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Design of Greenhouse Prototype Controller and Monitor on Green Mustard Plants IoT

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***Abstract*— The prototype greenhouse control and monitoring system for green mustard plants is expected to facilitate greenhouse farmers in farming activities. Control and monitoring are carried out on the intensity of incoming sunlight, greenhouse temperature, greenhouse humidity, and soil moisture. The control and monitoring system is carried out by ESP32, BH1750 sensor, DHT22 sensor, and soil moisture sensor. The control process is assisted by an actuator that will turn on and off automatically according to the value limits entered by the greenhouse owner and the readings from the sensor. The control and monitoring device uses Blynk IoT which is connected to an IoT connection. The purpose of this study is to describe the design process of the controller and monitor of the prototype greenhouse for green mustard plants based on the IoT and to find out the results of the controller and monitor of sunlight intensity, air temperature, air humidity, and soil moisture on green mustard plants in the greenhouse. This study uses quantitative descriptive research. The results of this study are the realization of a prototype greenhouse control and monitor for green mustard plants based on the IoT with the main control system being ESP32. The results of the calibration values of the 4 sensor variables are very satisfactory and can be considered as valid tools. The R_square values of the 4 sensor calibrations, namely the BH1750 light sensor, DHT22_1 temperature sensor, DHT22_2 temperature sensor, DHT22_1 humidity sensor, DHT22_2 humidity sensor, and soil moisture sensor are respectively 0.9936; 0.9689; 0.9665; 0.9412; 0.9451; 0.9574.**

Index Terms*— Controller; Monitor; ESP32; Blynk Iot; Internet of Things.

I. Introduction

Green mustard greens are a type of mustard greens or brassicaceae that is quite popular. Also known as caisim, caisin, or bakso mustard greens, this vegetable can be eaten fresh or processed into pickles, lalapan, and various other dishes[1]. Traditional farmers tend to still plant mustard greens in open environments. As a result, during the rainy season, mustard greens are susceptible to rainwater and are susceptible to disease. While during the dry season, the quality of mustard greens can decrease due to exposure to temperatures that are too high. This requires innovation related to the creation of a new environment that is separated from the outside environment and in accordance with the needs of the growth of mustard greens. One solution is to create a new climate environment that can be implemented by using greenhouse farming.

Greenhouse is a structured building that aims to create environmental conditions that suit the needs of existing plants[2]. A greenhouse is a medium that is isolated from the outside environment, which causes the temperature, humidity, and light intensity trapped inside the greenhouse to be different from the outside environment[3]. Greenhouses are made of transparent materials such as transparent plastic or glass so that sunlight can enter the building[4]. Greenhouses are made with the aim of creating an optimal artificial microenvironment with the growth of a plant[5]. Planting in a Greenhouse is one way to increase agricultural productivity, because in a greenhouse environmental condition, such as: humidity, temperature, light and irrigation in the greenhouse can be controlled[6].

Controlling and monitoring in the greenhouse can be done automatically using IoT. The IoT can be described as a connected network consisting of several interconnected components that form a system and enable the network to detect, capture, distribute, and analyze data[7]. The concept of the IoT can be applied to the ESP32 which is connected to several sensors and actuators that act according to the logic system expected by the user. The use of the IoT can be used to control the intensity of sunlight, room temperature, room humidity, and soil moisture in the greenhouse. This control can be used by automating the opening and closing of the roof, plant lights, plant fans, plant foggers, and plant pumps.

ESP32 is a low-power microcontroller that is useful for developing IoT projects. ESP32 has built-in Wi-Fi and Bluetooth, so no additional modules are needed. This tool is capable of accommodating many sensors and devices with a total of 48 GPIO pins[8]. Blynk IoT is one of the interface platforms that can be used to control and monitor microcontroller projects from Android and IOS[9]. The BH1750 sensor is a sensor used to measure light intensity in lux units[10]; [11].

The DHT22 sensor is a sensor that is capable of measuring temperature with a range of values between -40° C to 125° C and air humidity with a range of values between 0% to 100%[12]. The soil moisture sensor has a function to detect the moisture content of water in the soil[13].

II. Methods

A. System Block Diagram

As can be seen in Fig. 1 there is information about 3 parts that communicate with each other. The first part is the remote control block. There is Blynk IoT which functions as a controller and monitor carried out by the greenhouse owner and there is also Gmail which functions to receive sensor reading reports by the greenhouse owner and also functions to send messages that the system is in error to the greenhouse technician. The second part is the software block. There is Arduino IDE which functions to enter code into ESP32 and there is also Blynk Cloud which functions as a virtual communication intermediary between ESP32 and Blynk IoT and Gmail. The third part is the hardware block. There is ESP32 as the control center and main control system, there is a BH1750 sensor, DHT22 sensor, and soil moisture sensor, there is also a stepper motor actuator, lights, foggers, and water pumps.

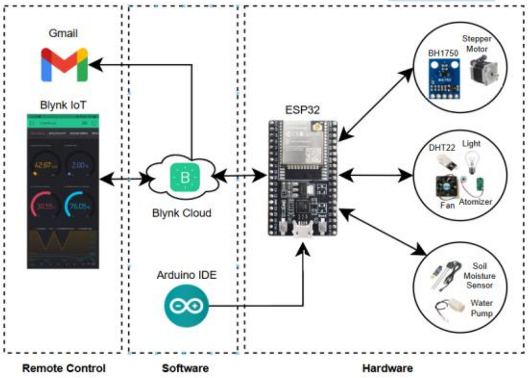

Fig. 1. System Block Diagram

B. Schematic Diagram

In Figure 2 there is an ESP32 that functions as a control center and decision-making center. The ESP32 is connected to several sensors, namely the BH1750 sensor functions to read the intensity of sunlight, the DHT22 sensor functions to read the temperature and humidity of the room, and the soil moisture sensor functions to read the humidity of the soil. There are also several actuators, namely the Nema 17 stepper motor functions to open and close the greenhouse roof made of paranet, the 12V DC lamp functions to replace the role of sunlight, the 5V DC fan functions to circulate the air in the greenhouse, the 5V DC fogger functions to humidify the greenhouse, and the 5V DC pump functions to water the plants.

