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Light Control and Watering System in Greenhouse for The Cultivation of Chrysanthemum Sp

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ABSTRACT

Chrysanthemum (Chrysanthemum Sp) is sensitive to temperature and humidity. Greenhouse is an appropriate planting medium since temperature and humidity can be engineered there. This article presents the design of systems using DHT-22 and SEN0057 sensors. Real Time Clock (RTC) is used for providing timing input and functions as an extra light intensity timer. Arduino Mega 2560 is used as a microcontroller functioning to receive the results of sensor measurement and to give output instructions to condition the temperature and humidity. The testing on chrysanthemum Sp placed inside the greenhouse equipped with the system for 7 days shows an increase of height of 3.7 cm. As for chrysanthemum Sp placed outside the greenhouse equipped with the system for 7 days, there is an increase of height of 0, 2 cm. These greenhouse light control and Watering systems can engineer the temperature and humidity in accordance with the needs of chrysanthemum Sp cultivation in the greenhouse.

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1. INTRODUCTION

Technology is made to improve the quality of human life [1]-[3], one of the technology that can be used to help the effectiveness and efficiency of farming is controlilng climate with greenhouse. Greenhouse is a place used to maintain the climate control in a room [4]. The structure of greenhouse can be perfectly enclosed to protect plants and to promote the growth of crops [5]. Greenhouse is used to maintain the room temperature stability, and soil moisture and acid levels to suit the needs of plants, thus the plant can grow well [6]. To work properly, greenhouse has some parameters to consider, namely: room temperature, soil temperature, humidity, watering system, light intensity, and ventilation [7]. Due to its function, greenhouse is widely used to develop plants sensitive to the room temperature and humidity, one of which is chrysanthemum (Chrysanthemum Sp).

Chrysanthemum is a plant that cannot stand puddles and is less suited to direct sunlight and direct rainwater splashing. Therefore, it is recommended to cultivate Chrysanthemum in a greenhouse to avoid direct sunlight and rainwater. Chrysanthemum requires longer lighting than other plants do. If chrysanthemum gets less than 12 hours of light, its vegetative phase (growth of height) does not last long and cause the height of chrysanthemum at harvest time only about 40 cm. To maintain the vegetative phase well, it is necessary to add the light at night that is 70-100 lux. Thus it will make chrysanthemum reach the expected height, i.e. more than 76 cm or increase of 6-7 cm each week [8].

Research on humidity and temperature control in greenhouse has been mostly done for various plants [9], [10]. This study focuses on designing a greenhouse environmental control system, capable of controlling temperature, humidity, and lighting systems for chrysanthemum cultivation.

2. MATERIALS AND METHOD

2.1. Materials

a. Sensor DHT-22

DHT-22 Sensor is a digital sensor that can measure the air temperature and humidity [8]. The Specification of DHT-22 sensor (Figure 1) is presented in Table 1.

Table 1. The Specification of DHT22 Sensor

Sensor	DHT22
Supply Voltage	5V
Temperature Range	-40-80℃ / resolution 0.1℃ / error <±0.5℃
Humidity Range	0-100% RH/ resolution 0.1% RH / error ± 2% RH.
Temperature Response	Condition: 1/e(63%) Min 6s Max 20s
Humidity Response Rime	Condition: 1/e(63%)25℃, 1m/s in the air.
Interface Sequence	VCC, GND, Output.

Figure 1. DHT22 Sensor Module [11]

b. Sensor SEN0057

SEN0057 sensor is used to measure the soil moisture. The Specification of SEN0057 sensor (Figure 2), is presented in Table 2.

Table 2. The Specification of SEN0057 Sensor

Sensor	SEN0057
Power Supply	3.3V or 5 V
Output Voltage Signal	0 - 4.2V
Current	35 mA
Pin Definition	Analog Output, GND, Power
Size	60 x 20 x 5 cm

Figure 2. SEN0057 Sensor [12]

c. Arduino Mega 2560.

Arduino Mega 2560 is a microcontroller device using ATmega2560 [13]. This module has the devices needed to program a microcontroller such as a USB cable and power supply with adapters or batteries. The specification of Arduino Mega 2560 (Figure 3) is presented in Table 3.

