Thus, the method of farming grey oyster mushrooms was involved several specifications that need to be complied with where the climate conditions in Malaysia are constantly changing causing abnormal and slow growth of mushrooms. Some problems have been identified as follows:

i. Due to the growing demand to produce high quality mushrooms it is necessary to control the humidity of the mushroom house environment to achieve the appropriate temperature. However, oyster mushroom operators still use conventional methods by conducting regular monitoring and causing a waste of time and energy to perform monitoring activities. Indirectly there will be inefficient monitoring in terms of work and time management.
ii. Operators may overlook and forget to monitor as well as control the temperature and eventually it is not carried out consistently in the mushroom house. Finally, mushroom cannot be produced with the desired quality such as less and small weight and size of mushrooms.
iii. In order to lower the temperature and control the humidity, human energy was used to watering the mushroom house. Indirectly, will involve wastage of water when do watering manually.
iv. To control the humidity and ambient temperature of the mushroom house there are operators using other alternatives, but the device is found to have high operating costs where it uses a lot of electricity consumption rate, in turn resulting in high monthly electricity bills.

1.2 Research Objective

Based on the background and problem statement, below are the objectives of the study that have been identified to ensure that the purpose of the study can be achieved:

i. Design an automatic ambient temperature control system of oyster mushroom house.
ii. Develop a mushroom house power supply system using photovoltaic (PV) solar energy.
iii. Test the functionality of an automatic temperature control system using photovoltaic (PV) solar energy.

2. Methodology

The Design Thinking Model was chosen as the methodology to develop the Oyster Mushroom Care Monitoring Green Technology System. This model is a practical method especially in the development of products and services that aims to solve more creatively the problems encountered. In addition, this model also aims to find innovative answers to the problems faced by focusing on the real needs of users. The Design Thinking Model is used to perform the develop process for this project and it has five (5) main phases in product development such as the empathy phases, define phases, ideate phases, prototype phases and testing phases.

2.1 The empathy phases

In this phase it is aimed to gather the information needed in the development of grey oyster mushroom monitoring products by identifying the problems faced the farmers. To know in more detail and understand the problems in the monitoring of oyster mushrooms, an interview session was conducted with one of the grey oyster mushroom entrepreneurs in Parit Raja, Johor. Through the interviews, among the problems identified were shortage of manpower to watering the mushroom house to maintain its moisture. Besides that, it is also requiring regular monitoring to check the temperature and humidity around in the mushroom house to produce high quality oyster mushrooms. They need to come to the mushroom house to read the temperature and humidity in the mushroom house. In addition, high electricity consumption if an ambient control system to be installed in the mushroom house.

2.2 Define Phases

In this phase, based on the problems faced by entrepreneurs, more depth analysis has been done that related to the purpose of product development from the technical aspects, product requirements and functionality as well as technical requirements and product development capacity. The purpose of this project is to solve problems in the agricultural sector in small and medium enterprises (SMEs).

2.3 Ideate phases

In this phase, focuses on the designing a prototype for temperature and humidity control system sourced from green technology as well as identifying the components used and the area where the system will be built.

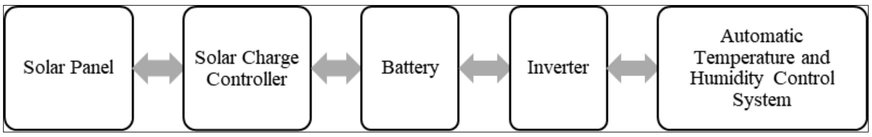

Figure 1: Solar PV Power Supply Block Diagram.

Based on Figure 1, the connection of solar PV power supply starts from the solar panel 25W 6V connected to the solar charge controller 10A. Then from the solar charge controller is connected to the battery with capacity 12v 7.0Ah before connecting directly to the inverter to convert direct current (DC) to alternating current (AC) to supply to the system. The selection of the battery capacity used is able to drive the operation of the system lasting up to three (3) days without recharging. It is found that the overall power consumption of the system in a day is approximately 7.35 W/h. Next, the quantity of batteries and solar panels have been identified that is the quantity of batteries used is one (1), while the quantity of solar panels that need to be used is also one (1), to charge the battery quickly.

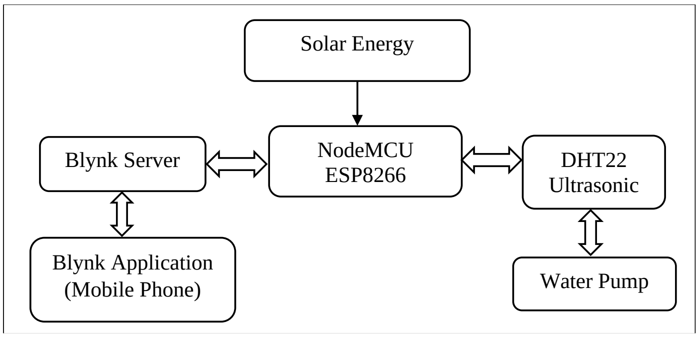

Figure 2: Block Diagram of the Green Technology Monitoring System for Oyster Mushrooms.