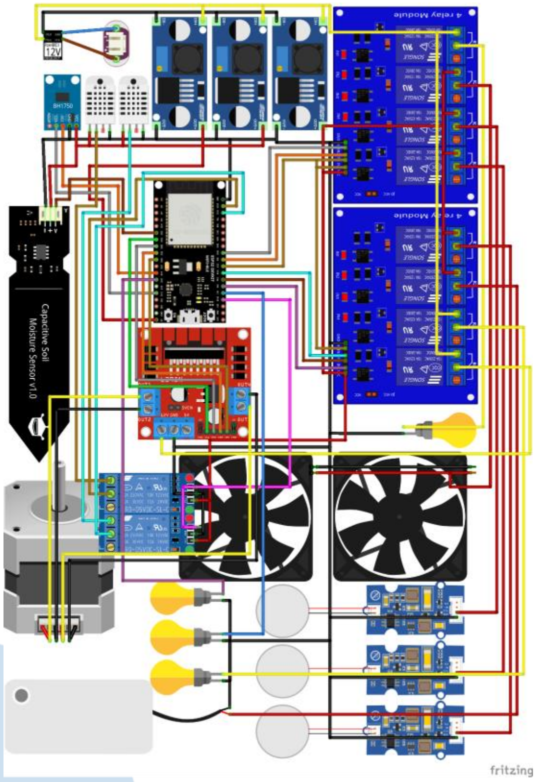

Fig. 2. Schematic Diagram

C. Greenhouse Design, Sensor Placement, and Actuators

In this section, we will explain the greenhouse design from different observation positions. There are also sensor and actuator placement positions in this greenhouse design. The size scale used in drawing this design has been adjusted to the comparison of the original design. The design of the greenhouse will be explained in the Fig. 3 – Fig. 8.

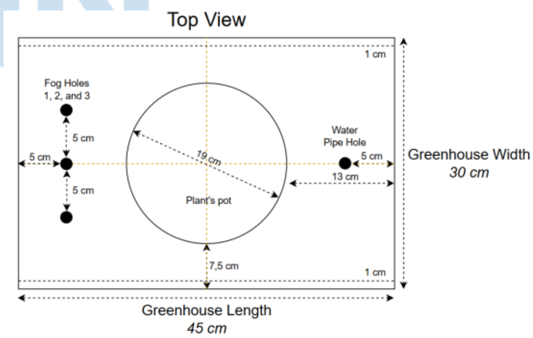

Fig. 3. Greenhouse Design: Top View

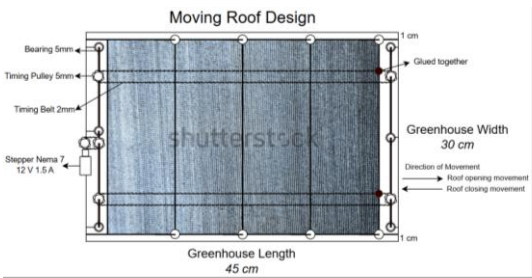

Fig. 4. Greenhouse Design: Moving Roof Design

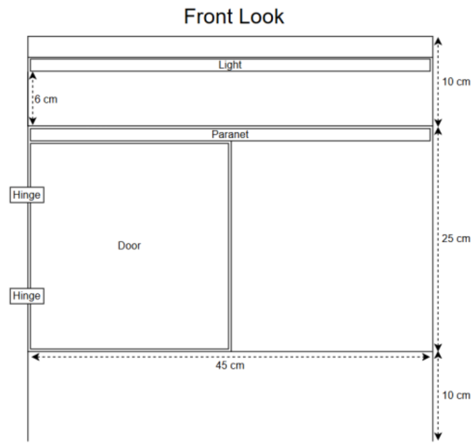

Fig. 5. Greenhouse Design: Front Look

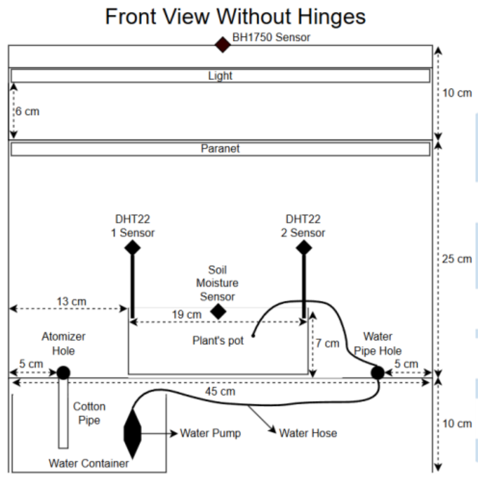

Fig. 6. Greenhouse Design: Front View Without Hinges

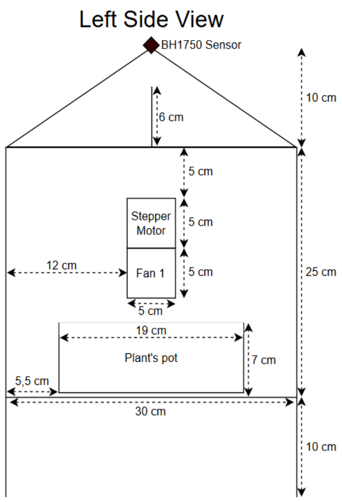

Fig. 7. Greenhouse Design: Left Side View

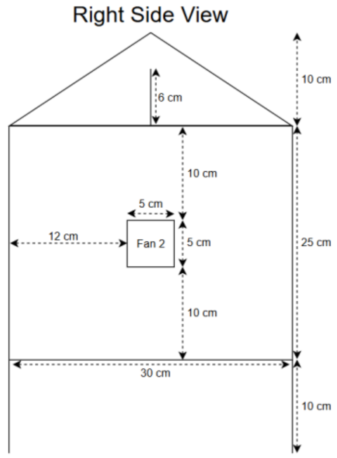

Fig. 8. Greenhouse Design: Right Side View

D. System Flow

This section will explain the system algorithm that will be run on this tool. After the greenhouse owner opens the Blynk IoT application. The first step that must be taken is to select the initial condition of the open roof or select the initial condition of the closed roof. The initial condition of the roof is adjusted to the condition of the roof on the greenhouse prototype. The second step is that the greenhouse owner selects the active mode condition that will be run on this system. There are automatic mode and manual mode active modes that can be selected. While the emergency active mode will be run automatically if the sensor experiences an error. The results of the system flow design can be seen in Fig. 9.

