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Design of Smart Green House Using pH and Water Temperature Optimization in Lettuce, Hydraulic Plant Media based on Arduino Uno

Yosef Weisrawei, Dwi Arman Prasetya, Aries Boedi Setiawan
Department of Electrical Engineering, University of Merdeka Malang, Indonesia,

*Corresponding Author: yosep.weisrawei@gmail.com

Abstract

In terms of cultivating lettuce using hydroponic media there are several things that must be considered such as pH levels, water temperature and sufficient light requirements. Manually checking is done so badly by the farmer that it takes a lot of time, therefore an automation system is needed in this case to overcome routine checks. This system is an alternative to modern control systems to optimize the control of pH levels, water temperature of Arduino-based lettuce plants, and the addition of a 40 watt LED lamp, pH measurement using the SEN0161 pH sensor, for measuring water temperature using the Ds18b20 sensor. Control of pH and water temperature is carried out automatically, using a peltier as a coolant and a selenoid valve as a dropping liquid pH until it reaches the required value, i.e., a pH level of 6.0-7.0, a water temperature <27 ° C and a 40 watt LED lamp as an addition to light intake in plants The stability of water temperature and pH levels that are always maintained by this tool can save time for farmers in routine checking of pH and water temperature, this tool also produces better growth of lettuce compared to the usual method.

Keywords: Smart Green House, pH optimization, Lettuce, temperature.

1. Introduction

The shift of the function of agricultural land to industrial areas has resulted in the narrowing of potential agricultural land for cultivation, therefore, it is necessary to have a farming system that can use narrow land without reducing agricultural productivity and can produce higher quality production [1]. One of the agricultural technologies that can be used is hydroponic cultivation technology.Hydroponics is a way of farming without using soil media but can use water or other porous materials. The axis system is a hydroponic system. The wick system utilizes the capillary principle of the nutrient solution which is absorbed directly by the plant through the axis. One of the materials that have the best water absorption and can be used as a wick in the wick system is fabric [2]. Constraints that are often experienced by conventional farmers in Indonesia are unfavorable environmental conditions such as high rainfall [3]. So that plants cannot carry out the photosynthesis process completely due to lack of sunlight, and changes in pH levels and water temperature

that can affect plant growth. A good acidity condition for hydroponic plants, especially curly lettuce is in the range of Ph 6.0-7.0, and the water temperature does not exceed 28 ° C [4]. The role of sunlight in plants can be replaced by providing special light from lights so that even though the plant is in a closed room, the photosynthesis process can still take place [5].Periodic monitoring is carried out continuously for monitoring and controlling pH levels and water temperature. To help and facilitate the work of hydroponic farmers, a tool that is able to control the acidity, water temperature, and light supply is needed. So a pH and water temperature controller was made that could work automatically, using Arduino Uno as a microcontroller.

2. Literature Review

2.1 Lettuce

Lettuce or sla leaf (Lactuca sativa) is a vegetable plant commonly grown in temperate and tropical regions. Its main use is as a salad. World lettuce production is estimated at around 3 million tonnes planted on more than 300,000 ha of land. one way of applying technology to lettuce plants, by looking at several factors in the land, soil quality, weather, and other factors that can inhibit lettuce plant growth, so hydroponic planting methods or methods are applied by controlling with an Arduino microcontroller.

2.2. Hidroponic

Hydroponics is a method of cultivating plants using water without using soil media by emphasizing meeting the nutritional needs of plants. The water requirement in hydroponics is less than the water requirement for cultivation with soil. Hydroponics uses water more efficiently, so it is suitable to be applied in areas that have a limited water supply.moreovere, on this research focus on two paramaters i.e., pH and temperature on the hydroponic system. The complete system design to be built in this reseach is shown in Figure 3.

2.3 pH and temperature

Temperature: affects the processes of photosynthesis, respiration, transpiration, and reproduction in plants. the temperature that is too high or low will inhibit these processes. The optimum temperature for plants is between 10C - 38C.