Table 3. The Specification of Arduino Mega 2560

Module	Arduino Mega 2560
Microcontroller	ATmega2560
Operating Voltage	5 V
Input voltage (recommended)	7-12 V
Input voltage (limits)	6-20 V
Digital I/O Pins	54 (15 PWM output)
Analog Input Pins	16
DC current for I/O pin	40 mA
DC current for 3.3 V pin	50 mA
Flash Memory	256 KB (of which 8 KB used by boot loader)
SRAM	8 KB
EEPROM	4 KB

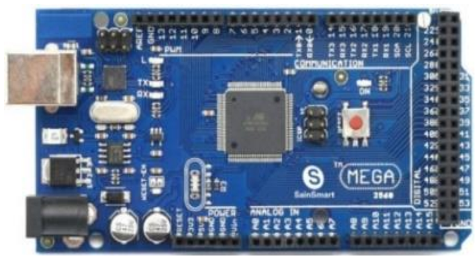


Figure 3. Arduino Mega 2560 [14]

d. Chrysanthemum.

Chrysanthemum (*Chrysanthemum Sp*) belongs to *family Compositae* originating from China (Figure 4). It grows well in medium to high lands ranging from 700 to 1200 masl [15]. The characteristics of the requirement for ideal chrysanthemum growth are presented in Table 4.

Table 4. The Specification of SEN0057 Sensor

Flower name	Chrysanths (Chrysanthemum Sp)
Crop Geographical Location	700-1200 masl
Ideal Temperature Requirement	• 22-28^{o}C (Early growing phase and vegetative phase) • 16-18^{o}C (Flowering phase)
Ideal Humidity Requirement	• 90-95% (Early growing phase) • 70-85% (Vegetative phase and Flowering phase)
Ideal Soil Characteristics	• Clay, sandy, fertile, loose • pH 5,5-6,5

Figure 4. Chrysanthemum sp[8]

e. Greenhouse

The use of greenhouse is to protect plants from environmental conditions such as temperature, air humidity, and adjustable light intensity [16]. The use of greenhouse will greatly affect the microclimate conditions different from the climate in the surrounding environment [15].

2.2. Menthod

The designed system is light control automation and greenhouse for humidity-sensor-based chrysanthemum cultivation following the flowchart as shown in Figure 5. The greenhouse light control and watering system devices in this study use a 9 volt voltage to meet the expected performance. The main system or controller of these devices uses Arduino Mega 2560 module. Inputs received by Arduino Mega 2560 consist of a DHT-22 sensor module functioning to measure the air temperature and humidity, and a SEN0057 sensor module functioning to measure the soil moisture. In addition, Real-Time Clock (RTC) is used as the input functioning to provide the timer used to enable the schedule of high or low lights. These devices have several outputs with their own functions.