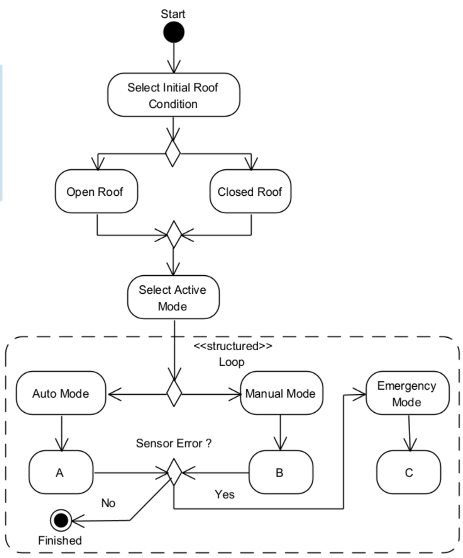

Fig. 9. System Flow

When the automatic mode is run by the greenhouse owner. Then the greenhouse owner can set the limits of the sunlight sensor, the limits of the greenhouse temperature sensor, the limits of the greenhouse humidity sensor, and the limits of the soil humidity sensor. These sensor limits are adjusted to the needs of the plants in the greenhouse building. In this study, the plants in it are green mustard greens. When the system is running, when the limits of the sunlight sensor are greater than the reading results of the sunlight sensor, the greenhouse roof will be closed, but when the limits of the sunlight sensor are not greater than the reading results of the sunlight sensor, the greenhouse roof will open. In parallel to other system processes, when the limits of the greenhouse temperature sensor are greater than the reading results of the greenhouse temperature sensor, the greenhouse lights will turn off, but when the limits of the greenhouse temperature sensor are not greater than the reading results of the greenhouse temperature sensor, the greenhouse lights will turn on. In parallel to other system processes, when the limits of the greenhouse humidity sensor are greater than the reading results of the greenhouse humidity sensor, the greenhouse fogger and fan will turn off, but when the limits of the greenhouse humidity sensor are not greater than the reading results of the greenhouse humidity sensor, the greenhouse fogger and fan will turn on. In parallel with other system processes, when the soil moisture sensor limit is greater than the soil moisture sensor reading, the greenhouse pump will turn off, but when the soil moisture sensor limit is not greater than the soil moisture sensor reading, the greenhouse pump will turn on. The results of the automatic mode system flow design can be seen in Fig. 10.

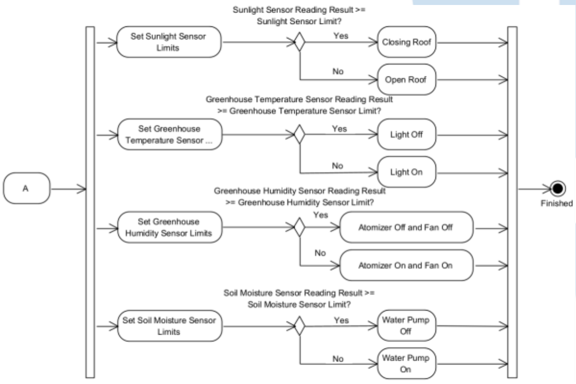

Fig. 10. Automatic Mode System Flow

When manual mode is run by the greenhouse owner. So, the greenhouse owner can manually open and close the greenhouse roof, turn on and off the greenhouse lights, turn on and off the greenhouse fogger, turn on and off the greenhouse fan, and turn on and off the greenhouse pump. The results of the manual mode system flow design can be seen on Fig. 11.

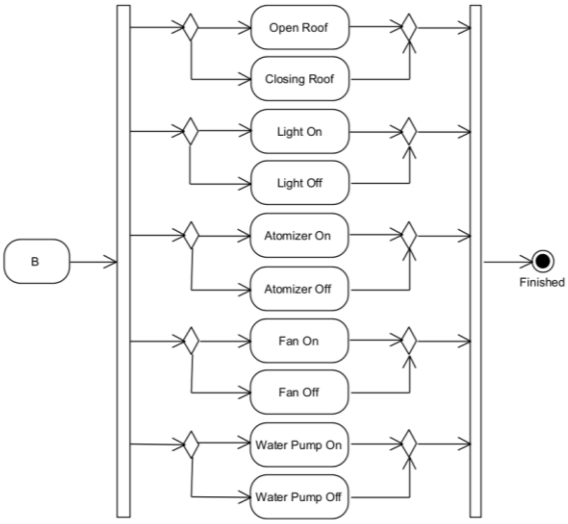

Fig. 11. Manual Mode System Flow

Emergency mode will be automatically activated by the system if there is a sensor that experiences an error. When emergency mode is active, the system will run a sensor error check. When the sensor error check process is running, the system will run the BH1750 error check function, DHT22 error check, and soil moisture sensor error check in parallel. After the system finds the error sensor. The system will automatically select the type of actuator that will be run in automatic mode and manual mode. For more details, see Table I. While the process that occurs in emergency mode can be seen in Fig. 12.

TABLE I. EMERGENCY MODE ACTUATOR

Emergency Mode				
Sensor Error			Actuator is running in Mode -	
BH1750	DHT22	Soil moisture	Automatic	Manual
Error	Normal	Normal	Lights, Fans, Atomizer, Water Pumps	Roof
Normal	Error	Normal	Roof, Water Pump	
Normal	Normal	Error	Roof, Lights, Fans, Atomizer	Water pump
Error	Error	Normal	Water pump	Roof, Lights, Fans, Atomizer
Error	Normal	Error	Lights, Fans, Atomizer	Roof, Water Pump
Error	Error	Error	-	All Manuals

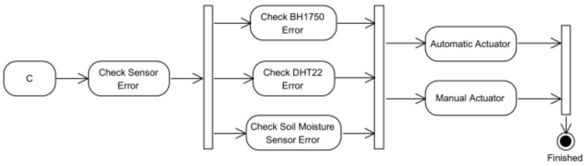

Fig. 12. Manual Mode System Flow

For example, when the BH1750 sensor experiences an error in reading sensor data, while the DHT22 sensor and soil moisture sensor are both still normal. Then the system will automatically run in emergency mode, the system will run the Lights, Fans, Atomizers, Water Pumps actuators in automatic mode, specifically for the roof actuator the system will run it in manual mode. So that the greenhouse owner can open and close the roof manually. Keep in mind at this stage, the Lights, Fans, Atomizers, Water Pumps actuators on and off are still affected by the applicable sensor limits and sensor readings.

E. Blynk IoT App View

On the Blynk IoT application display, it will explain the existing menus. Each menu has a specific task. Keep in mind, the main function of the Blynk IoT application is as a controller and monitor of the greenhouse prototype. So that greenhouse owners can control and limit the amount of sunlight entering the greenhouse, the temperature and humidity that are appropriate for the growth of green mustard plants, and the soil moisture that is appropriate for green mustard plants. Greenhouse owners can also monitor the value of sunlight, greenhouse temperature and humidity, and soil moisture in real time. The appearance of the menus in the Blynk IoT application can be seen in the Fig. 13 – Fig. 17.

