Temperature and Humidity Control using Nextion 3.2 HMI in the Natural Greenhouse

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Abstract. Maintaining stable temperature and humidity conditions is a crucial part of the plant growth stage. Ignoring the urgency of controlling this parameter causes plant growth to be not optimal. This research was conducted to monitor the temperature and humidity inside and outside the greenhouse and to create a temperature and humidity control system. The research method was experimental by observing red spinach *(Amaranthus tricolor L)* plants with a combination of planting media (cocopeat, husk charcoal, and compost). The air conditioning system built applies the IoT (Internet of Things) concept, which utilizes internet connectivity for interaction between the microcontroller and the web system by using Nextion 3.2 HMI as a medium for monitoring and controlling system parameters for temperature and humidity thresholds. Temperature and humidity conditions in the natural greenhouse can be monitored properly by obtaining the highest average temperature value for 14 days, which is 33.5°C and the lowest average temperature is 25.1°C , while the highest humidity value is 91.06% and the lowest is 72%. The temperature and humidity outside the greenhouse can also be monitored with an AWS (Automatic Weather Station) that is functioning properly. The average outdoor air temperature has increased starting at 06.00 am, from the lowest temperature at 22.3°C to the highest point of 33.6°C at noon around 12.00 noon. The temperature and humidity data retrieval using the DHT22 sensor displays on the Nextion 3.2 HMI screen where the data has been successfully set as desired. From the results of the data analysis, the MAPE (Mean Absolute Percentage Error) values obtained for the temperature and humidity sensors are 4.81% and 8.37%, respectively, which means that the interpretation of the MAPE value on the accuracy of the prediction model is very accurate (<10%).

Keywords: Humidity, Internet of Things, Nextion 3.2 HMI, Temperature.

1 Introduction

Temperature and humidity are environmental variables that are crucial to consider in growing plants in a greenhouse. Red spinach plants are more suitable if planted in the highlands with sufficient sunlight intensity, because during their growth the red spinach

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plants require low to warm temperatures (22 - 33 °C), soil temperatures in the range of 7 - 28 , environmental humidity ± 75 % [1]. Maintaining stable and optimal air temperature and humidity conditions is a very important part in the plant growth stage [2]. In addition, neglecting the urgency of controlling temperature and humidity causes plants to wither and the development of disease seeds so that plant growth is not optimal.

An air conditioning system is a system designed to condition or stabilize the temperature and humidity of the air in a certain area [3]. In this study, the air conditioning system built applies the concept of IoT (Internet of Things), which utilizes internet connectivity for interaction between a microcontroller and a web system that will control the fan and sprinkler pump automatically as well as a medium for monitoring and setting temperature and humidity threshold parameters. and water temperature in red spinach plants with cocopeat mixed growing media in a greenhouse.

Research on microclimate modeling to predict the temperature in a natural greenhouse, has been carried out by Singh et al [4]. Based on this research and the model obtained can be used to evaluate the microclimate conditions in the greenhouse, the planting media used, as well as agricultural commodities grown in the greenhouse. In this study, the temperature in the planting room fluctuated which tended to increase to harvest conditions during the planting period. Previous researchers measured the temperature at 3 points, namely air, leaves and planting media/close to the root area. The data is used as input and model validation to predict the temperature on the day after the next planting, to monitor and evaluate the Natural Greenhouse used.

Meanwhile, we carried out our research on the island of Lombok, where we are a sizable coconut producer. The districts of West Lombok and North Lombok are the largest coconut producing areas among other districts in the province of West Nusa Tenggara. Based on data from the government of West Nusa Tenggara Province in NTB One Data [5], the harvested area of the two districts is more than 10,000 ha each. With such great potential, of course, a lot of coconut fiber waste is produced and has not been utilized optimally. One of the uses of coconut fiber waste is to apply cocopeat as a planting medium.