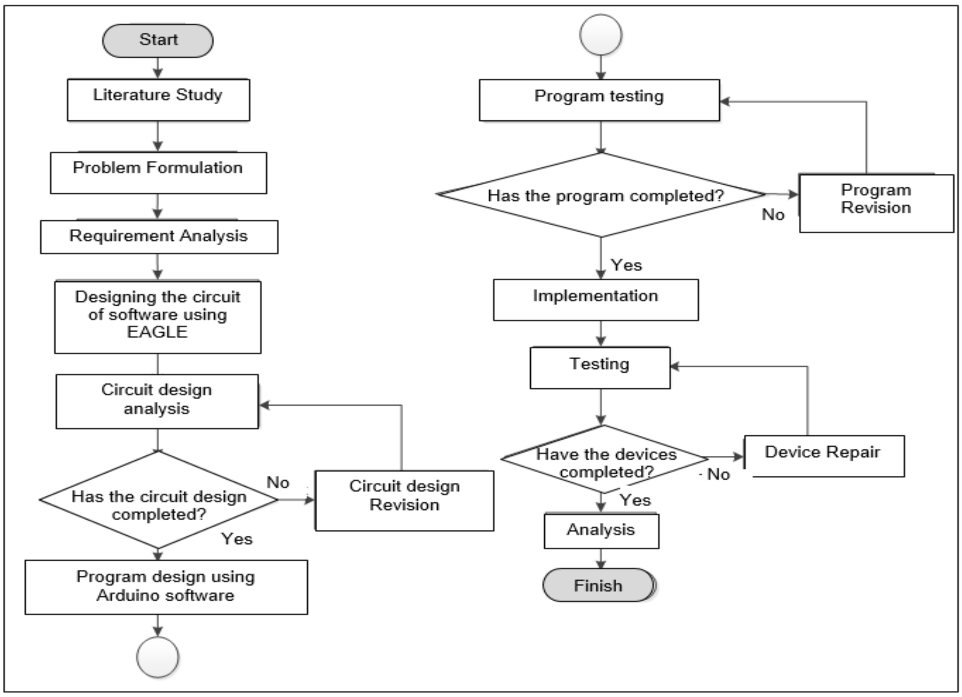


Figure 5. Research Flowchart

The LCD functions to display the results of measurement made by DHT-22 and SEN0057 sensor modules to make it easy to identify. The output is an actuator or tools that can be instructed by the Arduino Mega 2560 module in response to inputs given by the sensor. The output of these tools consists of heating lamp, lamp, blower, dry fan and water pump. The block diagram of the design of tools can be seen in Figure 6.

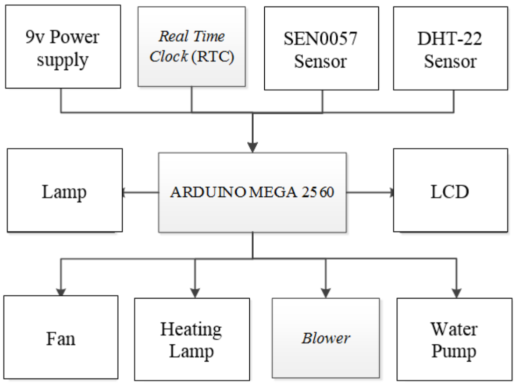


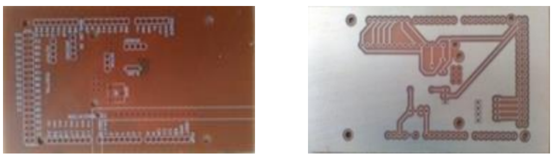
Figure 6. The block diagram of greenhouse light control and watering system

3. RESULTS AND DISCUSSION

3.1. Implementation

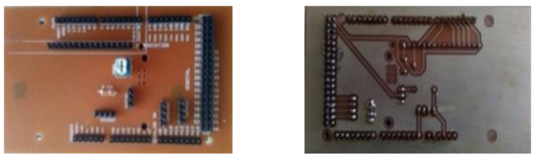
After the design stage in the form of circuit scheme and overall design of the main system program code, it is continued to the stage of assembling devices. This stage is carried out by designing PCB circuit and design using software, EAGLE, and then, printing the PCB used in the making of devices for monitoring the light control and watering system in the greenhouse for chrysanthemum cultivation. Printed PCB can be seen in Figure 7.

PCB with installed components can be seen in Figure 8. The PCB is then connected with Arduino board and relay board using cable as in Figure 9. It is done in order that the devices work in accordance with the intended specifications.



(a) Top View (b) Bottom View

Figure 7. PCB



(a) PCB Top View (b) PCB Bottom View

Figure 8. PCB with components installed

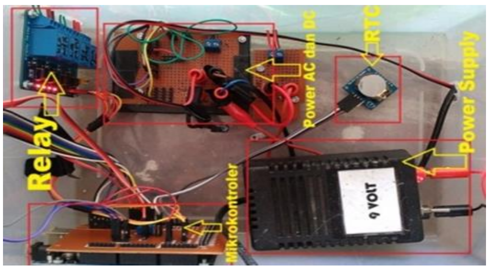


Figure 9. Hardware circuit of the main system

3.2. Circuit Testing and Analysis

Circuit testing is done to check whether the circuit works as expected. The circuit is considered to work well if all components connected by it are on and work properly, including: sensor module, LCD, Arduino, relay, fan, lamp, pump, blower and other supporting components. Based on the testing result, all components connected by the circuit are on and work properly, indicated by one of the main indicators, i.e. the LED that lights up well.