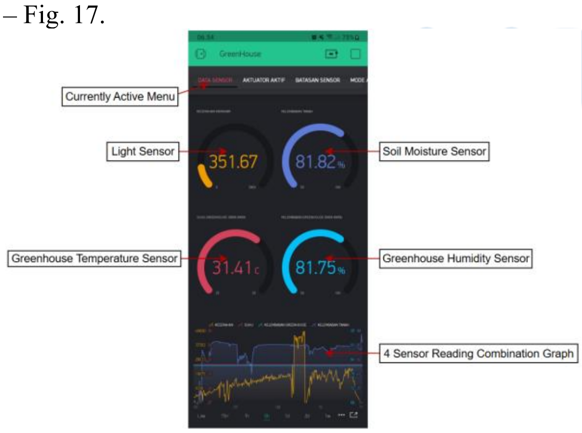

Fig. 13. Blynk IoT: Data Sensor

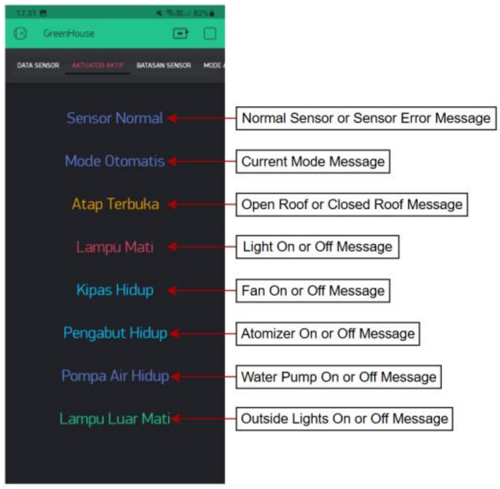

Fig. 14. Blynk IoT: Active Actuator

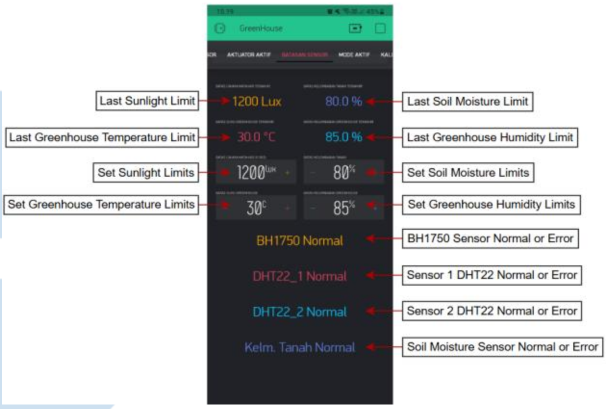

Fig. 15. Blynk IoT: Sensor Limitations

Fig. 16. Blynk IoT: Active Mode

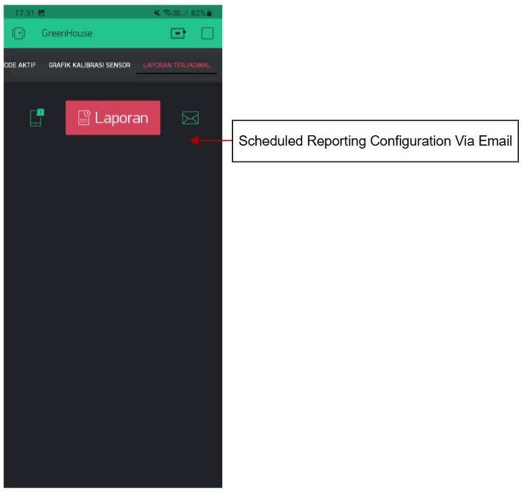

Fig. 17. Blynk IoT: Scheduled Reports

F. *Characteristics of Green Mustard Plants*

Green mustard greens are classified as vegetables that are widely consumed by the Indonesian population, because they taste sweet and have high nutritional content. Green mustard greens contain protein, fat, carbohydrates, fiber, and vitamins[14]. Traditional farmers still plant mustard greens in open environments. During the rainy season, many mustard greens are damaged due to rainwater and disease. Meanwhile, during the dry season, mustard greens are susceptible to being eaten by insects[15]. Green mustard greens require sufficient sunlight intensity, because during their growth, mustard greens require low to warm temperatures (22 - 33 ° C), soil temperatures in the range of 7 - 28 °C, environmental humidity ± 75% and soil moisture in the range of 60 - 88%. The quality of sunlight exposure is a major factor in the optimal growth of mustard greens.

III. Results and Discussion

A. *Sensor Calibration Testing*

Calibration of the BH1750 sensor or sunlight intensity sensor was carried out with the AS803 lux meter. The calibration process was carried out 14 times with a data collection interval of every 30 minutes. Data collection was carried out from 05.30 WIB to 12.00 WIB. The BH1750 sensor calibration data with the AS803 lux meter can be seen on Fig. 18. From the calibration results, the value $y = 0{,}8571x + 2436{,}6$, was also obtained, this value will be entered into the calibration function contained in the code that will be uploaded into the ESP32 microcontroller or this system.

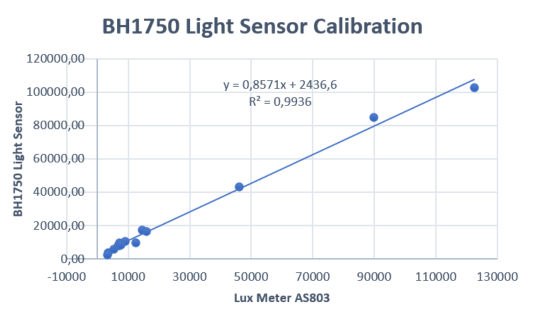

Fig. 18. BHI750 Sensor Calibration Chart

The calibration of the DHT22_1 temperature sensor was carried out with HTC 1 temperature. The calibration process was carried out 14 times with a data collection interval of every 30 minutes. Data collection was carried out from 05.30 WIB to 12.00 WIB. The calibration data of the DHT22_1 temperature sensor with HTC 1 temperature can be seen in Fig. 19. From the calibration results, the value $y = 0{,}8898x + 2{,}4332$, was also obtained, this value will be entered into the calibration function contained in the code that will be uploaded into the ESP32 microcontroller or this system.

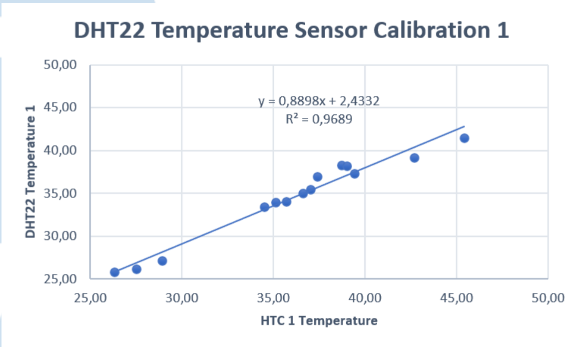

Fig. 19. DHT22 Sensor Calibration Chart 1 Greenhouse Temperature

The calibration of the DHT22_2 temperature sensor was carried out with HTC 1 temperature. The calibration process was carried out 14 times with a data collection interval of every 30 minutes. Data collection was carried out from 05.30 WIB to 12.00 WIB. The calibration data of the DHT22_2 temperature sensor with HTC 1 temperature can be seen on Fig. 20. From the calibration results, the value $y = 0{,}9129x + 1{,}9394$, was also obtained, this value will be entered into the calibration function contained in the code that will be uploaded into the ESP32 microcontroller or this system.

