Red onion growth monitoring system in hydroponics environment

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Abstract. Red onion plants using hydroponic method is a method performed by cultivating plants using water, nutrients, and oxygen with no soil required. Hydroponics method is an alternative solution to grow onions in limited soil. The changes in air temperature, bright light, plant temperature and humidity greatly affect hydroponic growth. Red onion plants using hydroponic planting medium is a method performed by cultivating plants using water, nutrients, and oxygen with no soil required. Hydroponics method is an alternative solution to grow onions in the limited land. The changes in air temperature, bright light, plant temperature and humidity greatly affect hydroponic growth. The difficulty of knowing the environmental conditions of hydroponic planting media, often makes the hydroponic farmers fail in the middle of the process of plant growth. This monitoring system uses water temperature sensor, air temperature sensor, Light Sensor, GSM SIM800L, LM2596Relay module and Arduino Uno as a microcontroller. The result of tests conducted for eight weeks on the onion environment monitoring by taking into account the water temperature, humidity, air temperature, and light intensity. The leaves amount and height acquired from the test is 12 leaves with 29 cm of height.

1. Introduction

Red onion is a plant that belongs to the bulb type. Allium cepa L. Var Aggregatum is a type of plant which serves as spices in various cuisines of Southeast Asia and the world. It can be used as medicine, so this commodity has an important role. One example of onion in the field of health is as a traditional medicine for wound healing or infection. According to Pulle, onion belongs to the group of Spermatophyta, Subclass of Angiospermae, Class of Monocotyledoneae, ordo of Liliflorae and Family of Amaryllidaceae, but some botanists considered red onion as the family of Liliaceae because the flower and its arrangements resemble Lilies (tulips) [1]. However, red onions are more likely similar to Amaryllis (narcissus flowers).

One method of farming that can be applied to growing the onions is the hydroponic method. Hydroponics is a method of planting the crops without using soil. In simple term, hydroponics is a plant that utilizes water, nutrients, and oxygen. Hydroponics method is an alternative solution to cultivate vegetables in the limited land. The changes in air temperature, light composition, plant temperature and humidity greatly affect hydroponic growth. The difficulty of knowing the environmental conditions of hydroponic planting media often makes the farmers who use this planting method to fail in the middle of the process of plant growth.
The technological development, especially in the field of sensors, allows people to identify the condition of an environment based on the sensor type. [2] This technology can be applied to hydroponic planting media to facilitate the cultivator to have an understanding of the status of their planting media environment. Changes in the environmental condition can be quickly identified by sensors in accordance with their respective functions. In determining or monitoring the state of the hydroponic environment, several types of sensors are required, namely; Air Temperature Sensor, Light Sensitivity Sensor, Plant Temperature Sensor and Humidity Sensor.

The output given by the sensor is not something that can be read with the daily language. A microcontroller is needed to process the output from the sensor to be more easily understood by humans. Arduino is one of the microcontrollers that can accommodate several data received from numerous sensors at the same time. This allows the system to be built to process the data simultaneously, so no data with the same data retrieval process are found in a different time. Therefore, an approach is required to handle the process of data grouping, so it will be easier for the data to be stored in the database.

The environmental impact is very influential in the development of hydroponic planting medium. To obtain maximum results from the hydroponic onion crops, farmers and growers should monitor changes in air temperature, water temperature, light, and moisture. Therefore, a system is needed to monitor environmental factors in real time mode which affecting the quality of plant growth.

The purpose of this research is to monitor the growth of shallots in hydroponic planting medium based on changes in water temperature, air temperature, light intensity, and humidity Using Arduino microcontroller device in real time.

This research is expected to provide the following benefits: As an alternative solution for farmers and who care for monitoring the onions growth in hydroponic media, improving the quality of hydroponic crops especially onion plants by performing a continuous examination to obtain the status of shallot crops, and add more variations to the hydroponic onion plant monitoring system. Whereas, the scope of the research are as follows; the data used for testing in this study, are obtained from the monitoring of onion crop quality on hydroponic planting medium. The parameters used to determine the quality of the results are the changes in air temperature, light intensity, water temperature and humidity and the study was conducted for eight weeks, starting from onion seeds.