3.3. DHT-22 Sensor Testing and Analysis

DHT-22 sensor module works to measure the air temperature and humidity in the greenhouse. Based on the testing result, the data obtained by the DHT-22 and calibrator sensors are not significantly different (average difference are ±0.0875°C for air temperature, and ±3.75% for air humidity).

3.4. SEN0057 Sensor Testing and Analysis

At this stage SEN0057 sensor is tested to ensure the sensor works properly. Sensor SEN0057 works to measure the soil moisture used as a medium for growing chrysanthemum. verification of the accuracy of soil moisture measurements by SEN0057 can be seen in Table 5. The testing result show that the data obtained by the two devices are significantly different. The difference is expected because of differences in methods used by both devices. SEN0057 uses highly accurate digital method with small calculation errors since the digital method has the least probability to get disturbance from noise. Meanwhile, the calibrator used in this study uses analog method whose accuracy is likely to be influenced by noise, causing high probability of error in its calculation.

Table 5. The Testing Results of SEN0057 Sensor and Calibrator

No	Testing Time	Soil Moisture (%)		
		SEN0057	Calibrator	Difference
1	05.00	100	92	8
2	05.24	100	92	8
3	17.14	95	87	8
4	17.51	94	85	9
5	21.40	90	82	8
6	22.00	90	82	8
7	22.12	89	80	9
8	22.36	89	80	9
Average Difference				8.375

3.5. System Performance Testing and Analysis

Testing and analysis of the performance of light control and watering system automation system in greenhouse for chrysanthemum cultivation is conducted to ensure the system works according to the initial specification.

System performance testing is done in various conditions. Response time is the time taken to stabilize the condition from not ideal to ideal. In the first testing, the outputs, lamp and pump, are on while the blower and fan are not. This is in line with the initial reference, namely if the air temperature is below 22˚C, the light is on and if the soil moisture is below 70%, the pump is on, while the fan and blower are not because the temperature and humidity do not exceed 28ºC for the fan and are below 70% for the blower. On the other hand, the fan and blower are on while the lamp and pump are not in the second testing since it is given a condition as in Table 6.

Table 6. The Results of System Performance Testing Affected by Sensors in Various Conditions

No	Air Temperature (ºC)	Air Humidity (%)	Soil Moisture (%)	On/Off condition & Response time (Second/s)			
				Fan	*Blower*	Heating Lamp	Pump
1	21.0	75	67	-	-	√ (90 s)	√ (5 s)
2	29.0	55	80	√ (120 s)	√ (300 s)	-	-
3	28.0	70	90	-	-	-	-
4	21.9	60	55	-	√ (200 s)	√ (30 s)	√ (10 s)
5	20.0	80	72	-	-	√ (180 s)	-
6	27.0	80	60	-	-	-	√ (7 s)
7	28.0	60	90	-	√ (210 s)	-	-
8	30.0	75	85	√ (240 s)	-	-	-

In the third testing, the outputs are off. This is because the condition of air temperature, air humidity and soil moisture is in stable condition or in accordance with the requirement of the growth of chrysanthemum i.e. air temperature between 22-28˚C, air humidity 70-100% and soil moisture 70-100%. In the fourth testing, the blower, the lamp and the pump are on because the condition has been met according to the initial reference. Meanwhile, the fan is off because its condition will be inversely proportional to the lamp's, namely, when the fan is on, the lamp must be off, and vice versa. This is because the fan is related to too high temperature while the lamp is related to too low temperature.

Testing and analysis is done not only for outputs affected by the sensors, but also for the system performance influenced by Real-Time Clock (RTC): if the time is at 19:00 to 23:59, the lamp will be on or in a high condition (1); if the time is not at 19:00 to 23:59, the lamp will be off or in a low condition (0).