Based on Figure 2, the initial operation is from the supply source which is obtained from the solar energy source directly into the NodeMCU ESP8266. Next, a DHT22 sensor is used to detect the ambient, humidity and temperature. While an ultrasonic sensor is used to detect the level of the water storage tank. The entire system sensor will operate according to the instructions set on the NodeMCU ESP8266 which is guided by the temperature and humidity detected using DHT22, while the ultrasonic sensor will detect the level of the water storage tank. The power supply is divided into two channels. A 12VDC power supply is supplied to the water pump control circuit while another power supply is lowered by using a relay to 7V for supply to the ESP8266 NodeMCU. Next, the display on the Blynk app will display the current ambient temperature and the water pump will work automatically in three (3) second if the DHT22 sensor detects a temperature above 30˚C or a humidity of less than 70%. Then, the Blynk server will act as a receiver of information from the NodeMCU ESP8266 where it will receive temperature and humidity data of the current mushroom house environment. The received data will be displayed on the mobile phone via the Blynk application.

2.4 Prototype phases

In this phase, a product prototype will be built based on the system design that has been developed and applied in mushroom house. All the data will be displayed on the mobile phone via the Blynk application as shown in Figure 3.

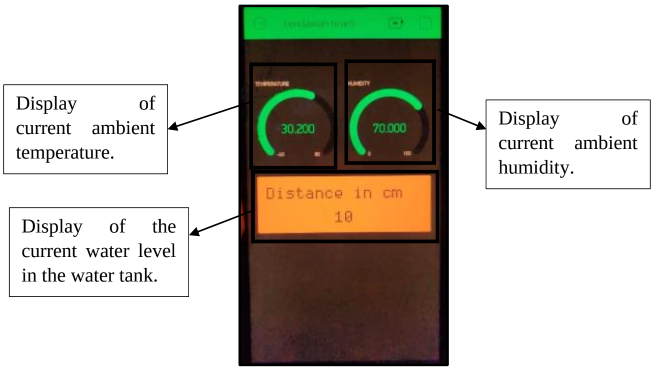

Figure 3: Display of the Blynk app.

The Figure 4 shows overall component position of the system, which is the ultrasonic sensor that placed on the tank cover and its position should be opposite to the water by facing down to detect the distance between the water and the water tank cover and the DHT22 sensor that was placed on the mushroom rack to detect the temperature and humidity around the oyster mushroom chunks. Meanwhile, the water channel is fastened to the iron of the mushroom rack with a position on the body of the oyster mushroom chunk, and the solar panels are placed in open areas that can receive a lot of sunlight.

Figure 4: The Prototype of Green Technology Monitoring System for Oyster Mushrooms.

2.5 Testing Phases

In this section some testing has been done on the developed product. The testing carried out consists of engineering analysis that involves testing the system circuit, namely the functionality of the system and solar power supply. Whilst, expert analysis is done to focus on product design aimed at ensuring that the product design developed is appropriate to the environmental conditions of the mushroom house.

3. Results and Discussion

The results and discussion section presents data and analysis of the system. All the data and the results organized in the table form. All the data of results analysis were taken when the system was applied to a mushroom house.

3.1 Analysis of Solar Power Supply

Analysis toward solar power supply aims to find out the input power that can recharge the battery in a day. The Isc data obtained is then multiplied by the maximum voltage on the battery which is 12V to get the total power received from the solar panel. Results are identified an average of 47.12Wh was produced in a day by the panel to recharge the battery. Table 1 and Table 2 display the details of the analysis.

Table 1: Power Supply Analysis of Solar Panels.

Day	Information	Data			Weather
		1	2	3	
1	Voc (V)	6.65	7.03	6.45	Sunny
	Isc (A)	3.41	4.46	3.72	
	Pin (W)	40.92	53.52	44.64	
2	Voc (V)	6.82	7.10	6.41	Sunny
	Isc (A)	3.4	4.78	3.62	
	Pin (W)	40.80	57.36	43.44	
3	Voc (V)	6.73	7.04	6.51	Sunny
	Isc (A)	3.62	4.56	3.77	
	Pin (W)	43.44	54.72	45.24	

Table 2: Analysis of Total Charge Input of Solar Power Supply

Day	Pin (W)			Total Power (W) In A Day	Total Power Per Hour (Wh)
	1	2	3		
1	40.92	53.52	44.64	139.08	46.36
2	40.80	57.36	43.44	141.60	47.20
3	43.44	54.72	45.24	143.4	47.80
Average Power Per Hour (Wh) In A Day					47.12

3.2 Analysis of DHT22 Sensor Module

The Table 3 shows the DHT22 sensor module used on the system and the readings taken on digital thermo hygrometer that used on the mushroom house to find out the percentage difference or better known as the error to find out the readings on the system are accurate or not. Based on Table 3, the result shown that only 2.7% difference in error for temperature readings for the two components. Meanwhile, only 2.5% error difference for environmental humidity readings. Overall, the difference in error percentage for both temperature and humidity readings is still acceptable because it is found that the difference is not too much.

