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Design of automatic control system on pakcoy plant parameters in nutrient film technique hydroponic media

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ABSTRACT

Technology in agriculture is always developing, one of which is cultivation using hydroponic media One of the hydroponic cultivation techniques is the NFT hydroponic. The hydroponic cultivation of the NFT is carried out by placing plant roots in a shallow and circulating layer of water. One of the plants that can be used in NFT hydroponic media is the pakcoy mustard plant. During the growth period of pakcoy mustard in the hydroponic NFT media, parameters such as air and water temperature, water level and pH, and plant nutrients will greatly affect. The optimal air temperature during the growth of mustard greens is 22-33˚C, water temperature is 25-28˚C, water level is 25-35 cm or depending on the tank used, water pH is 6-7, and plant nutrition is 900-1400 PPM. If the parameter conditions in the hydroponic greenhouse are not in accordance with the optimal limits, the growth of the mustard greens will be stunted or die. In this study an automatic control system was designed using the WEMOS Mega 2560 microcontroller as the control center, DHT22 sensor, MAX6675 sensor, HC-SR04 ultrasonic sensor, PH-4502C sensor, analog TDS sensor, misting pump, peltier, water pump, and mini DC pump. The results of this study are in the form of sensor reading values consisting of air and water temperature, water level and pH, and plant nutrients which have been transferred to the microcontroller so that they can be processed to be displayed on the LCD screen and if the sensor reading values do not match the optimal limits then the microcontroller will activate the misting pump, peltier, water pump, and mini DC pump automatically. With the automatic control system, the condition of these parameters can be maintained at optimal limits.

ABSTRAK

Teknologi di bidang pertanian selalu berkembang salah satunya yaitu budidaya menggunakan media hidroponik. Salah satu teknik budidaya hidroponik yakni hidroponik NFT. Budidaya hidroponik NFT dilakukan dengan menempatkan akar tanaman pada lapisan air yang dangkal dan tersirkulasi. Salah satu tanaman yang dapat digunakan dalam media hidroponik NFT adalah tanaman sawi pakcoy. Parameter yang mempengaruhi pertumbuhan sawi pakcoy di media hidroponik NFT adalah suhu udara dan air, ketinggian dan pH air, serta nutrisi tanaman. Suhu udara yang optimal selama pertumbuhan sawi pakcoy yakni 22-33˚C, suhu air 25-28˚C, ketinggian air 25-35 cm ataupun bergantung pada tangki yang digunakan, pH air 6-7, dan nutrisi tanaman 900-1400 PPM. Jika kondisi parameter dalam greenhouse hidroponik tidak sesuai dengan batasan optimal maka pertumbuhan sawi packoy akan terhambat ataupun mati. Penelitian ini telah merancang sistem kendali otomatis dengan menggunakan mikrokontroler WEMOS Mega 2560 sebagai pusat kendali, sensor DHT22, sensor MAX6675, sensor ultrasonik HC-SR04, sensor PH-4502C, analog TDS sensor, pompa misting, peltier, pompa air, dan pompa mini DC. Hasil dari penelitian ini berupa nilai pembacaan sensor yang terdiri dari suhu udara, suhu air, ketinggian air, pH air, dan nutrisi tanaman yang telah ditransfer menuju mikrokontroler sehingga dapat diproses untuk ditampilkan ke layar LCD. Pada saat nilai pembacaan sensor tidak sesuai dengan batasan optimal maka mikrokontroler akan mengaktifkan pompa misting, peltier, pompa air, dan pompa mini DC secara otomatis. Oleh karena itu, adanya sistem kendali otomatis telah membuat kondisi parameter-parameter tersebut dapat terjaga pada batasan optimal.

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1. Introduction

Over time, the human population has increased so that many agricultural lands have been used as settlements [1]. Cilegon City itself is a city that has many industries and residential areas, but agricultural land in the city has been decreasing. This motivated the residents of Cilegon City to think about how to produce hygienic food in a narrow area [2]. One way to overcome this problem is to use alternative growing media such as hydroponics.