Water affects on :

- determine the rate of photosynthesis
- helps the seed germination process
- as a universal solvent
- transporting nutrients and photosynthesis products
- as a medium for enzymatic reactions

3. Method, Data, and Analysis

The research stages to be carried out are as follows:

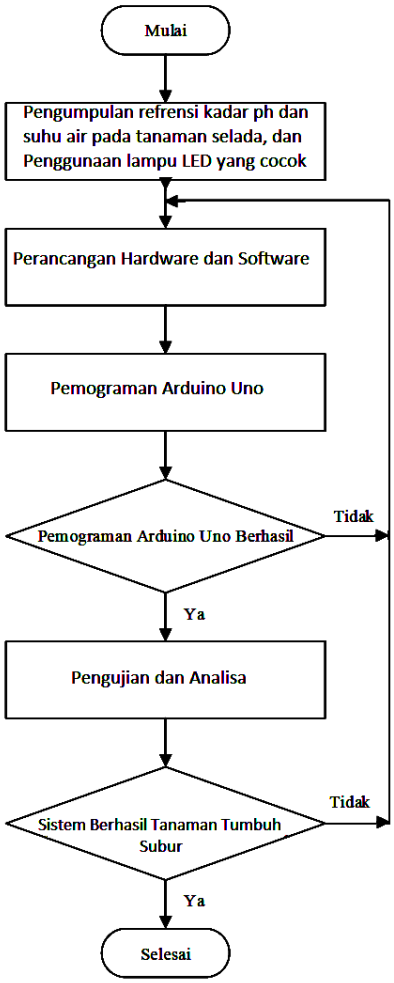

Figure 1. Research Flowchart

A Block diagram is a system used for the initial design of this final project tool.

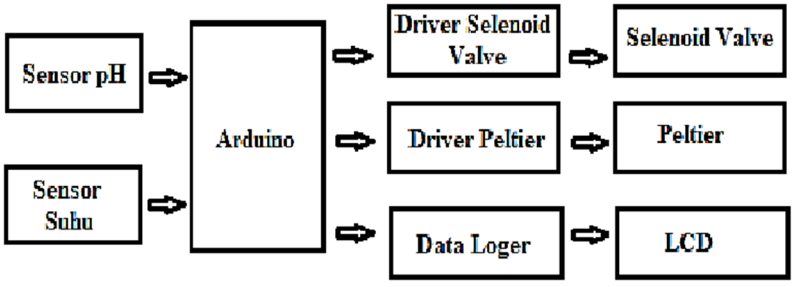

Figure 2. Research Block Diagram

The block diagram in Figure 2 is the working principle of this control device, where the pH sensor and temperature sensor are the inputs that will read the pH and temperature values

in the water, the resulting values will be continued and processed. The values that are issued will go to Arduino and be processed according to the program that has been entered. The output from Arduino will activate the solenoid valve as a drop of ph liquid, and activate the Peltier driver as a water cooler, the pH values and water temperature received by Arduino will be sent to the logger data which will then be displayed on the LCD. moreover, The Prototype system on this research is an illustration of how this tool will be made and worked, therefore, that it can help during the tool or prototype creation process.