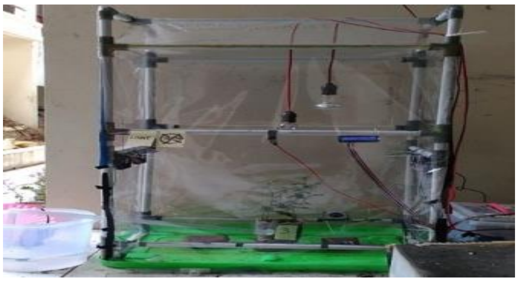


Figure 10. Greenhouse and light control system and watering system for the cultivation of chrysanthemum

The testing and analysis that have been described show that each output is on in accordance with the reference that has been set, therefore, it can be concluded that the system performance has been in accordance with the initial specification and can be implemented in greenhouse for chrysanthemum cultivation.

3.6. System Implementation Testing and Analysis

System implementation testing is done to know the extent to which the system can work well and properly for chrysanthemum cultivation. The result of this testing is presented in Table 7. This testing has been conducted for seven consecutive days with the object of observation focusing only on the height increase of chrysanthemum each day. It is done using two chrysanthemums placed in pots with different placement. Pot 3 is placed inside the greenhouse equipped with the system, while Pot 6 (control) is placed outside the greenhouse as well as outside the system created.

Table 7 shows that the height of chrysanthemum placed in Pot 3 placed inside the greenhouse equipped with the system increases of 3.7 cm and its average daily increase is 0.616 cm. Meanwhile, the height of chrysanthemum placed in pot 6 which is placed outside the greenhouse and outside the system increases of 0.2 cm and its average daily increase is 0.033 cm. The comparison of height growth of chrysanthemums can be seen in Figure 11 and Figure 12.

Table 7. The Results of System Implementation Testing

Day-	Plant Height (cm)		Plant Height Increase (cm)	
	Pot 6 (Outside the system)	Pot 3 (inside the system)	Pot 6 (Outside the system)	Pot 3 (inside the system)
1.	21	21.3	-	-
2.	21	21.9	0.0	0.6
3.	21	22.6	0.0	0.7
4.	21.1	23.4	0.1	0.8
5.	21.1	24.0	0.0	0.6
6.	21.1	24.6	0.0	0.6
7.	21.2	25.0	0.1	0.4
Average Daily Height Increase			0.033	0.616

The significant difference in the height increase of the chrysanthemums placed in the two pots is due to the different placement. Pot 3 is placed inside the greenhouse equipped with a system to support the growth of chrysanthemum according to the characteristics adapted for, from temperatures to additional light. Based on the literature that has been described in the previous chapter, it is said that chrysanthemum requires longer lighting for the process of height growth, namely more than 12 hours to get a maximum height i.e. about 6-7 cm per week [17]. In the system, additional light from the lamp is set automatically for five hours. In addition, the air temperature, air humidity and humidity of the plant are engineered by the system by means of automation to adapt to the characteristics required by chrysanthemum. Meanwhile, pot 6 is placed outside the greenhouse and is not equipped with the system so that the light, air temperature, air humidity and soil moisture are not engineered there. In other words, it follows the natural conditions resulting in environmental conditions that are not in accordance with the characteristics of chrysanthemum, thus causing the growth of chrysanthemum not optimal.

Figure 11. The plant condition before the testing (plants used are no. 6 and 3)

Figure 12. The plant condition after the testing

4. CONCLUSION

Based on the testing results on the function and performance of the sensors, it can be concluded that DHT-22 sensor can measure the temperature and humidity of the air, and SEN0057 sensor can measure soil moisture. Moreover, according to the result of testing and analysis of the design and development of the system, it can be concluded that the system works well according to the initial specification because the heater lamp is on when the temperature is lower than 22^{o}C, the fan is on when the temperature is higher than 28^{o}C, the blower is on when the air humidity is less than 70%, the pump is on when the soil moisture is less than 70%, and the lamp for additional light is on at 19.00-23.59 WIB. The system performance testing on the process of height increase shows a significant change with the height increasing of 3.7 cm in 7 days, compared to the height increase of chrysanthemum treating without the system and outside the greenhouse, namely, 0.2 cm in 7 days.

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