Hydroponics is a farming method that uses mineral nutrient solutions and without the use of soil, so it can reduce expenses for using water and fertilizer [3]. Maintenance of hydroponic cultivation can be done more easily because it uses a relatively small portion of land, the cultivation area is quite clean, and the possibility of pest and disease attacks is relatively small [4]. Hydroponics has several types of systems such as aeroponics, fertigation, and nutrient film techniques. The Nutrient Film Technique (NFT) is a method of cultivating plants that uses circulating nutrient solutions to the roots growing in pipes so that the plants will get enough oxygen, nutrients and water [5]. There are several plants that can be cultivated using this hydroponic system such as lettuce, tomatoes, and pakcoy.

The pakcoy plant (genus barassica) is a type of mustard which has morphological characteristics such as short stems, fibrous roots, oval leaves, and small mustard seeds [6]. In the pakcoy plant there are chemical compounds, such as flavonoids and isothiocyanates which help prevent cancer types such as lung cancer [7]. Therefore, the pakcoy plant is needed by the people in Cilegon City to reduce the possibility of getting cancer due to air pollution caused by industry or vehicles. Pakcoy plant production in Cilegon City is still very rare. This is evidenced by the Central Bureau of Statistics for the City of Cilegon which has not yet obtained data on the production of pakcoy plants from 2018 to 2021 in the City of Cilegon. In Figure 1 below it shows that there is no high enthusiasm in the people of Cilegon City in producing pakcoy plants.

Jenis Tanaman *Kind of Plants*	2018	2019	2020	2021[x]
(1)	(2)	(3)	(4)	(5)
Sayuran/*Vegetables*:				
Bawang Merah/*Shallots*	-	-	131	312
Bawang Putih/*Garlic*	-	-	-	-
Cabai Besar/*Chili/Big Chili*	2 070	2 771	4 340	3 700
Cabai Rawit/*Chili/Cayenne Pepper*	832	558	1 235	2 401
Kentang/*Potato*	-	-	-	-
Kubis/*Cabbage*	-	-	-	-
Tomat/*Tomato*	306	410	255	4
Kacang Panjang	3 212	3 382	5 230	5 444
Ketimun/*Cucumber*	6 229	5 309	2 520	6 163

Figure 1 Vegetable Production Data in Cilegon City [8]

Based on an interview that was conducted with one of the pakcoy farmers, this happened because the people in Cilegon City were still cultivating manually so they often had difficulty maintaining the parameters needed by the pakcoy plant such as air temperature, water temperature, PH (Power of Hydrogen), water level, and nutrients. These parameters can affect the results of the development of pakcoy plants, for example, the volume given is not in accordance with the needs, it will have a wilting or rotting effect [9]. Nutrition or PPM (Parts Per Million) given to pakcoy plants requires macro and micro elements, if one of these elements cannot be fulfilled in pakcoy plants it can inhibit growth and production [10]. The pH parameter also needs to be observed, if the pH does not meet the needs of the plant, then the ability of the plant to absorb the necessary nutrients will disappear [11]. Then other parameters, namely water temperature and ambient temperature, are very important to note, if the temperature of the water temperature and the environment in the pakcoy plant exceeds the appropriate limit for its growth period, the growth of the pakcoy plant will slow down or quickly wither.

Based on the description of the background and several methods used in the research above, the authors try to develop these research methods. This research will apply additional sensor modules that can assist in monitoring and controlling the five parameters needed in pakcoy plants. So the author will propose the title Design and Build of an Automatic Control System on Pakcoy Plant Parameters in NFT Hydroponic Media.

2. Materials and Methods

In designing and testing the system, several stages of the process are needed in its implementation. This is necessary so that the process of activities in designing and testing the system runs according to the expected target. In Figure 2 is a form of flowchart in the process of implementation stages for this research.