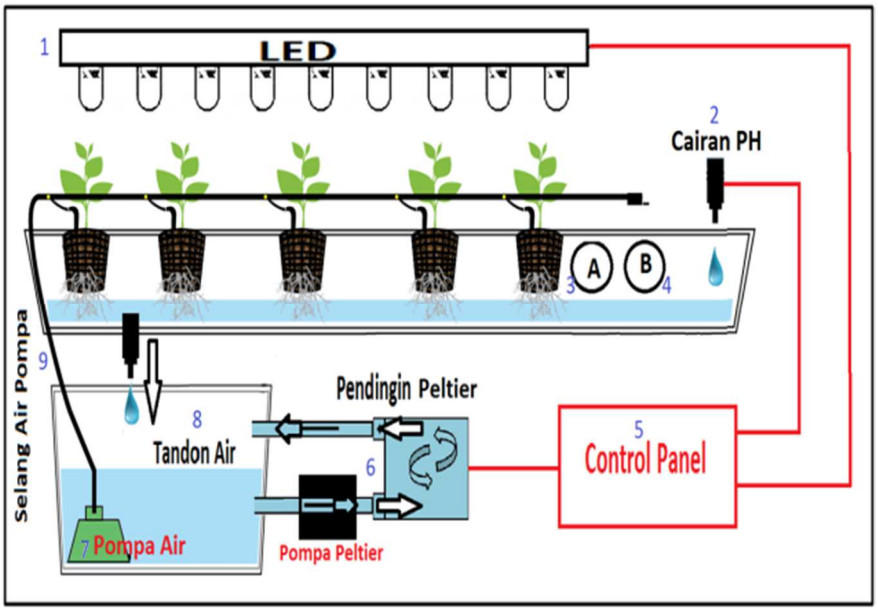

Figure 3. a Prototype system on this research

Captions in Figure 3 are as follows:

1. Led
2. Liquid pH
3. pH sensor
4. DS18B20 temperature sensor
5. Control Panel
6. Peltier Coolers and Peltier Pumps
7. Tandon Water Pump
8. Water reservoir
9. Water Hose

C. Manufacture of Hardware

In electronic devices, there are several elements that must be arranged to be able to control the pH and temperature properly. These elements are as follows:

1. Microcontroller, namely Arduino as a control and processing unit of sensor data.
2. pH sensor as a component to identify the pH level in the water.

3. DS18B20 sensor as a component of water temperature identification.
4. Power supply voltage source for all components in this tool.
5. Solenoid valve to open / close pH liquid flow valve
6. Peltier as a tool to cool the water temperature.
7. Datalogger as data storage
8. LCD tool for displaying status