The use of Cocopeat growing media, has been studied by Nugroho [6], for nurseries of pine shrimp (Casuarina equisetifolia var. Incana) on coastal sand dunes. The results obtained were planting media with a composition of 20% soil, 30% manure, 30% sand and 20% Cocopeat gave the best total dry weight, shoot dry weight, and root dry weight of 27.1 g, 18.02 g, and 9.03 g. [7] also stated that the application of organic mulch (straw, cow manure, coconut husk, pine shrimp leaf litter) on coastal sandy soils can increase growth in height, diameter, media moisture content, organic matter content and available N nutrient content.

Soeparjono [8], in a similar study, on the effects of growing media and organic fertilizers on the growth and production of red ginger (Zingiber officinale Rosc.). Based on the results obtained, it was concluded that the concentration of organic fertilizers and also the interaction between organic fertilizers and planting media greatly affected the growth parameters and yield of red ginger rhizomes. The combination of M3P3 treatment (bokashi 60%: husk charcoal 20%: Cocopeat 20% with organic fertilizer concentration of 4.5%) gave the best response for all parameters: plant height (58.8 cm), number of leaves (25.2), number of shoots (35.6), rhizome fresh weight per plant

(2329.64 g), total biomass (258.14 g), Zingeron content (1.88%) and oleoresin content (1.57%).

Cocopeat application as a growing medium is used for vegetable production and is able to produce organic fresh vegetables in the Federated States of Micronesia [9]. The use of Cocopeat is able to solve the problem of high land degradation and the use of coconut waste which is very much in the Micronesia archipelago, which has a very high potential for coconut production.

The success of using the right planting media certainly cannot be separated from the application of the right irrigation system so that this study uses a drip irrigation system. Jafari et al [10] measured evapotranspiration on citrus trees using a drip irrigation system in southern Iran. The value of evapotranspiration is needed to provide irrigation input to plants so that the irrigation provided is precise and efficient, in accordance with what is needed by plants. The results obtained in this study were conventional irrigation provided over irrigation by 21%. This can be minimized or even avoided by applying the results of the crop water demand analysis obtained for future irrigation water supply inputs. Reducing the negative impact of over irrigation requires specific irrigation management and handling [11] .

Other studies have also been carried out by Dholu and Ghodinde [12], where the development of IoT (Internet of Things) leads to the idea of device communication applied to precision agriculture, the Internet is experiencing a very explosive growth nowadays with the number of devices connected so that users can access them remotely. [12] They carry out cloud-based IoT deployments in the agricultural domain, where the parameters considered important include temperature & relative humidity around plants, soil moisture, and light intensity. Supported by the potential of natural resources on the Lombok Island for the utilization of coconut waste and the urgency of controlling microclimate parameters supported by previous studies, control and monitoring systems for temperature and humidity conditions of red spinach (*Amaranthus tricolor L*) planting media in a natural greenhouse needs to be done. The research was conducted on a lab scale, at the Natural Greenhouse at the Agricultural Conservation and Environmental Engineering Laboratory, Agricultural Engineering Study Program, University of Mataram.

2 Research Design and Methodology

The research method was experimental by observing red spinach (Amaranthus tricolor L) plants with a combination of planting media (cocopeat, husk charcoal, and compost). The composition of the growing media has been investigated in the previous phase of research [13] where the best comparison results are 50: 30: 20 for cocopeat: husk charcoal: organic fertilizer. The Automatic Weather Station (AWS) is used for climate monitoring outside the greenhouse, while for monitoring the microclimate inside the greenhouse using an air conditioning system that was built using the IoT (Internet of Things) concept, which utilizes internet connectivity for interaction between the microcontroller and the web system. This system uses Nextion 3.2 HMI as a medium for monitoring and controlling the temperature and humidity threshold parameter control system. Furthermore, the MAPE (Mean Absolute Percentage Error) method is used to determine the percentage error and the success rate of estimation on the accuracy of the prediction model.