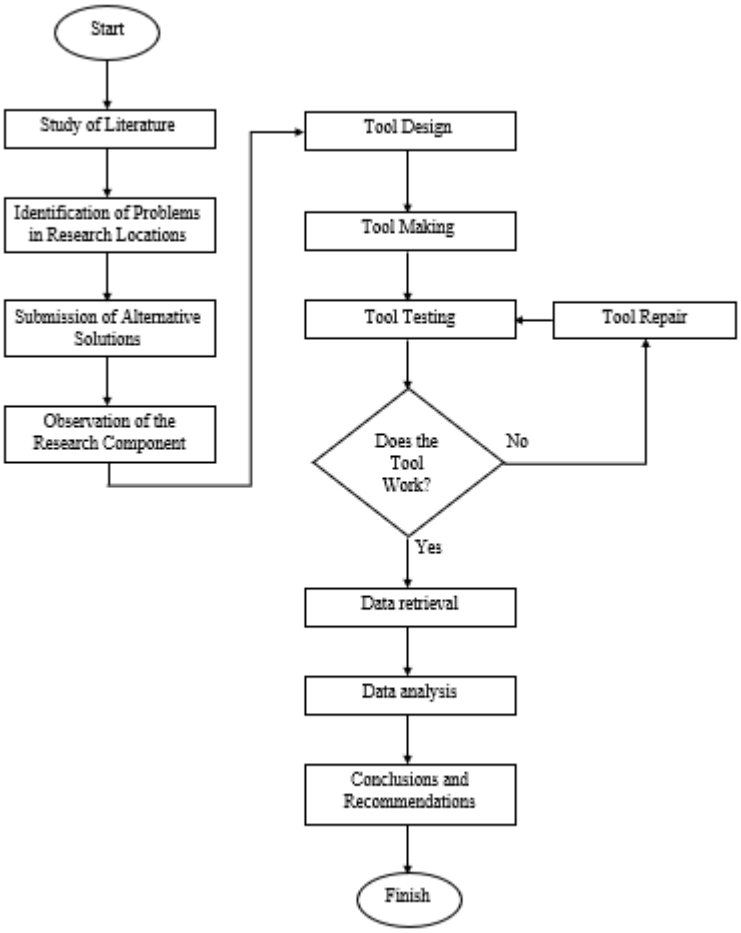

Figure 2 Research Methodology

After knowing the research method through Figure 2 as a conceptual design, then do the hardware design so that each component combines into a unified system that can work and be controlled. Components ranging from sensors to actuators are connected via cables to the pins of the WEMOS Mega 2560 microcontroller. With the WEMOS Mega 2560 microcontroller, it can be programmed according to the desired design and needs. In designing the circuit schematic, Microsoft Power Point software was used to display the shape of the device in two dimensions and the relationship of each component to the WEMOS Mega 2560 microcontroller.