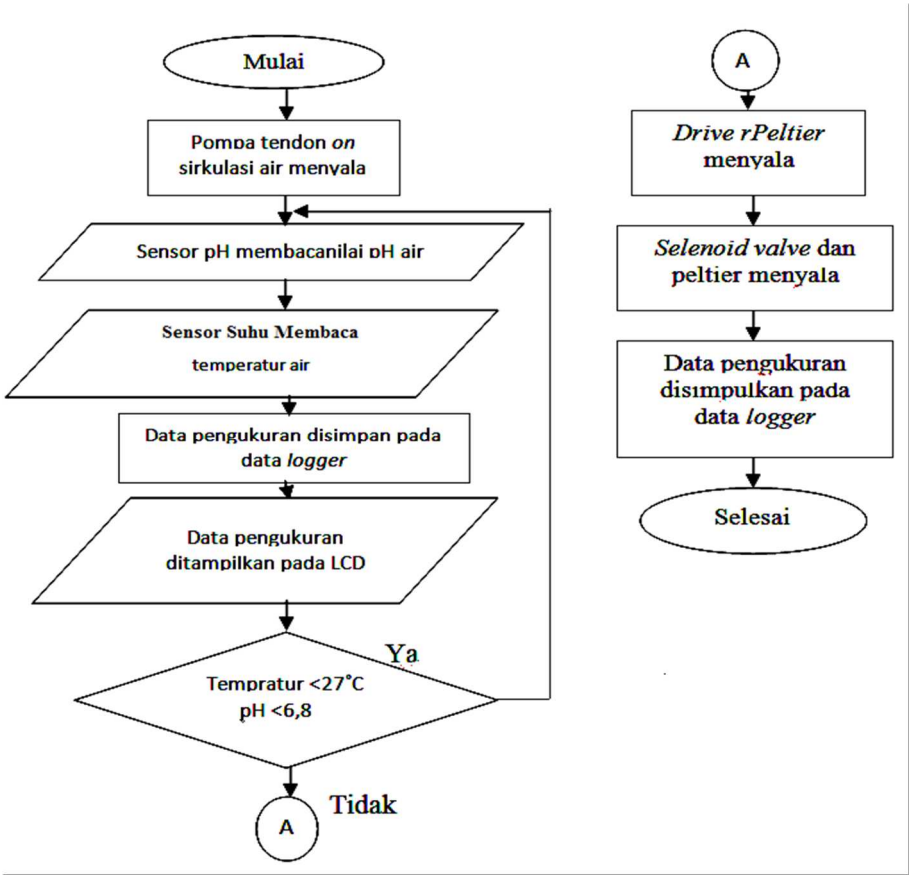

Figure 4. Flowchart on the main program

In the software, there are several programs that must be made to be able to read sensors and control temperature and pH properly. The stages in making can be seen on the flowchart on figure 4. Furthermore, Based on Figure 4, it is explained how the program process when it is run, which starts with starting, the reservoir pump is on and the water circulation turns on, then the pH sensor reads the pH value in the reservoir water and the temperature sensor reads the water temperature, measurement data from the pH sensor and temperature sensor are stored in the data. The logger and stored data are displayed on the LCD then enter the decision section, if the temperature is below 27°C and the pH is below 6.8, if yes then the connecting line will return to the pH sensor reading the pH value of the water, otherwise, the program will turn on the Peltier driver and Selonoid valve driver then the measurement data is concluded in the data logger and the program is complete.

4. Results

This stage will be discussed about testing based on the planning of the system is made. Testing and data analysis are carried out to determine the work of the system and to determine whether or not it is appropriate with the planning that has been made. Testing is first carried out separately on each unit circuit and then carried out in an integrated system. Moreover, Testing of the pH sensor is carried out by connecting the wiring from pH to Arduino in the form of Vout, ground, and VCC while the output results are displayed on the Arduino monitor serial.

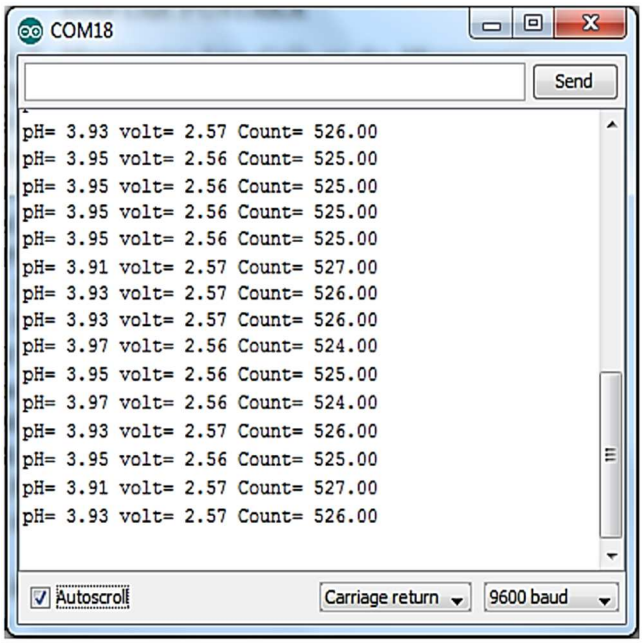

Figure 5. Serial Monitor output

Figure 5 shows the output of the pH sensor.To get the output from the pH sensor, calculations can be done with the following equation:

$$\text{Volt} = \text{analogread} / 2^{\eta} \text{ x vcc} \qquad (1)$$

$$\text{pH} = (\text{intercept} + (\text{volt x slope})) + 0.07 \qquad (2)$$

analogread is an input value of the signal conditioner at the electrode, 2^{η} a bit resolution on the microcontroller, which is 10 bits, therefore 2^{1} ° = 1024 vcc = 5 volts, while the intercept and slope are the standard values of the slope of a pH sensor manufacturer calibration, the intercept value = 13.720 and the slope = -3,838. If one of the values in Figure 5 is entered in to prove the above equation then;

$$\text{Volt} = \text{analogread} / 2^{\eta} \text{ x vcc}$$

$$= 527/1024 \text{ x } 5 = 2.57$$

$$\text{pH} = (\text{intercept} + (\text{volt x slope})) + 0.07$$

$$= 13{,}720 + (2.5732421875 \text{ x } -3{,}838)$$

$$= 13{,}720 + -9{,}876 = 3.84 + 0.07 = 3.91$$

The first test of a pH sensor is carried out by calibrating a pH sensor value used with the pH value in a standard buffer solution that has been measured by another tool. This test also aims to determine the change in the reading of the pH value with time. Furthermore, Temperature sensor testing aims to calibrate the sensor so that the measurement is in accordance with its original state. The temperature sensor was tested by DS18B20 and a comparison of the measurement results from the DS18B20 temperature sensor was carried out with a thermometer. The medium used is water from melted ice, ice mixed with water, and warm water. The test results can be seen in Table 1.