3 Result and Discussion

3.1 Climate Monitoring Outside the Greenhouse

To ensure that the research can continue despite unfavorable weather conditions, one of which is due to high rainfall, this research was carried out inside and outside the greenhouse of the Faculty of Food Technology and Agroindustry (FATEPA), University of Mataram. Plant growth in a greenhouse is strongly influenced by microclimate conditions [14], especially the temperature and humidity parameters [15] [16]. In addition, changes in climatic parameters in the atmosphere outside the greenhouse also greatly affect the temperature and humidity of the air inside the greenhouse [17]. In addition, the intensity of sunlight, rainfall, and wind speed are parameters that also greatly affect the microclimate conditions in the greenhouse. All of these parameters will affect the value of plant evapotranspiration (ETc) which represents plant water requirements, although in this study it is limited to monitoring only temperature and humidity.

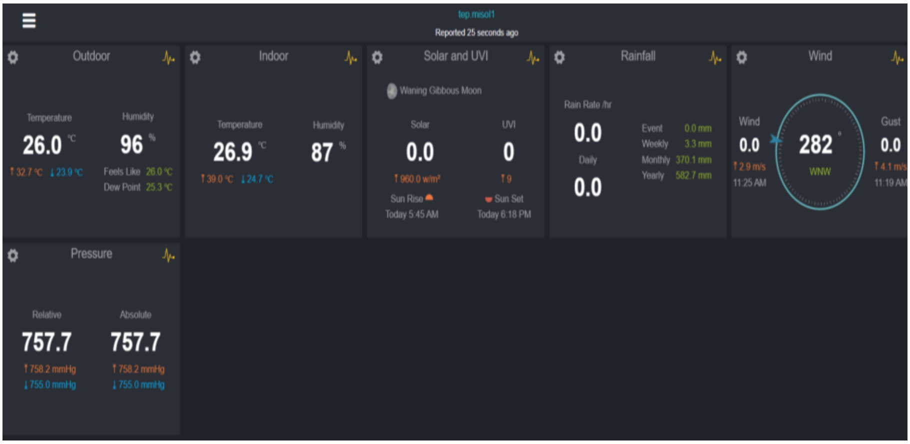

Fig. 1. Real time view of AWS MISOL WS-2320 climate data in the cloud

Climate data outside the greenhouse is monitored daily using the Automatic Weather Station (AWS) MISOL WS-2320. AWS is a system that is used to monitor weather conditions in real time with a communication system in the form of sending sensor data [18]. Fig. 1 shows the display of climate data recorded by AWS and stored in the cloud on the https://ecowitt.net website. This data comes from sensors placed on the 2nd floor deck of Fatepa Building which are sent continuously to AWS devices placed in the greenhouse (Fig. 2.c). Besides functioning to display data in real time on the LCD screen, this device is also equipped with temperature and humidity sensors that function to measure temperature and humidity data in the greenhouse (indoor).

Fig. 2. Installation of AWS for observing climate data outside the greenhouse (a and b) and AWS display devices placed inside the greenhouse (c)

In addition to displaying data in real time, data stored in the AWS cloud can be downloaded in the form of a graphical display according to the specified time duration. Figure 3 (a) shows the display of climate data in the form of temperature and humidity parameters outside the greenhouse for a duration of 1 day (as of 7 June 2022) and Fig. 3 (b) shows climate data per 1 week (as of 12 June 2022 to 18 June 2022).

Fig. 3. Display of temperature and humidity data outside the greenhouse (a) for 1 day (top) and 1 week (b)

Based on Fig. 3, it can be seen that the average air temperature has increased starting at 06.00 am, from the lowest temperature at 22.3 to the highest point of 33.6 at noon around 12.00 noon. After reaching the peak, the air temperature slowly decreases, followed by an increase in air humidity (RH), where the highest humidity reaches 99% in the morning from 06.00 to 07.00. The results of this observation are in accordance with the research of Misra & Ghosh [19] which shows temperature data that is inversely proportional to air humidity.