Table 3: Analysis of DHT22 Sensor Module.

Time	Termo Hygrometer		DHT22		Different Error (%)	
	Temperature (°C)	Humidity (%)	Temperature (°C)	Humidity (%)	Temperature	Humidity
10.00	25.90	84.00	25.80	83.90	0	0
11.00	28.80	73.80	28.60	73.20	1	2
12.00	29.60	68.00	28.70	67.80	3	1
13.00	31.00	67.00	31.80	67.90	3	3
14.00	30.30	66.40	31.60	67.70	5	5
15.00	28.70	78.70	28.80	79.80	4	4
Average Error (%)					2.7%	2.5%

3.3 Analysis on Oyster Mushroom House Ambient Control

The analysis was conducted to evaluate the functionality of the water pump to pump water for five (5) seconds according to the temperature and humidity set for the DHT22 sensor. Based on Table 4, it can be seen that water pumping will work when the DHT22 sensor detects temperatures above 30 or humidity below 70.

Table 4: Ambient Control System

No.	Temperature (°C)	Humidity (%)	Water Pump
1.	30.2	70	Not Function
2.	29	70	Not Function
3.	30.1	71	Not Function
4.	31.5	63.3	Function
5.	30	62	Function
6.	31.2	70	Function

3.4 Analysis on the Design and functionality of the Green Technology Monitoring System for Oyster Mushrooms

The testing phase done by validation from experts to ensure that the product developed meets the main requirements. Four (4) experts has been selected to test the Green Oyster Mushroom Care Monitoring Technology System to evaluate product design, product functionality and product commercial potential. Overall, all the expert agreed on all items.

i. Design Aspect of Green Technology Monitoring System for Oyster Mushrooms.

Table 5: Evaluation of the Design Aspect by the Experts

No.	Item	Yes		No	
		Total	%	Total	%
1	The specifications of the power source used are appropriate for use.	4	100	0	0
2	The overall layout of the system corresponds to the conditions of the mushroom house.	4	100	0	0
3	The DHT22 sensor used to detect humidity and temperature in a mushroom house is suitable for use.	4	100	0	0
4	Ultrasonic sensor used to detect the level of water tanks are suitable for use.	4	100	0	0
5	The data display mechanism used in the Blynk application is easy to understand and convenient to use.	4	100	0	0
6	The prototype developed safe to use.	4	100	0	0

Based on Table 5 shows there are six (6) items had been asked to the experts through the system evaluation checklist. The result from the checklist show all of them agreed with all of the items. The output mechanism has received full rating from experts.

ii. Functionality Aspects of Green Technology Monitoring System for Oyster Mushrooms.

Table 6: Evaluation of the Functionality Aspect by the Experts

No.	Item	Yes		No	
		Total	%	Total	%
1	The capacity of the solar energy supply source can supply sufficient electricity.	4	100	0	0
2	The supplied solar energy source can be used efficiently to operate the entire system.	4	100	0	0
3	The Blynk app can display current temperature and humidity readings.	4	100	0	0
4	The Blynk app can display water tank level readings.	4	100	0	0
5	The water pump works for 5 seconds and water drips on the mushroom chunks when the temperature exceeds 30°C and the humidity is less than 70.	4	100	0	0

Based on Table 6 shows there are five (5) items had been asked to the experts through the evaluation checklist. The results show all of them are agreed with all of the items. So for that reasons, experts has given 100% rating to this product as well.

iii. Commercial Potential of Green Technology Monitoring System for Oyster Mushrooms.

Table 7: Evaluation of the Commercial Potential Aspect by the Experts

No.	Item	Yes		No	
		Total	%	Total	%
1	Able to save electricity consumption and electricity bills.	4	100	0	0
2	Facilitates the process of monitoring the temperature and humidity in the mushroom house.	4	100	0	0
3	Facilitates the automatic watering process when the temperature and humidity are not at the appropriate level.	4	100	0	0
4	Able to maintain the quality of mushrooms produced.	4	100	0	0
5	System easy to use.	4	100	0	0

They are also five (5) items had been asked to the experts through the system evaluation checklist. Based on Table 7, shows that all of the experts agreed with all of five items. So all of the experts agreed that this system has commercial potential, which indicated that this product has a great potential to penetrate the market.