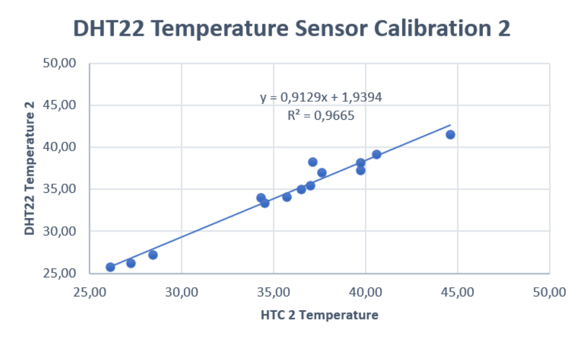

Fig. 20. DHT22 Greenhouse Temperature Sensor Calibration Chart

The DHT22_1 humidity sensor calibration was performed with HTC 1 humidity. The calibration process was performed 14 times with a data collection interval of every 30 minutes. Data collection was carried out from 05.30 WIB to 12.00 WIB. The DHT22_1 humidity sensor calibration data with HTC 1 humidity can be seen in Fig. 21. From the calibration results, the value $y = 0{,}9952x - 4{,}3267$, was also obtained, this value will be entered into the calibration function contained in the code that will be uploaded into the ESP32 microcontroller or this system.

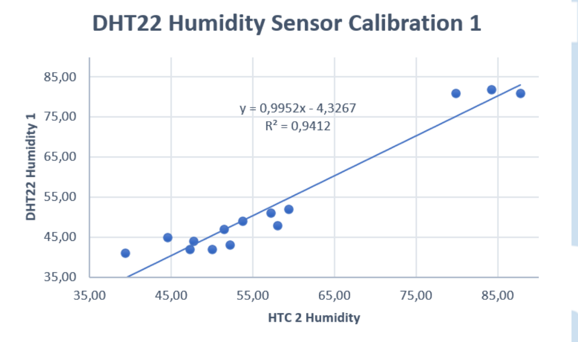

Fig. 21. DHT22 Sensor Graph 1 Greenhouse Humidity

The DHT22_2 humidity sensor calibration was performed with HTC 1 humidity. The calibration process was performed 14 times with a data collection interval of every 30 minutes. Data collection was carried out from 05.30 WIB to 12.00 WIB. The DHT22_2 humidity sensor calibration data with HTC 1 humidity can be seen in Fig. 22. From the calibration results, the value $y = 1{,}0058x - 7{,}9798$, was also obtained, this value will be entered into the calibration function contained in the code that will be uploaded into the ESP32 microcontroller or this system.

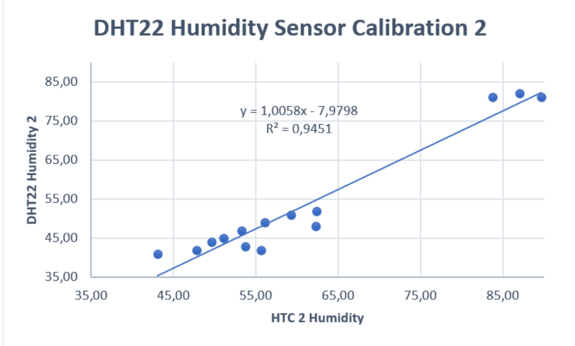

Fig. 22. DHT22 Sensor Graph 2 Greenhouse Humidity

Calibration of soil moisture sensors was done with Grain Moisture Meter AR991. The calibration process was done 8 times. Soil moisture sensor calibration data was done with Grain Moisture Meter AR991 can be seen on Fig. 23. From the calibration results, the value $y = 1{,}0894x - 7{,}4549$, was also obtained, this value will be entered into the calibration function contained in the code that will be uploaded into the ESP32 microcontroller or this system.

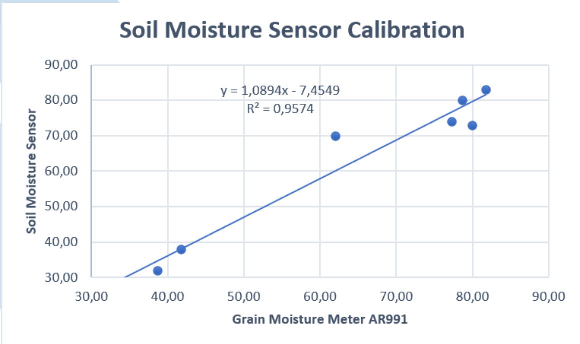

Fig. 23. Soil Moisture Sensor Graph

B. Testing of Greenhouse Prototype Controller and Monitoring Design Tools for Green Mustard Plants Based on IoT

The test was carried out in the Gumuk Kerang Regency housing complex on November 24 2024 to November 26 2024. The test time was carried out 24 hours. This test focuses on collecting data from sensor readings and focuses on the automatic on and off conditions of the actuator according to the sensor limits that have been entered into the Blynk IoT application. Based on research by Gallagher in 1990, mustard plants require low to warm temperatures (22 - 33 ° C), soil temperatures in the range of 7 - 28 °C, environmental humidity ± 75% and soil moisture in the range of 60 - 88% (wb); so the researcher took the sunlight sensor limit of 15000 lux, the greenhouse temperature sensor limit of 30 ° C, the greenhouse humidity sensor limit of 85%, and the soil moisture limit of 80%. Sensor reading data can be seen from Table II to Table V. Meanwhile, the actuator on and off time data can be seen in Table VI to Table VIII.

TABLE II. SUNLIGHT READING

Time	Sunlight Reading		
	24/11/2024	25/11/2024	26/11/2024
00.00.00	0,00	-1,00	6,70
00.30.00	0,00	-1,00	6,55
01.00.00	0,00	-2,00	6,61
01.30.00	0,00	-2,00	6,60
02.00.00	0,00	-2,00	6,54
02.30.00	0,00	-2,00	10,00
03.00.00	0,00	-2,00	10,00
03.30.00	0,00	-2,00	10,00
04.00.00	0,00	-2,00	5,83
04.30.00	0,00	-2,00	5,00
05.00.00	-2,00	-2,00	17,41
05.30.00	1749,17	-2,00	109,76
06.00.00	3652,80	-2,00	295,67
06.30.00	7500,33	-2,00	398,21
07.00.00	10455,36	0,78	775,92
07.30.00	11957,81	1141,67	989,76
08.00.00	15959,53	8698,69	1254,90
08.30.00	16841,51	17289,76	1604,70
09.00.00	18543,85	19848,81	1555,89
09.30.00	10677,61	18630,02	1247,81
10.00.00	9808,87	19342,31	1554,00
10.30.00	17593,33	19820,15	1228,06
11.00.00	20072,60	19150,88	1273,18
11.30.00	22518,44	17750,68	900,06
12.00.00	223,07	11206,35	1296,24
12.30.00	310,68	16969,78	698,36
13.00.00	187,76	15536,63	521,56
13.30.00	293,33	6770,65	407,69
14.00.00	294,84	191,94	172,13
14.30.00	305,94	30,62	266,64
15.00.00	167,55	49,56	385,49
15.30.00	180,10	78,95	200,03
16.00.00	155,57	110,61	194,58
16.30.00	67,38	66,27	116,64
17.00.00	28,33	45,49	56,56
17.30.00	10,36	45,49	15,83
18.00.00	8,33	10,00	13,28
18.30.00	8,33	10,00	13,33
19.00.00	8,39	9,93	13,33
19.30.00	8,23	9,73	13,33
20.00.00	8,24	9,73	13,33
20.30.00	6,16	9,73	13,33
21.00.00	-2,00	9,87	8,36
21.30.00	-2,00	9,81	8,33
22.00.00	-2,00	10,00	12,50
22.30.00	-2,00	9,54	11,67
23.00.00	-2,00	10,00	7,52
23.30.00	-2,00	6,61	7,50