In detail, temperature and humidity data is displayed weekly according to the settings on the ecowitt.net website. Temperature data in the first week (day 1 to day 7) and the display of temperature data in the second week (day 8 to day 14) can be exported in Excel format. While the data in graphical form, are presented in Fig. 4 (a) and Fig. 4 (b) below.

Fig. 4. Display of temperature data for the first week (a) and the second week (b)

Fig. 4(a) shows the highest temperature of 33.2 at 12.00 noon on day 2 and the lowest temperature of 22.3 at 06.00 am on the same day. While Fig. 4 (b) shows the highest temperature on the 13th day reaching 33.6 at 12.00 noon and the lowest temperature at 22.3 at 06.00 on the 12th day. Next, Figures 5 (a) and 5 (b) show humidity data in graphical form where this data is also presented on a weekly basis.

a

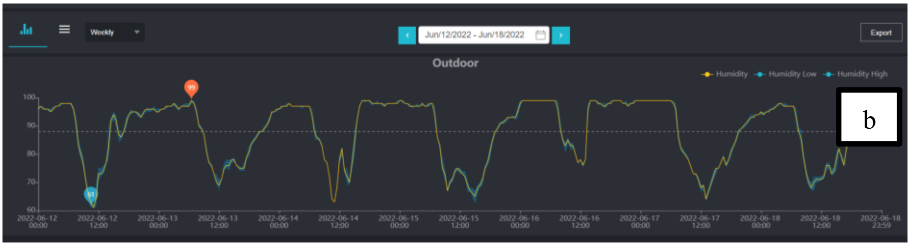

Fig. 5. Display of air humidity data for the first week (a) and the second week (b)

Fig. 5 (a) shows the highest humidity reaching 99% at around 07.00 am on day 1 and the lowest humidity 61% around 11.00 pm on day 3. While Fig. 5 (b) shows the highest humidity on day 9 reaching 99% at 07.00 am and the lowest humidity is 61% at 11.00 pm on day 12.

3.2 Design and Build a Micro Climate Monitoring System in the Greenhouse

The process of making a series of microclimate monitoring systems in the form of temperature and humidity is the initial stage carried out until the experiment of making the tool.

This Nextion series is a series for data collection on the temperature and humidity of red spinach plants. This circuit is also connected to the SHT10 sensor to sends data to the data logger. This IoT-based temperature and humidity monitoring tool is designed to use the ESP8266 as a control device for the sensors used. Data from monitoring temperature and humidity in the greenhouse will be sent using an internet connection in the form of wifi which can be accessed using a smartphone via the Cayenne application and sent to the Cayenne server in the form of temperature and humidity to make data retrieval easier. ESP8266 is connected to a relay to disconnect and connect the electricity that is connected to the fan and water pump.The data logger will process the data sent from the SHT10 sensor to the display temperature and humidity data on the Nextion 3.2 HMI LCD. LCD Nextion display module is an HMI (Human Machine Interface) solution that provides a control and visualization interface between humans and processes, machines and applications [20]. In addition to hardware, this product from Nextion also provides Nextion Editor software. By using the Nextion Editor, it is very easy to create or design a GUI (Graphical User Interface) so that it can reduce the development workload by up to 99%[20].