Table 1. Data Comparison of temperature sensor measurements

conditions of the treatment site	**Temperature of DS18B20 (°C)**	**Termometer (°C)**
Melting ice water	4	3.80
Ice mixed with water	15	15,75
Warm water	55	55,25

This test is done to find out whether the cooler is functioning according to its function. Therefore, it can stabilize the water temperature as desired, moreover, the Cooling test result data can be seen on the table 2.

Tabel 2. Cooling Test Result Data

Time (menit)	Temperatur Before (°C)	Temperatur After (°C)
0	29.50	29.50
5	29.50	27.30
10	29.50	25.55
15	29.50	23.60

The test aims to calculate the time used by the solenoid valve to drain water from the bottle to the outside. From the test results generated in Table 3, it is obtained results with different values.

Tabel 3. Solenoid Valve Testing Results Data

No	Water Volume(cm^3)	time(s)
1	300	42
2	400	58
3	500	79
4	600	93

This data logger test is done to find out whether the data logger is functioning according to its function. This test is done by connecting the logger data with Arduino, from this test a file with the extension ".txt" is obtained on the SD card according to the time format, namely yymmddhh (year, month, date, and time). Moreover, In this step of testing the whole tool is carried out in order to find out whether the system works as much as possible.

Figure 6. View of the Prototype

Various stages are carried out in the overall testing, testing is carried out in stages:

1. The appliance is connected to a 220 Volt AC power source

2. Temperature sensors and pH sensors are placed in the water reservoir to measure the temperature and pH level of the water in the reservoir.

3. The water pump will run continuously to flow water to the hydroponic plant. Irrigation is continuously carried out for water circulation.

4. When the water temperature in the reservoir is above 27 ° C, the relay driver will be active to turn on the water cooler in the reservoir until it reaches a value below 25 ° C, then the relay driver will be disabled.

5. The solenoid valve driver will be active when the pH sensor detects the pH value in the water reaches more than 6.8. The solenoid valve will drop the pH neutralizing liquid until the pH sensor detects the pH value of the water reaches less than 6.8.