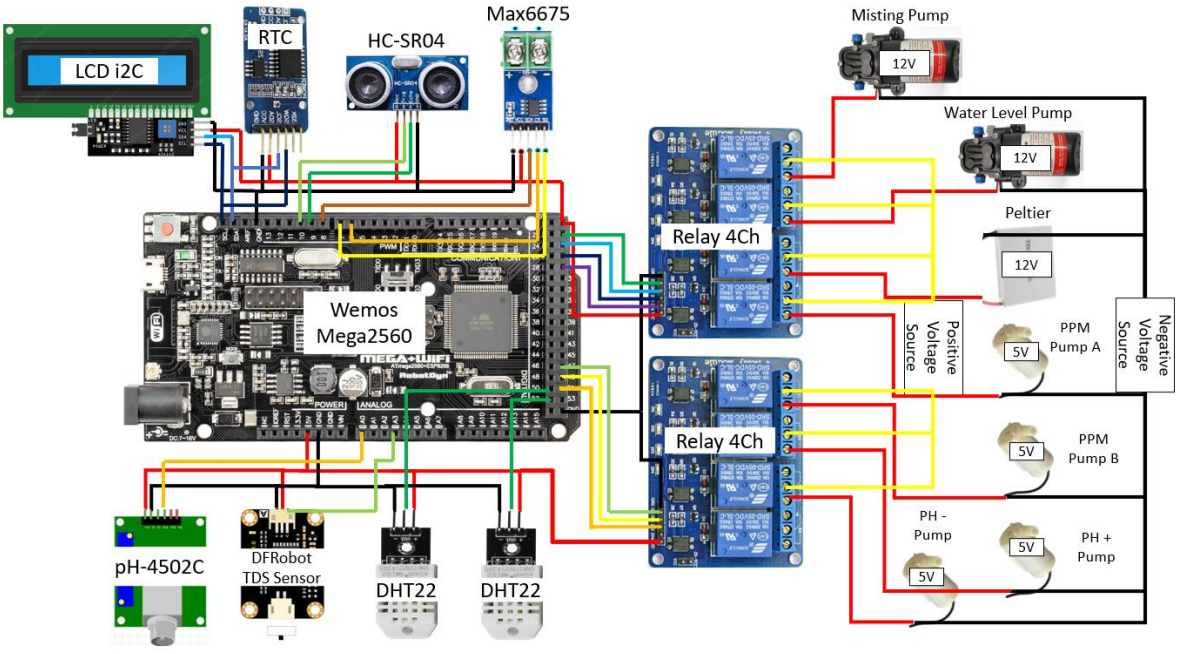

Figure 3 Schematic of the Control System Circuit

Based on Figure 3, an overview of the designed system has been explained, namely all sensors used such as the DHT22 sensor for air temperature or room temperature, the MAX6675 sensor for water temperature, the PH-4502C sensor for water pH, the DFRobot TDS sensor for plant nutrition, and the HC-4 sensor. SR04 for water level will read the value of each parameter. The DS3231 RTC module is used to calculate the time that has been set according to western Indonesian time. The results of all sensor reading data and time data from the RTC module will be transferred to the WEMOS Mega 2560 microcontroller for processing so that the data can be displayed on the LCD screen which is used as a local interface and can manage actuator control via a 4 channel relay. The microcontroller can activate and deactivate the relay connected to each actuator such as a mini DC pump, misting pump, water pump, and peltier if the parameter values for room temperature, water level, water temperature, water pH, and plant nutrients are outside the limits set. determined. Through the I2C LCD the user can see and monitor directly the time and sensor reading values when the tool has been activated.

3. Discussion

3.1 Tool Testing on Hydroponic Gerem Greenhouses

Automatic control system testing is carried out to determine the performance of the system performance in controlling five parameters of the pakcoy plant so that it is within optimal limits such as air temperature below 33˚C, water temperature below 28˚C, water level above 35 cm, pH water is in the 6-7 range, and plant nutrients are in the 900-1400 PPM range. This test can also prove the results of comparisons on the growth of pakcoy plants when using the manual method and using an automatic control system. Data collection was carried out for 27 days starting from November 28 – December 24 2022. The data obtained is the result of sensor reading values for each parameter such as air temperature, water temperature, water level, water pH, and plant nutrition. If from sampling sensor readings in the morning, afternoon, evening and night, a graph is obtained which can be seen in Figure 4 to Figure 8.