TABLE III. GREENHOUSE TEMPERATURE READING

Time	Greenhouse Temperature Reading		
	24/11/2024	25/11/2024	26/11/2024
00.00.00	0,00	27,63	27,68
00.30.00	0,00	27,46	27,59
01.00.00	0,00	27,33	27,42
01.30.00	0,00	27,20	27,31
02.00.00	0,00	27,09	27,08
02.30.00	0,00	26,98	27,09
03.00.00	0,00	26,88	26,98
03.30.00	0,00	26,83	26,97
04.00.00	0,00	26,76	26,97
04.30.00	0,00	26,68	26,91
05.00.00	26,62	26,59	26,86
05.30.00	27,09	26,71	26,87
06.00.00	27,99	26,99	27,08
06.30.00	29,94	26,99	27,45
07.00.00	36,80	28,04	27,98
07.30.00	37,56	28,94	28,55
08.00.00	36,43	33,48	29,35
08.30.00	37,67	35,76	30,20
09.00.00	39,26	38,11	30,85
09.30.00	37,78	38,95	31,58
10.00.00	41,11	39,02	30,61
10.30.00	41,07	40,40	32,23
11.00.00	40,96	40,49	32,51
11.30.00	41,35	40,28	33,18
12.00.00	33,88	39,62	33,73
12.30.00	32,12	40,74	33,43

Time	Greenhouse Temperature Reading		
	24/11/2024	25/11/2024	26/11/2024
13.00.00	31,80	40,73	33,02
13.30.00	31,43	37,42	32,17
14.00.00	31,05	33,44	31,77
14.30.00	30,69	31,39	31,61
15.00.00	30,27	28,14	31,85
15.30.00	29,85	27,94	31,33
16.00.00	29,50	27,81	30,91
16.30.00	29,25	27,73	30,23
17.00.00	29,03	27,86	30,23
17.30.00	28,70	27,88	30,28
18.00.00	28,58	27,87	30,15
18.30.00	28,57	27,87	30,04
19.00.00	28,51	27,86	29,98
19.30.00	28,47	27,77	29,86
20.00.00	28,47	27,64	29,83
20.30.00	28,43	27,53	29,62
21.00.00	28,59	27,84	29,60
21.30.00	28,14	27,64	29,33
22.00.00	28,03	27,52	29,31
22.30.00	27,98	27,46	29,17
23.00.00	27,80	27,53	27,95
23.30.00	27,77	27,59	28,41

TABLE IV. GREENHOUSE HUMIDITY READING

Time	Greenhouse Humidity Reading		
	24/11/2024	25/11/2024	26/11/2024
00.00.00	0,00	92,50	93,29
00.30.00	0,00	92,65	93,22
01.00.00	0,00	93,08	93,48
01.30.00	0,00	93,07	93,74
02.00.00	0,00	92,31	93,94
02.30.00	0,00	92,49	94,01
03.00.00	0,00	93,10	94,22
03.30.00	0,00	93,32	94,36
04.00.00	0,00	93,47	94,39
04.30.00	0,00	93,03	94,46
05.00.00	89,34	93,56	94,70
05.30.00	88,70	93,63	94,66
06.00.00	86,77	92,70	94,98

Time	Greenhouse Humidity Reading		
	24/11/2024	25/11/2024	26/11/2024
06.30.00	83,89	90,79	94,54
07.00.00	85,53	89,49	93,20
07.30.00	78,90	80,98	91,79
08.00.00	83,22	79,73	88,55
08.30.00	80,23	79,61	87,52
09.00.00	80,38	83,45	86,16
09.30.00	81,83	80,74	90,16
10.00.00	82,76	80,85	90,66
10.30.00	81,72	81,69	84,65
11.00.00	80,01	81,51	84,78
11.30.00	79,34	81,65	75,48
12.00.00	84,86	81,81	74,44
12.30.00	89,58	79,64	75,00
13.00.00	85,19	80,22	76,43
13.30.00	85,98	84,88	81,14
14.00.00	85,67	82,19	81,96
14.30.00	85,76	88,59	81,40
15.00.00	87,43	90,87	81,12
15.30.00	86,14	92,60	83,52
16.00.00	88,45	93,07	84,71
16.30.00	89,20	92,78	84,17
17.00.00	88,73	93,17	83,87
17.30.00	88,53	93,37	85,17
18.00.00	88,33	93,47	86,37
18.30.00	88,37	93,17	87,69
19.00.00	88,48	93,30	88,30
19.30.00	88,73	93,45	89,17
20.00.00	88,61	93,77	89,79
20.30.00	88,95	94,03	90,54
21.00.00	88,27	93,34	90,63
21.30.00	89,66	93,70	91,60
22.00.00	90,00	94,09	91,71
22.30.00	89,91	94,20	92,00
23.00.00	90,31	94,00	92,00
23.30.00	91,15	93,56	97,38

TABLE V. SOIL MOISTURE READING

Time	Soil Moisture Reading		
	24/11/2024	25/11/2024	26/11/2024
00.00.00	0,00	81,57	80,17
00.30.00	0,00	81,53	80,22
01.00.00	0,00	81,81	80,55
01.30.00	0,00	81,31	80,53
02.00.00	0,00	81,45	79,97
02.30.00	0,00	81,65	81,00
03.00.00	0,00	81,61	80,56
03.30.00	0,00	81,48	80,09
04.00.00	0,00	81,15	80,25
04.30.00	0,00	80,35	80,75
05.00.00	78,67	79,71	80,61
05.30.00	80,69	80,09	80,53
06.00.00	84,00	78,14	80,41
06.30.00	84,55	80,36	80,39
07.00.00	83,55	80,30	80,56
07.30.00	80,73	80,93	80,56
08.00.00	75,55	81,81	79,28
08.30.00	81,10	80,28	80,76
09.00.00	81,13	75,42	81,73
09.30.00	79,17	80,17	81,06
10.00.00	81,14	81,47	81,01
10.30.00	80,43	75,52	80,13
11.00.00	78,94	79,40	80,41
11.30.00	82,82	80,16	79,67
12.00.00	89,72	80,80	80,47
12.30.00	82,90	75,03	81,17
13.00.00	86,43	76,46	81,34
13.30.00	83,82	83,56	81,16
14.00.00	79,14	78,34	80,82
14.30.00	79,70	84,18	81,09
15.00.00	81,47	80,24	80,97
15.30.00	78,70	81,81	80,97
16.00.00	74,66	83,84	80,97
16.30.00	80,48	80,77	80,99
17.00.00	81,07	81,17	80,91
17.30.00	81,30	80,84	80,78
18.00.00	81,46	80,66	80,78
18.30.00	80,31	80,92	80,72
19.00.00	80,15	82,16	80,77
19.30.00	70,65	81,56	80,80
20.00.00	75,96	81,88	80,76
20.30.00	80,89	82,39	80,78
21.00.00	78,39	82,08	80,85
21.30.00	80,58	81,76	81,01
22.00.00	80,23	79,20	80,96
22.30.00	80,62	82,14	80,95
23.00.00	80,87	81,69	76,41
23.30.00	81,08	81,25	63,91