Onion is a seasonal plant and has layered bulb. The bulbs are formed from a unified leaf base which form stem that changes its shape and function then enlarges to form a layered bulb. The onion bulbs are formed from layers of enlarged and united leaves. They are not a true bulb such as potato or taro [3]. Unused pots or jars can be used for the media to plant shallots hydroponically. Hydroponic red onion can be planted using husk charcoal and cocopeat with a 1:1 ratio. The beginning of the red onion planting (counted since seedlings have shoots -/+ 1cm) is at 400 ppm, the second week at 800 ppm, the third, fourth, and fifth week at 1000 ppm, while the sixth week and so on is around 1200 ppm.

Generally, red onion is reproduced using its bulb as a seed. The quality of the seed determines the amount of onion production. The splitting of the onion tubers will be able to save up the amount of plant seeds. According to Galvan et al, onion bulbs originating from one bulb will be split into 2 with growth percentage of 87.77% and 68.90% and production amount of 632.30 gram and 284.0 gram per plot respectively where compared to the growth of shallots with no cleavage at percentage of 100% with production amount of 1001.00 grams per plot [4].

A sensor is a component or device that aims to detect an event or change of its surrounding environment then produce the output according to its function. A device that serves to detect symptoms or signals originating from a change in energy such as electrical energy, physical energy, chemical energy, biological energy, mechanical energy, and many more [5]. Here are some sensors that will be used in this research:

- Sensor DS18B20 to measure water temperature.
- The DHT22 sensor, used for measuring air temperature and humidity.
- LDR sensor, to measure the intensity of light.
The related research to the study conducted by authors are as follows, Romadloni conducted research in 2015, to design a hydroponic automation system NFT (Nutrient Film Technique). In the study, the author used a microcontroller with Atmega 328P IC that is able to integrate with various sensors, automation system for hydroponics to regulate the pump, LED grow light, fertilization system, and to provide information of the hydroponic situation to the owner [6].

In 2012, Hadita et al. conducted a study on light regulation for hydroponic methods using android and Arduino devices. In the system, hydroponic method can be performed indoors. Hydroponic plants still need a light source to perform the process of photosynthesis. Only few of the emitted light energy were required for plants to conduct photosynthesis because the light waves captured by each plant differ from one another depending on the type of plant. Therefore, it is necessary to create a light regulation tool for hydroponics plant to obtain optimal result [7].

Another research shows the farming monitoring system based on internet of things which combine wireless network node, embedded development, GPRS communication technology, web service, data acquisitions, data transmission and visualization with the alarm [8]. Ginting conducted a study on Vegetable Quality Monitoring on Hydroponics Using Arduino to calculate amount of data sent from each sensor per 10 minutes in 2017. Data storage from Arduino to the server is using the help of GSM Shield [9].

2. Methodology

2.1. System Analysis
After the power is connected and the voltage has been regulated by lm2596, the system is ready to operate. In the initial conditions the Arduino will read the LDR light sensor if the detected light source is not met, then the Arduino will turn the lamp on through the relay module automatically, and if the light is met, the Arduino will not turn on the lamp. Arduino will read LDR sensor for plants, humidity sensor, air temperature and water temperature sensor. All the readable data sensors will be sent to the online database via the gsm module.

2.2. General Architecture

2.2.1. Hardware
Hydroponics plants have a container containing water that has been mixed with liquid nutrients to meet the intake of these plants. The container will be inserted with a sensor that is Water Temperature Sensor. In addition to the sensor, there are also several kinds of sensors that will be connected that are the sensor humidity sensor and light sensor.

This process starts from measuring the nutritional needs contained in water as well as other needs for hydroponic plants. The water temperature sensor is used to measure the temperature of the water, the LDR sensor is used to measure the light intensity in the plant environment, and the air temperature sensor is used to measure the temperature of the plant scope. All these sensors will be combined in GSM and Relay Modules. Sensors will collect all data that will be sent to the light database by Arduino via GPRS module data/module 800L.

Arduino will calculate the amount of data from each sensor per 5 minutes. Data from each sensor will be directly sent using the internet network through the GPRS module for the server to send the data to the monitoring application system directly. After connected, Arduino will send data and access the web page on the server. The GPRS module is stackably installed on the Arduino and will connect the arduino to the server using the internet network.