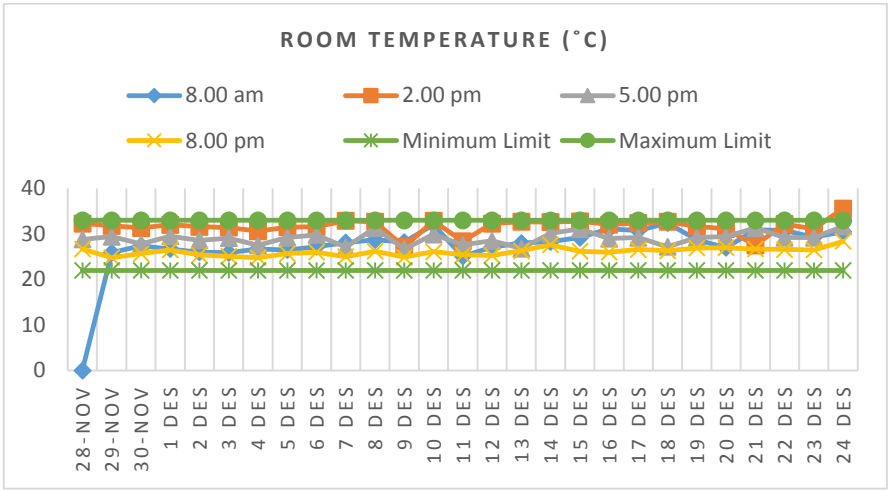

Figure 4 Room Temperature Control Test Data in a Greenhouse

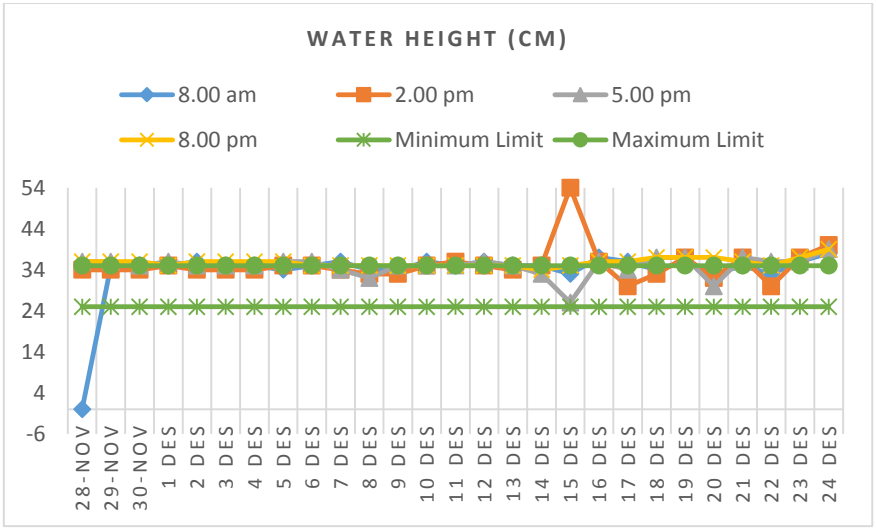

Figure 5 Test Data for Water Level Control in a Greenhouse

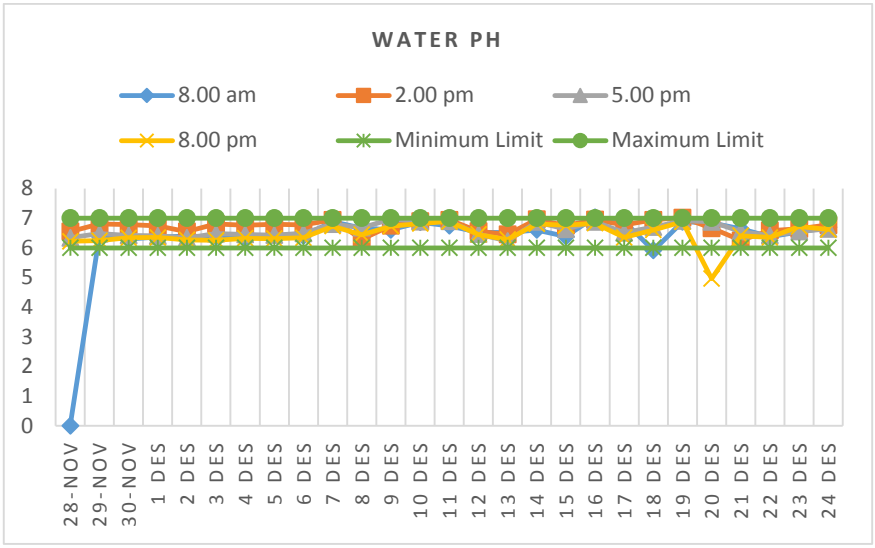

Figure 6 Test Data for PH Control of Water in a Greenhouse

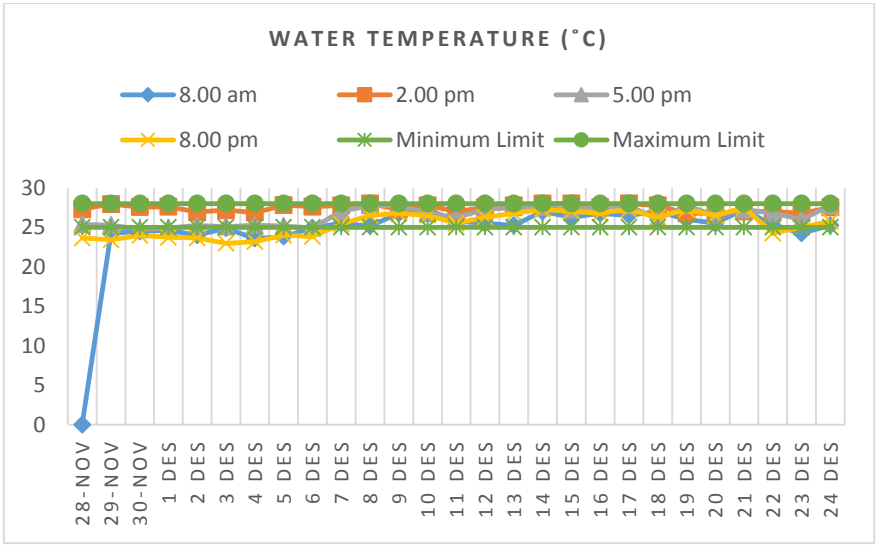

Figure 7 Test Data for Water Temperature Control in a Greenhouse

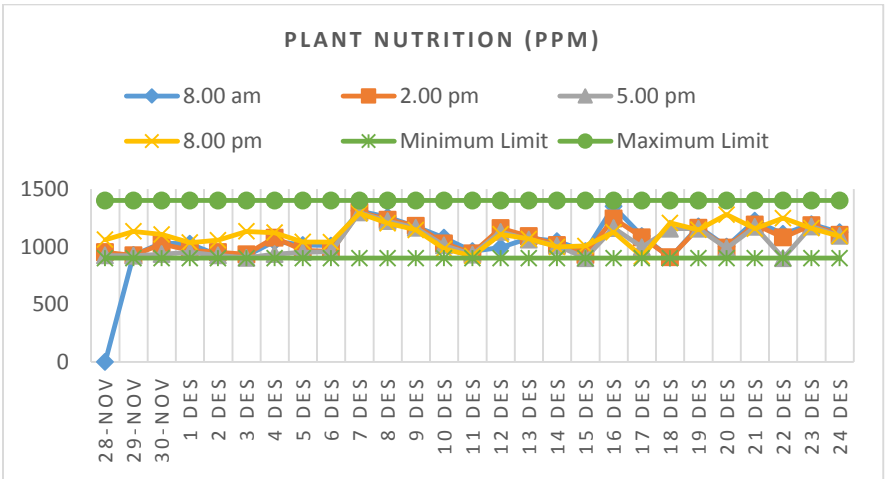

Figure 8 Test Data for Plant Nutrition Control in a Greenhouse

Based on Figure 4 to Figure 8, it has been proven that the control system that has been created can maintain the parameter values of air temperature below 33˚C, water temperature below 28˚C, water level above 35 cm, water pH within range 6-7, and plant nutrition is in the range 900-1400 PPM. This is because each actuator such as a mini DC pump, misting pump, water pump, and peltier will activate automatically if the parameter values for room

temperature, water level, water temperature, water pH, and plant nutrients in the greenhouse are outside the limits set. determined. However, for some time the actuator cannot maintain the parameter value to remain within optimal limits, this is due to unexpected events such as when the weather in the environment around the greenhouse is scorching hot and the water in the mist spray tank has run out, the misting pump cannot emit mist. to lower the room temperature. When the water in the mist spray tank has run out, there will be a decrease in the water level which reaches 26 cm – 30 cm. The ultrasonic sensor reading was 54 cm, this happened because the ultrasonic sensor had experienced rust on the transmitter and receiver eyes caused by the corrosion effect that came from the air temperature in the hydroponic tank. Then when the pH solution in the bottle has run out, there will be an increase or decrease in the pH of the water until it reaches 4.96. When the weather in the environment around the greenhouse is heavy rain, there will be a decrease in water temperature which can reach below 25˚C, this is because the designed system does not use an actuator that can heat water in the hydroponic tank when the water temperature is too cold.