TABLE VI. ACTUATOR ON AND OFF TIME DATA DATE 24 OCTOBER 2024

<table>
<tr><th rowspan="2">Time</th><th colspan="5">Active Actuator</th></tr>
<tr><th>Roof</th><th>Lamp</th><th>Fan</th><th>Sprayer</th><th>Water Pump</th></tr>
<tr><td>05.00.00</td><td>Manual</td><td rowspan="4">On</td><td rowspan="3">Off</td><td rowspan="3">Off</td><td>On</td></tr>
<tr><td>05.30.00</td><td rowspan="5">Open</td><td rowspan="5">Off</td></tr>
<tr><td>06.00.00</td></tr>
<tr><td>06.30.00</td><td>On</td><td>On</td></tr>
<tr><td>07.00.00</td><td rowspan="17">Off</td><td>Off</td><td>Off</td></tr>
<tr><td>07.30.00</td><td rowspan="10">On</td><td rowspan="10">On</td></tr>
<tr><td>08.00.00</td><td rowspan="3">Close</td><td>On</td></tr>
<tr><td>08.30.00</td><td rowspan="2">Off</td></tr>
<tr><td>09.00.00</td></tr>
<tr><td>09.30.00</td><td rowspan="2">Open</td><td>On</td></tr>
<tr><td>10.00.00</td><td rowspan="2">Off</td></tr>
<tr><td>10.30.00</td><td rowspan="3">Close</td></tr>
<tr><td>11.00.00</td><td>On</td></tr>
<tr><td>11.30.00</td><td rowspan="5">Off</td></tr>
<tr><td>12.00.00</td><td rowspan="12">Open</td></tr>
<tr><td>12.30.00</td><td rowspan="11">Off</td><td rowspan="11">Off</td></tr>
<tr><td>13.00.00</td></tr>
<tr><td>13.30.00</td></tr>
<tr><td>14.00.00</td><td rowspan="2">On</td></tr>
<tr><td>14.30.00</td></tr>
<tr><td>15.00.00</td><td>Off</td></tr>
<tr><td>15.30.00</td><td rowspan="5">On</td><td rowspan="2">On</td></tr>
<tr><td>16.00.00</td></tr>
<tr><td>16.30.00</td><td rowspan="3">Off</td></tr>
<tr><td>17.00.00</td></tr>
<tr><td>17.30.00</td></tr>
</table>

<table>
<tr><th rowspan="2">Time</th><th colspan="5">Active Actuator</th></tr>
<tr><th>Roof</th><th>Lamp</th><th>Fan</th><th>Sprayer</th><th>Water Pump</th></tr>
<tr><td>18.00.00</td><td rowspan="6"></td><td rowspan="12"></td><td rowspan="12"></td><td rowspan="12"></td><td rowspan="3"></td></tr>
<tr><td>18.30.00</td></tr>
<tr><td>19.00.00</td></tr>
<tr><td>19.30.00</td><td rowspan="2">On</td></tr>
<tr><td>20.00.00</td></tr>
<tr><td>20.30.00</td><td>Off</td></tr>
<tr><td>21.00.00</td><td rowspan="6">Manual</td><td>On</td></tr>
<tr><td>21.30.00</td><td rowspan="5">Off</td></tr>
<tr><td>22.00.00</td></tr>
<tr><td>22.30.00</td></tr>
<tr><td>23.00.00</td></tr>
<tr><td>23.30.00</td></tr>
</table>

TABLE VII. ACTUATOR ON AND OFF TIME DATA DATE 25 OCTOBER 2024

<table>
<tr><th rowspan="2">Time</th><th colspan="5">Active Actuator</th></tr>
<tr><th>Roof</th><th>Lamp</th><th>Fan</th><th>Sprayer</th><th>Water Pump</th></tr>
<tr><td>00.00.00</td><td rowspan="14">Manual</td><td rowspan="16">On</td><td rowspan="15">Off</td><td rowspan="15">Off</td><td rowspan="10">Off</td></tr>
<tr><td>00.30.00</td></tr>
<tr><td>01.00.00</td></tr>
<tr><td>01.30.00</td></tr>
<tr><td>02.00.00</td></tr>
<tr><td>02.30.00</td></tr>
<tr><td>03.00.00</td></tr>
<tr><td>03.30.00</td></tr>
<tr><td>04.00.00</td></tr>
<tr><td>04.30.00</td></tr>
<tr><td>05.00.00</td><td>On</td></tr>
<tr><td>05.30.00</td><td>Off</td></tr>
<tr><td>06.00.00</td><td>On</td></tr>
<tr><td>06.30.00</td><td rowspan="5">Off</td></tr>
<tr><td>07.00.00</td><td rowspan="3">Open</td></tr>
<tr><td>07.30.00</td><td rowspan="7">On</td><td rowspan="7">On</td></tr>
<tr><td>08.00.00</td><td rowspan="6">Off</td></tr>
<tr><td>08.30.00</td><td rowspan="5">Close</td></tr>
<tr><td>09.00.00</td><td>On</td></tr>
<tr><td>09.30.00</td><td rowspan="2">Off</td></tr>
<tr><td>10.00.00</td></tr>
<tr><td>10.30.00</td><td>On</td></tr>
</table>