2.2.2. Application
This application of monitoring system is a web-based application system using PHP.

2.2.3. Web Server
The web server of this study is a self-built web server. This web server serves as a place for collecting and processing data between Arduino, database, and client. The web server will receive data from Arduino in the form of water temperature, air temperature, and the light intensity in the scope of the plant. This data will then be stored in the database and ready to be displayed to the client. Each state of the sensor status will have an indicator light to tell whether the plant condition is in healthy condition or severe conditions. A separate graph on each sensor will be created on the web to display the data from the water temperature sensor, air temperature, light sensor, and humidity. The graph will be updated periodically within 10 minutes. This data processing will always be conducted either when the client access the web server or not. If the received data is beyond a threshold that is inconsistent with the requirement to grow the plant, the system will display the notification on each sensor. Notifications serve as a reminder to the user that the plant condition is not normal.

The general architecture of this research can be seen in Figure 1.

![General Architecture](image)

**Figure 1.** General Architecture.

3. Result and Analysis

3.1. Implementation

The system implemented PHP programming language and C programming language for monitoring water temperature, air temperature, and light intensity.
Figure 2. Login Page.

The status of red onion that appears on each sensor is the water temperature sensor, air temperature, humidity, and light intensity.

Figure 3. Shallot Status.

This page shows the values of water temperature sensor, air temperature sensor, light sensor, and humidity sensors obtained from plants in graphical form. The graphs are used to monitor the plant needs. These graphs will be updated periodically every 10 minutes so that users can monitor the status of each plant. The graphs can be seen in figure 4(a), 4(b), 4(c), and 4(d).
Figure 4. Graph of Each Sensor; (a) Air Temperature; (b) Light Intensity; (c) Water Temperature; (d) Humidity.

This section will display the values obtained by the plant sensors in tabular form. On this page, the value obtained from the sensor is always the latest. The latest data will change every hour. The plant monitoring table can be seen in figure 5.

Figure 5. Page of Log Sensor Table.

3.2. System Performance Test
This stage will discuss the problem of system performance testing. A test was conducted on the onion plant to monitor the plant condition on changes in water temperature, air temperature, humidity and light intensity. The experiment lasted for eight weeks. The system performance test can be seen in Figure 6.
The system performance test was performed to see the average value of water temperature, nutrition, air temperature, and light intensity, also the number of the plant leaves, and its height. This test was performed for eight weeks on shallot crops, and the obtained data are the average value of weekly counted data. This test was conducted since the plant was in the form of seeds.

In the first week, the plant was still placed in a regular container, and it was only showered with water for two weeks. On the third week, the plant was put in a particular hydroponic pot containing water and nutrient water with water temperature sensor.

The test performed in the first week showed that the sensor had not been working properly because it was still in a container differentiated for two weeks. The shallots condition on the second week has grown well with a height of 0.8 cm. The test result can be seen in Table 1.

| Day | Water Temperature ($^\circ$C) | Air Temperature ($^\circ$C) | Light Percentage (%) | Leaves Amount | Height (cm) |
|-----|-----------------------------|-----------------------------|----------------------|---------------|-------------|
| I   | -                           | -                           | -                    | -             | -           |
| II  | -                           | -                           | -                    | -             | -           |
| III | -                           | -                           | -                    | -             | -           |
| IV  | -                           | -                           | -                    | -             | -           |
| V   | -                           | -                           | -                    | -             | -           |
On the third and fourth, the sensor has been able to measure the environmental status of the plants such as air temperature, humidity, and light intensity. It resulted in the rapid growth of the plants through routine surveillance. On the last measurement, the plant has a height of 14.5 cm. The test result is shown in Table 2.