6. All measurement data is recorded in a data logger which is stored in the SD card.

7. The status of pH and water temperature levels will be displayed on the LCD.

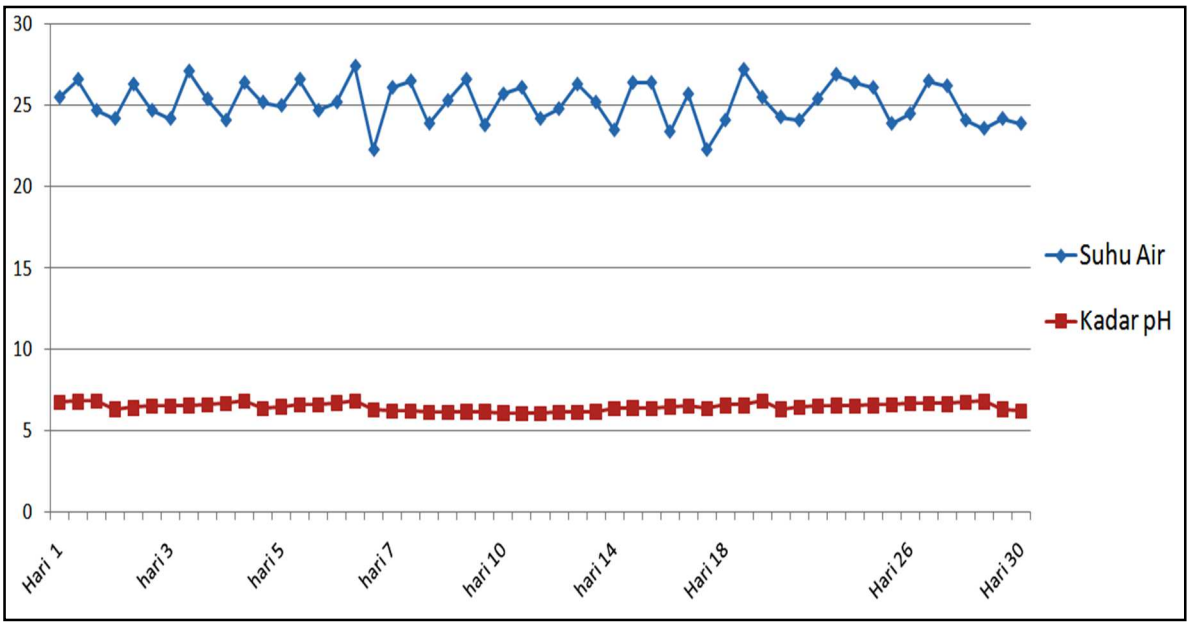

Figure 7. Graph of Water Temperature and pH Values for 1 Month

Monitoring of the values shown in Figure 7 is carried out to determine whether the water temperature and pH levels are always maintained as desired. Moreover, Testing and analysis of the behavior of the planting media were carried out to determine whether or not the water temperature controllers and pH levels were working well. The treatment was carried out with 2 treatments, namely controlled (on media A) and without control (on media B) carried out for 30 days.

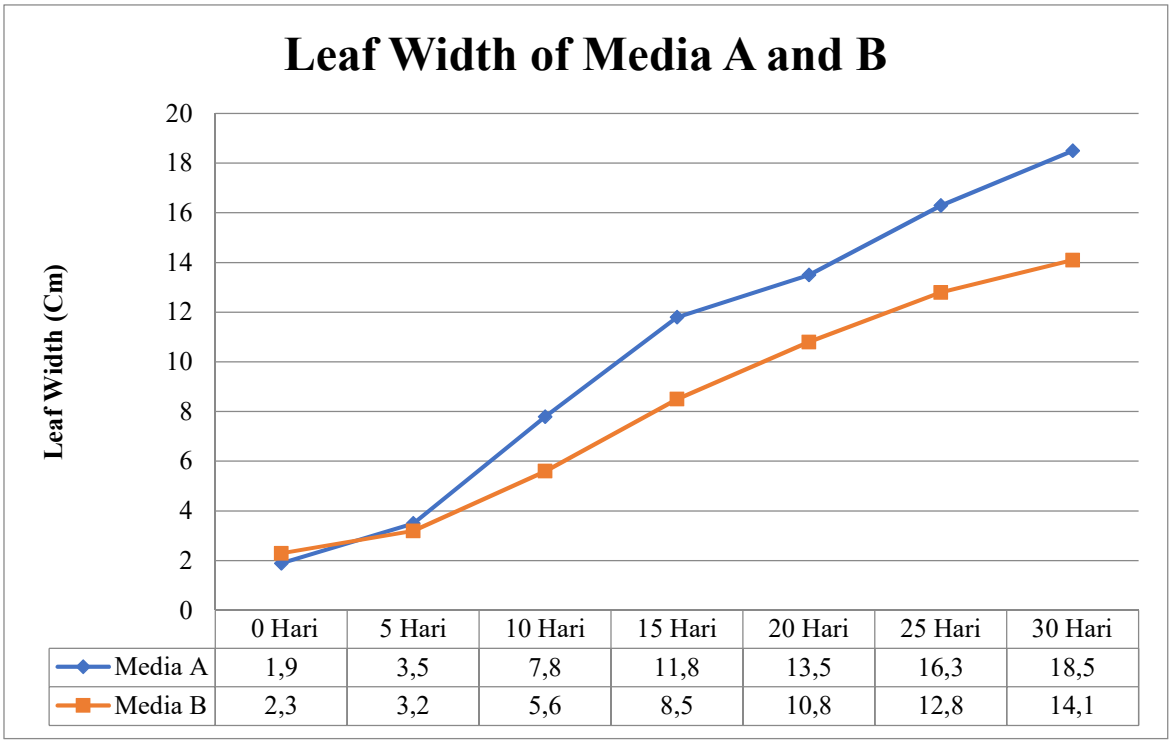

Figure 8. Leaf Width of Media A and B

Figure 8 shows the comparison of leaf widths in medium A and B, where the width of the leaves on medium B seedlings is wider than media A on day 0 with a difference of 0.4cm. On day 5, the width of the leaves in medium A exceeds the width of the leaves in medium B until the 30th day.