3.2 Results of Comparison of Pakcoy Plants

In this section you can see the results of the comparison on the growth of pakcoy plants for 27 days. Measurements were made using a tape measure on the leaf width and height of the pakcoy mustard stems as shown in Figure 9. The comparison results of the growth of the pakcoy plants are shown in Figure 10 and Figure 11.

(a) **(b)**

Figure 9 Measurements of Mustard Greens. (a) Stem Height; (b) Leaf Width

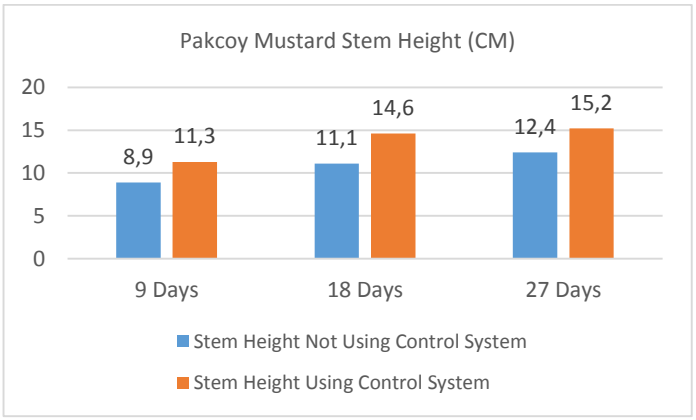

Figure 10 Graph of Comparison of Mustard Cabbage Height for 27 Days

Based on Figure 10, it has shown differences in growth in height of mustard greens, where treatment with a control system of the parameters of air temperature, water temperature, water level, water pH, and plant nutrition can produce better plant development, reaching 15.2 cm compared to when not using control system that only reaches 12.4cm.

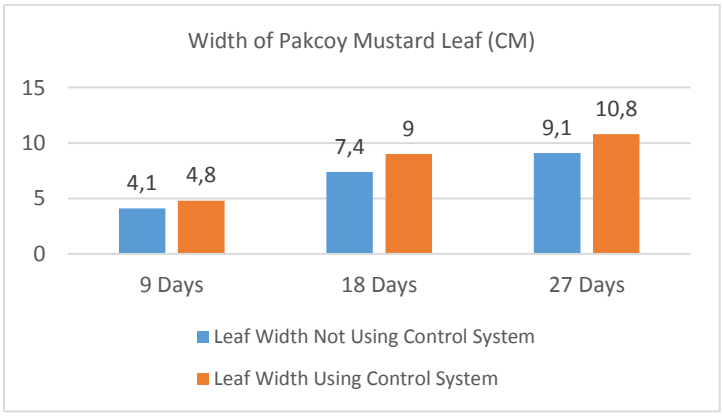

Figure 11 Graph of Comparison of Mustard Greens Leaf Width for 27 Days

Based on Figure 11, it has shown differences in growth in the width of mustard greens leaves, where treatment with a control system of the parameters of air temperature, water temperature, water level, water pH, and plant nutrition can produce better plant development, reaching 15.2 cm compared to when not using control system that only reaches 9.1 cm.

4. Conclusion

Based on the research activities that have been carried out, the following conclusions can be drawn:

1. The results of testing the tool in the greenhouse have proven that the control system that has been created can maintain the parameter values of air temperature below 33˚C, water temperature below 28˚C, water height above 35 cm, water pH within the range 6-7, and plant nutrition is in the range of 900-1400 PPM. This is because each actuator such as a mini DC pump, misting pump, water pump, and peltier will activate automatically if the parameter values for room temperature, water level, water temperature, water pH, and plant nutrients in the greenhouse are outside the limits set arranged.
2. NFT hydroponic cultivation on pakcoy plants with an automatic control system is better than cultivation using manual methods. This can be proven through the results of comparisons on the growth of stem height and leaf width, where the height of the mustard greens with an automatic control system is higher than the height of the mustard greens with the manual method.