**Table 2. Test Result for Week 3 and Week 4.**

| Day | Water Temperature (°C) | Air Temperature (°C) | Light Percentage (%) | Leaves Amount | Height (cm) |
|-----|------------------------|----------------------|----------------------|---------------|-------------|
| I   | 28                     | 30                   | 87                   | 2             | 2.9         |
| II  | 29                     | 32                   | 80                   | 3             | 7.2         |
| III | 29                     | 29                   | 75                   | 3             | 13          |
| IV  | 29                     | 30                   | 76                   | 5             | 13          |
| V   | 25                     | 29                   | 80                   | 5             | 14          |
| VI  | 25                     | 29                   | 82                   | 5             | 14.5        |
| VII | 25                     | 29                   | 81                   | 5             | 14.5        |

The plants began to grow with the addition of leaves in week 5 to week 8. The number of leaves that grow will reduce the number of tubers formed on the onion plants. Several factors greatly affect the crops which can lead to death caused by Moler disease, initially marked with the white colour on the base or the onion bulb then it spread to the leaves causing excessive growth of the leaves, and the leaves began twisting. The symptoms continued with the leaves started to fall. The different ways of the plant roots in absorbing the nutrients in the mixed water is another factor that can lead to the crop failure.

**Table 3. Test Result for Week 5 and Week 6.**

| Day | Water Temperature (°C) | Air Temperature (°C) | Light Percentage (%) | Leaves Amount | Height (cm) |
|-----|------------------------|----------------------|----------------------|---------------|-------------|
| I   | 30                     | 30                   | 87                   | 6             | 15          |
| II  | 32                     | 32                   | 80                   | 6             | 15          |
| III | 30                     | 29                   | 75                   | 6             | 16.9        |
| IV  | 29                     | 33                   | 76                   | 7             | 19          |
| V   | 29                     | 29                   | 80                   | 7             | 19          |
| VI  | 29                     | 29                   | 82                   | 8             | 20          |
| VII | 29                     | 29                   | 81                   | 8             | 22          |

**Table 4. Test Result for Week 7 and Week 8.**

| Day | Water Temperature (°C) | Air Temperature (°C) | Light Percentage (%) | Leaves Amount | Height (cm) |
|-----|------------------------|----------------------|----------------------|---------------|-------------|
| I   | 27                     | 30                   | 89                   | 9             | 23          |
| II  | 29                     | 30                   | 89                   | 9             | 24          |
| III | 29                     | 33                   | 80                   | 10            | 26.9        |
| IV  | 28                     | 28                   | 70                   | 11            | 27          |
4. Conclusion and Future Research
The conclusions that can be acquired based on the monitoring system testing of red onion growths are as follows. The research used Arduino as the microcontroller to monitor the environment and factors that can affect the quality of shallot plants on hydroponic cultivating media and GSM / SIM800L network for data communication with an additional regulator of mini lm2596. Based on the test result of 8 weeks, the plant requires continuous nutrients to grow. The water temperature sensor and LDR always receive a stabled average data in accordance with the crop environment. Different circumstances will occur if the level of humidity is too high causing the plant fails to grow properly. Automatic lighting will enhance and maximize the photosynthesis process of the plants also serves as bugs repellent.

References
[1] Pulle A A 1950. An Enumeration of the Vascular Plants Known from Surinam Together with Their Distribution and Synonymy. Netherland : Botani.
[2] Rahmat R F, Athmanathan A, Syahputra M F and Lydia M S 2016 Real time monitoring system for water pollution in Lake Toba International Conference on Informatics and Computing (ICIC) pp. 383–388
[3] Hervani D, Lili S, Etti S and Erbasrida 2008 Cultivation Technology on Shallots using Several Media in Padang Thesis: Universitas Andalas.
[4] Galvan G A, Wietsma W A, Putrasemedja S, Permadi A H and Kik C 1997 Screening for resistance to anthracnose(Colletotrichum gloeosporioides Penz.) in Allium cepa and its wild relatives Euphytica 95 2 173-178.
[5] Sharon D 1982 Principles of Analysis Chemistry New York: Harcourt Brace College Publisher.
[6] Romadloni P L 2015 System Design Automation Hydroponics NFT (Nutrient Film Technique) Thesis: Telkom University.
[7] Hadita N W, Alandani R and Muhaqiqin 2012 Light settings for Hydroponic planting methods using Android and Arduino devices Journal of Lampung University.
[8] Wang Y, Song J, Liu X, Jiang S and Liu Y 2013 Plantation Monitoring System Based on Internet of Things IEEE and Internet of Things (iThings / CPSCom) 366-369.
[9] Ginting R P 2017 Quality monitoring system for hydroponic vegetables using Arduino Thesis: Universitas Sumatera Utara.