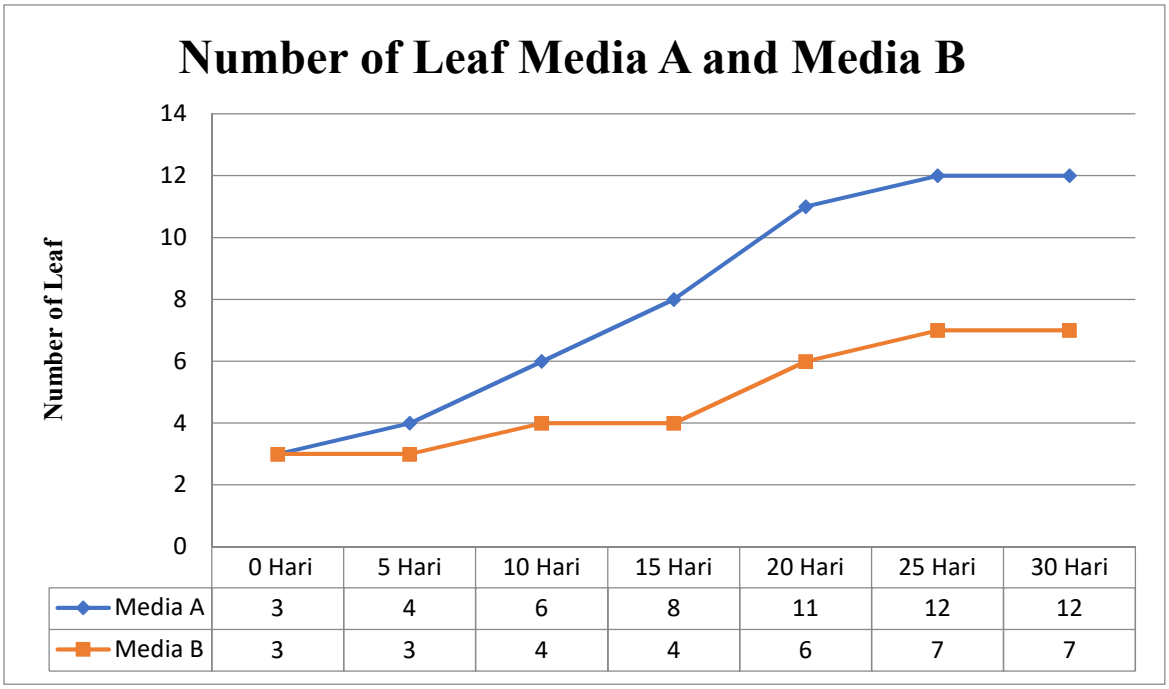

Figure 9. a Number of Leaf Media A and B

Figure 9 shows the difference in leaf count for 30 days, both seeds had the same number of leaves at the beginning of the study, the first difference was seen on day 5 where media A had 4 leaves while medium B had 3 leaves, and on day 30 the difference which is very significant where the difference in the number of leaves on media A and B reaches 5 leaves.