<table>
<tr><th rowspan="2">Time</th><th colspan="5">Active Actuator</th></tr>
<tr><th>Roof</th><th>Lamp</th><th>Fan</th><th>Sprayer</th><th>Water Pump</th></tr>
<tr><td>11.00.00</td><td rowspan="2"></td><td rowspan="8"></td><td rowspan="7"></td><td rowspan="7"></td><td></td></tr>
<tr><td>11.30.00</td><td rowspan="2">Off</td></tr>
<tr><td>12.00.00</td><td>Open</td></tr>
<tr><td>12.30.00</td><td rowspan="2">Close</td><td rowspan="2">On</td></tr>
<tr><td>13.00.00</td></tr>
<tr><td>13.30.00</td><td rowspan="21">Open</td><td>Off</td></tr>
<tr><td>14.00.00</td><td>On</td></tr>
<tr><td>14.30.00</td><td rowspan="19">Off</td><td rowspan="19">Off</td><td rowspan="15">Off</td></tr>
<tr><td>15.00.00</td><td rowspan="18">On</td></tr>
<tr><td>15.30.00</td></tr>
<tr><td>16.00.00</td></tr>
<tr><td>16.30.00</td></tr>
<tr><td>17.00.00</td></tr>
<tr><td>17.30.00</td></tr>
<tr><td>18.00.00</td></tr>
<tr><td>18.30.00</td></tr>
<tr><td>19.00.00</td></tr>
<tr><td>19.30.00</td></tr>
<tr><td>20.00.00</td></tr>
<tr><td>20.30.00</td></tr>
<tr><td>21.00.00</td></tr>
<tr><td>21.30.00</td></tr>
<tr><td>22.00.00</td><td>On</td></tr>
<tr><td>22.30.00</td><td rowspan="3">Off</td></tr>
<tr><td>23.00.00</td></tr>
<tr><td>23.30.00</td></tr>
</table>

TABLE VIII. ACTUATOR ON AND OFF TIME DATA DATE 26 OCTOBER 2024

<table>
<tr><th rowspan="2">Time</th><th colspan="5">Active Actuator</th></tr>
<tr><th>Roof</th><th>Lampu</th><th>Fan</th><th>Sprayer</th><th>Water Pump</th></tr>
<tr><td>00.00.00</td><td rowspan="8">Open</td><td rowspan="8">On</td><td rowspan="8">Off</td><td rowspan="8">Off</td><td rowspan="4">Off</td></tr>
<tr><td>00.30.00</td></tr>
<tr><td>01.00.00</td></tr>
<tr><td>01.30.00</td></tr>
<tr><td>02.00.00</td><td>On</td></tr>
<tr><td>02.30.00</td><td rowspan="3">Off</td></tr>
<tr><td>03.00.00</td></tr>
<tr><td>03.30.00</td></tr>
</table>

<table>
<tr><th rowspan="2">Time</th><th colspan="5">Active Actuator</th></tr>
<tr><th>Roof</th><th>Lampu</th><th>Fan</th><th>Sprayer</th><th>Water Pump</th></tr>
<tr><td>04.00.00</td><td rowspan="40"></td><td rowspan="9"></td><td rowspan="13"></td><td rowspan="13"></td><td rowspan="8"></td></tr>
<tr><td>04.30.00</td></tr>
<tr><td>05.00.00</td></tr>
<tr><td>05.30.00</td></tr>
<tr><td>06.00.00</td></tr>
<tr><td>06.30.00</td></tr>
<tr><td>07.00.00</td></tr>
<tr><td>07.30.00</td></tr>
<tr><td>08.00.00</td><td>On</td></tr>
<tr><td>08.30.00</td><td rowspan="21">Off</td><td rowspan="6">Off</td></tr>
<tr><td>09.00.00</td></tr>
<tr><td>09.30.00</td></tr>
<tr><td>10.00.00</td></tr>
<tr><td>10.30.00</td><td rowspan="14">On</td><td rowspan="14">On</td></tr>
<tr><td>11.00.00</td></tr>
<tr><td>11.30.00</td><td>On</td></tr>
<tr><td>12.00.00</td><td rowspan="22">Off</td></tr>
<tr><td>12.30.00</td></tr>
<tr><td>13.00.00</td></tr>
<tr><td>13.30.00</td></tr>
<tr><td>14.00.00</td></tr>
<tr><td>14.30.00</td></tr>
<tr><td>15.00.00</td></tr>
<tr><td>15.30.00</td></tr>
<tr><td>16.00.00</td></tr>
<tr><td>16.30.00</td></tr>
<tr><td>17.00.00</td></tr>
<tr><td>17.30.00</td><td rowspan="13">Off</td><td rowspan="13">Off</td></tr>
<tr><td>18.00.00</td></tr>
<tr><td>18.30.00</td></tr>
<tr><td>19.00.00</td><td rowspan="10">On</td></tr>
<tr><td>19.30.00</td></tr>
<tr><td>20.00.00</td></tr>
<tr><td>20.30.00</td></tr>
<tr><td>21.00.00</td></tr>
<tr><td>21.30.00</td></tr>
<tr><td>22.00.00</td></tr>
<tr><td>22.30.00</td></tr>
<tr><td>23.00.00</td><td rowspan="2">On</td></tr>
<tr><td>23.30.00</td></tr>
</table>

The data collection process is carried out 24 hours, at night the greenhouse building will be moved to a shady and safe place. This aims to secure the tool from potential theft by others. Another goal is to avoid potential rain at night that escapes the supervision of researchers. Researchers realize that this tool is still not resistant to heavy rain. The researcher understands that the design of the tool in this study is still in the prototype stage, so it still needs to be refined by further researchers or in further research. Especially in the control and monitoring variables at the greenhouse temperature, in the greenhouse temperature sensor reading data contained in Table III the greenhouse temperature touches a value of 41 C, this has the potential to make the green mustard plants wilt and can even cause the green mustard plants to die. The researcher's suggestion for further researchers is the use of a greenhouse fogger actuator that has more qualified specifications so that it is hoped that the use of the fogger actuator can increase greenhouse humidity and will reduce the value of the greenhouse temperature.

IV. Conclusion

This study designs a prototype greenhouse controller and monitors for green mustard plants based on IoT with the main control system being ESP32. This controller and monitor system is integrated with the Blynk IoT application so that greenhouse owners can control and monitor anywhere and anytime. This system can be run in automatic mode so that it is very helpful in smart agricultural automation efforts. The results of the calibration values of the 4 sensor variables are very satisfactory and can be considered as valid tools. The R_square values of the 4 sensor calibrations, namely the BH1750 light sensor, the DHT22_1 temperature sensor, the DHT22_2 temperature sensor, the DHT22_1 humidity sensor, the DHT22_2 humidity sensor, and the soil moisture sensor are respectively 0.9936; 0.9689; 0.9665; 0.9412; 0.9451; 0.9574. Based on the interpretation of the simple linear regression coefficient according to Sugiyono (2020), this tool can be categorized as a valid tool.

Based on the research results, suggestions for further research are: a. To overcome the problem of noise or ripple from DC voltage or voltage drop on the sensor that can cause the sensor to experience an error, the next researcher needs to add a voltage filter circuit to the signal input pin of each sensor. b. During the data collection process, the placement of the tool box needs to be placed in a position that is free from water or high humidity potential that can damage the hardware components in the tool box.

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