4. Discussions

In this section, the result was discussed based on the objectives that has been stated for this research study.

4.1 Designing an Automatic Ambient Temperature Control System for Oyster Mushroom House.

Based on a study conducted by Sihombing, et al. (2018), the developed product has used the Bluetooth module HC-05 to make the connection between the phone and the micro-controller and found that the use of this module can only be controlled at a limited radius. Therefore, for this study, the automatic control of the ambient temperature of the environment has applied technology to further facilitate operators to monitor and control remotely via mobile phones using components such as the NodeMCU ESP8266 micro-controller connected to WiFi in the system which serves as the main control component on the entire system that helped in developing this automatically controlled system.

Improvements are made from existing products to detect the ambient temperature and humidity of the mushroom house. Based on product by Sihombing, et al. (2018), the system that used HSM-20G sensor which is the sensor can respond very slow and send the data after a minute. Next, Cikarge and Arifin (2018) developed products using DHT11 sensors to detect moisture. Research by Setiawati, et al. (2021) also used DHT11 sensor to detect the ambient of the mushroom house. But the use of DHT11 sensor detected temperature and humidity data is less accurately and has a limitation of sensor values. Therefore, in this study the DHT22 sensor used to detects humidity and temperature in the mushroom house. This is because, based on the comparison made between DHT22 and thermo hygrometer, the data generated on the DHT22 sensor is accurate and on average has only 2.7% error for detecting temperature and 2.5% for detecting humidity. The study made by Agustianto, et al. (2021) has used a MySQL application to display temperature and humidity data on a mobile phone. However, the use of MySQL is found to be costly in the development of this system. Therefore, the Blynk application was used for monitoring work in the mushroom house. This is because, control development on Blynk applications is save cost and easy to operate. Nevertheless, experts recommended to put a display on the system inside the mushroom house by adding a LCD display to display the ambient of the mushroom house.

4.2 Develop a mushroom house power supply system using photovoltaic (PV) solar energy.

Based on previous studies by Mohammed, et al. (2018), it was found that products developed use electricity supply sources instead of using solar energy supply sources. Research by Mohammed, et al. (2018) have developed a system that used a lot of output and in return requires more energy consumption especially the use of light sensor using a power of 50W. Thus, the power consumption of the system developed by Mohammed, et al. (2018) is very high because the power consumption is as much as 50W for the light sensor component only and it does not include the power consumption for the other components.

Therefore, Green Technology Monitoring System for Oyster Mushrooms have developed systems that use a minimum power consumption and at the same time use minimum cost for the development of the entire system. The system only used a total power consumption of 7.35W/h and can operate non-stop 24 hours with a solar energy supply source. Thus, the system will always operate with the use of 100% power supply from the solar power supply system. This solar power supply can accommodate the operation of the developed system for three (3) days without sunlight. However, experts suggested to adding indicators on the mobile phone app to see the current solar battery capacity so that users can know the current battery capacity without go to the mushroom house.

4.3 Test the functionality of an automatic temperature control system using photovoltaic (PV) solar energy.

The testing phase by validation from experts to ensure that the product developed meets the main requirements. The experts have been selected to evaluate product design, product functionality and product commercial potential. Overall, all the expert agreed on all items. For designing of green technology monitoring system for oyster mushrooms, we also adapt ideas from Mohammed, et al. (2018), in terms of types of the sensors to opt the output mechanism. Meanwhile for functionality aspects, all of the experts agreed with all of the items. Similarly, the product from Setiawati, et al. (2021), water pump were used to control the temperature of the mushrooms house by running water on the roof of the mushrooms house were affective as this product.

Interm of commercial potential of green technology monitoring system for oyster mushrooms. All of the experts agreed taht this system has commercial potential. In the future, high demands are expected for the agricultural product with IoT system according to Agustianto, et al. (2021). Therefore, this product has a great potential to penetrate the market.

5. Conclusion

This prototype is developed to monitor the ambient of grey oyster mushroom house for SME entrepreneurs by developing automatic humidity and temperature control system, and subsequently mobilizing air irrigation system using solar energy to control the ambient of mushroom house. In return, the system can save excessive water consumption and maintain the quality of mushrooms while reducing the operation cost of electricity bills. Thus, entrepreneurs will be able to increase income as a result of the increasing in quality of mushrooms. The impact, this product facilitates the watering process during high temperatures for mushroom house to avoid risk of damage to the mushroom lumps. This product also using 100% of the electricity supply from the solar energy with minimum cost, subsequently, improve the quality of grey oyster mushrooms.

Acknowledgement

A special thanks to Faculty of Technical and Vocational Education, University Tun Hussein Onn Malaysia.

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