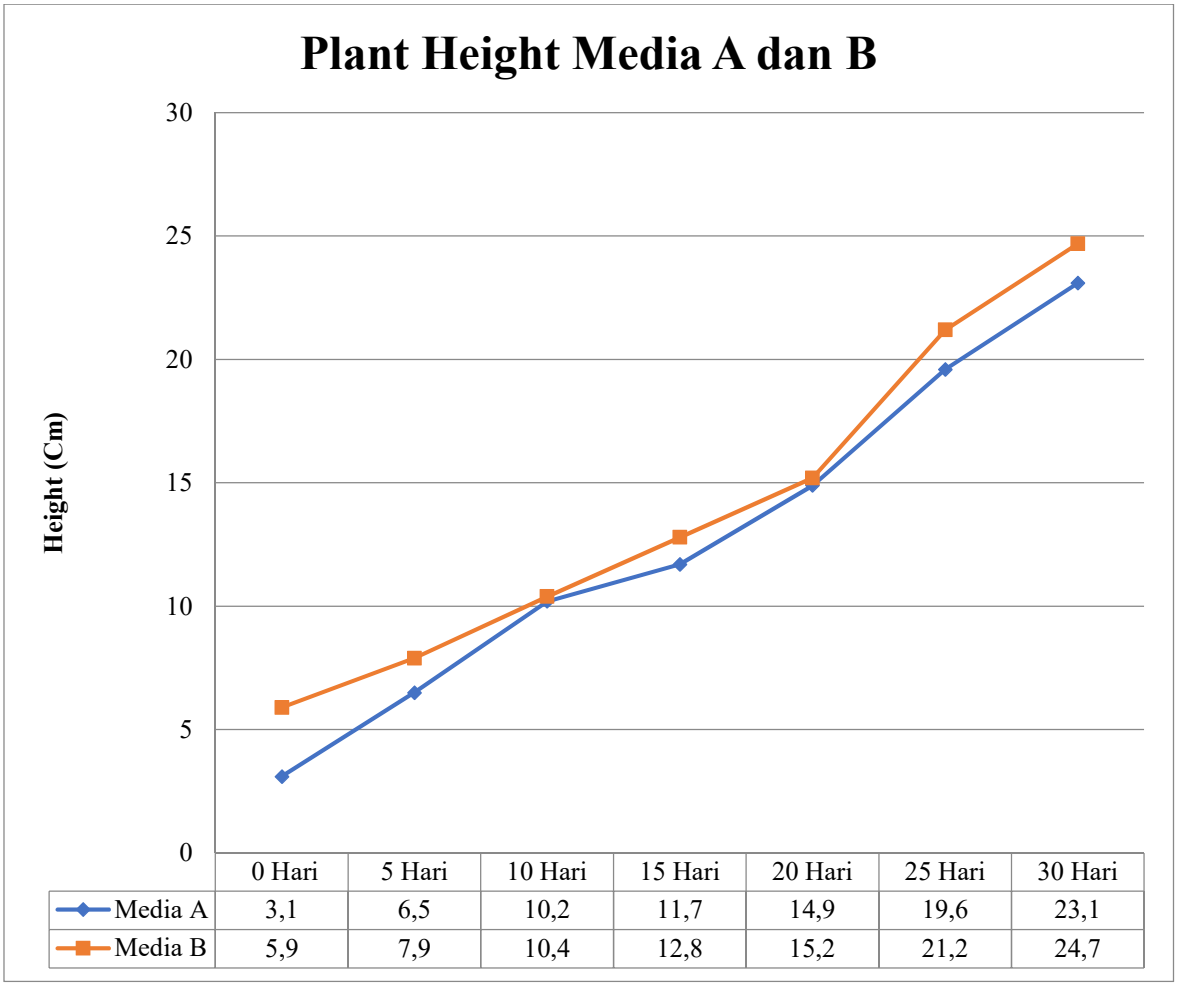

Figure 10. Height of Media Plants A and B

Figure 10 shows the difference in the height of lettuce plants for 30 days, where the difference at the beginning of the study was 2.8 cm, with the height of the medium A 3.1 cm and the B 5.9 cm. on the 10th day the difference reached 0.2 cm, and on the 30th day the difference reached 1.6 cm. Moreover, It can be seen from the results of the research, the development of plants on media A was better than on media B where the difference in growth could be seen in the differences during the 30-day growth study.

5. Conclusion

Based on the results of the research that has been done, it can be concluded as follows:

1) The pH and water temperature controller in lettuce can work according to the design.
2) The pH control system can control the pH value according to the desired value ranging from 6-6.8, and the temperature controller can keep the water temperature not past 27 ° C, so that the lettuce can grow well.
3) Lettuce plants in media A (controlled) were better than lettuce in media B (without control) where the lettuce plants in media A had more leaves and had wider leaf width, compared to media B plants.

6. Suggestions

The prototype or tools still need to be developed in a large dimension or scale to accommodate more lettuce plants.

Acknowledgement

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