REFERENCES

[1] Wibisono, V., & Kristyawan, Y. (2021). An Efficient Technique for Automation of The NFT (Nutrient Film Technique) Hydroponic System Using Arduino. *International Journal of Artificial Intelligence & Robotics (IJAIR),* vol. 3, no. 1, pp. 44-49.

[2] Zaini, A., Kurniawan, A., & Herdhiyanto, A. D. (2018). Internet of Things for Monitoring and Controlling Nutrient Film Technique (NFT) Aquaponic. In 2018 International Conference on Computer Engineering, Network and Intelligent Multimedia, CENIM 2018 - Proceeding (pp. 167-171). Article 8711304 (2018 International Conference on Computer Engineering, Network and Intelligent Multimedia, CENIM 2018 - Proceeding). Institute of Electrical and Electronics Engineers Inc.. https://doi.org/10.1109/CENIM.2018.8711304.

[3] Daud, M., Handika, V., & Bintoro, A. (2018). Design And Realization Of Fuzzy Logic Control For Ebb And Flow Hydroponic System. *INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH,* vol. 7, no. 9, pp. 138-144.

[4] Mashumah, S., Rivai, M., & Irfansyah, A. N. (2018). Nutrient Film Technique based Hydroponic System Using Fuzzy Logic Control. In Proceeding - 2018 International Seminar on Intelligent Technology and Its Application, ISITIA 2018 (pp. 387-390). Article 8711201 (Proceeding - 2018 International Seminar on Intelligent Technology and Its Application, ISITIA 2018). Institute of Electrical and Electronics Engineers Inc.. https://doi.org/10.1109/ISITIA.2018.8711201.

[5] Iswanto, Megantoro, P., & Ma'Arif, A. (2020). Nutrient Film Technique for Automatic Hydroponic System Based on Arduino. In Proceeding - 2020 2nd International Conference on Industrial Electrical and Electronics, ICIEE 2020 (pp. 84-86). Article 9276920 (Proceeding - 2020 2nd International Conference on Industrial Electrical and Electronics, ICIEE 2020). Institute of Electrical and Electronics Engineers Inc.. https://doi.org/10.1109/ICIEE49813.2020.9276920.

[6] Saidi, I. A., Azara, R., & Yanti, E. (2021). *Buku Ajar Pasca Panen dan Pengolahan Sayuran Daun*. Umsida Press, 1-123. https://doi.org/10.21070/2021/978-623-6292-21-1.

[7] Agustin, S. (2022). *5 Manfaat Pakcoy untuk Kesehatan Tubuh. Kementrian Kesehatan Republik Indonesia*. 25 Juni 2022. [Online]. Available: https://www.alodokter.com/ketahui-manfaat-pakcoy-untuk-kesehatan-tubuh#:~:text=Sebagai%20makanan%20yang20kaya%20akan,pembuluh%20darah%20dan%20otot%20jantung.. [Accessed 4 Agustus 2022]

[8] Badan Pusat Statisti Kota Cilegon. (2022). *KOTA CILEGON DALAM ANGKA 2022*. Cilegon: BPS Kota Cilegon, 2022.

[9] Waworundeng, J. M., Suseno, N. C., & Manaha, R. R. Y. (2019). Automatic Watering System for Plants with IoT Monitoring and Notification. CogITo Smart Journal, 4(2), 316–326. https://doi.org/10.31154/cogito.v4i2.138.316-326.

[10] Rizal, S. (2017). PENGARUH NUTRIASI YANG DIBERIKAN TERHADAP PERTUMBUHAN TANAMAN SAWI PAKCOY (Brassica rapa L.) YANG DITANAM SECARA HIDROPONIK. *Jurnal Sains dan Matematika (Sainmatika),* vol. 14, no. 1, pp. 38-44.

[11] Mufida, E., Anwar, R. S., Khodir, R. A., & Rosmawati, I. P.(2020) *Jurnal Inovasi dan Sains Teknik Elektro,* vol. 1, no. 1, pp. 13-19, 2020.