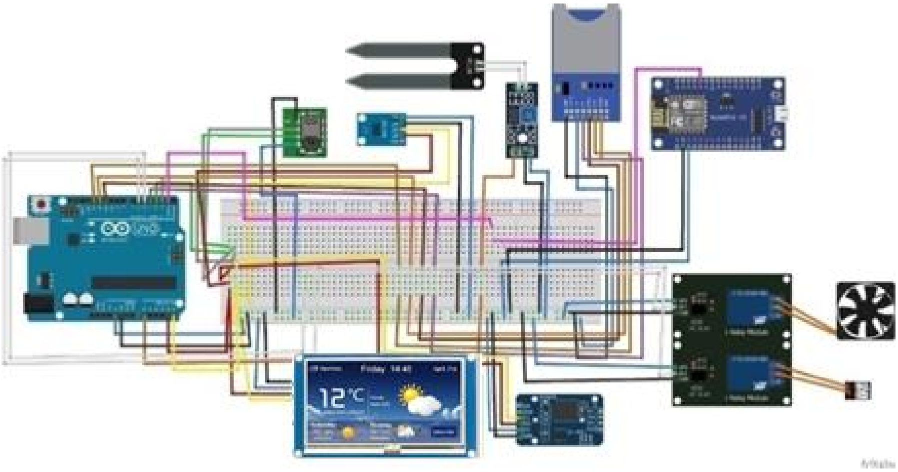

Fig. 6. Nextion circuit

3.3 Display Results of Temperature and Humidity Data on Nextion LCD

The data from the observation of temperature and humidity in the greenhouse were measured for 24 hours using a SHT10 sensor which has been connected to the internet via telegram. The results of temperature and humidity readings in the greenhouse are displayed on the LCD that has been prepared. In addition, data retrieval 3 times a day every 09.00, 10.00, 11.00 WITA.

LCD is one of the display devices that are now widely used. The appearance of the LCD began to be felt to replace the function of the CRT (Cathode Ray Tube) viewer, which has been used by humans for decades as an image/text viewer, both monochrome (black and white), and color. LCD technology provides an advantage over CRT technology, because in essence, CRTs are Triode tubes that were used before the transistor was invented [21]. Some of the advantages of LCD compared to CRT are relatively small power consumption, lighter, better display, and when lingering in front of the monitor, CRT monitors saturate the eyes faster than LCD [22].

3.4 Parts of the Nextion LCD

The Nextion tool consists of several circuits in it with their respective functions.

1. This receiver has a greater frequency range than the cellular network. Receiver can also receive data.
2. Data logger is automatic storage.
3. ESP8266 chip with the ability to run a microcontroller function and also an internet connection (WiFi).
4. The Nextion 3.2 inch module functions to replace the LCD / LED function, besides

that Nextion also provides Nextion editor software. This Nextion module is also used as an indicator or monitoring tool made.

5. Jumper cable is used to connect one data to another.

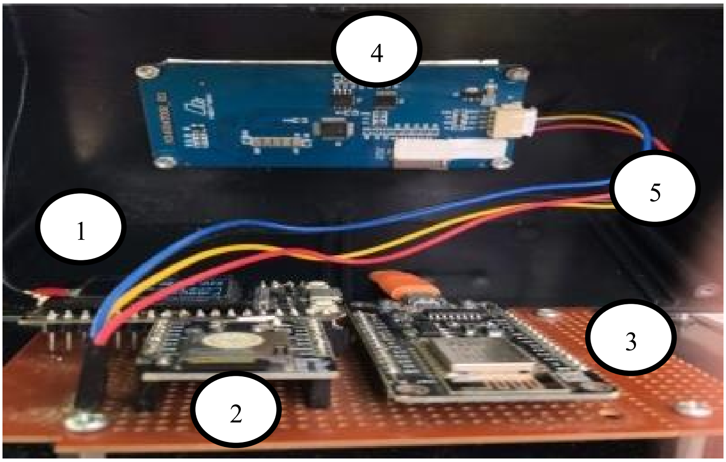

Fig. 7. Nextion Parts

3.5 Temperature and humidity data inside the greenhouse

The results of the study to collect data on temperature and humidity of red spinach plants were monitored for 14 days (Fig.8.a). This research was carried out in unpredictable rainy and hot conditions so that the temperature inside the greenhouse will certainly be affected by the temperature outside the greenhouse.

Fig. 8. Red spinach plants (a) Data are read on the Nextion LCD (b)

Fig. 8.b shows the tool has been installed in the greenhouse and the temperature and humidity readings can function properly. Temperature and humidity data are controlled to remain suitable for red spinach plant growth, which is no more than 32 °C. To keep the temperature stable, temperature and humidity data will be received every 5 minutes. If the temperature reaches 32 °C, then automatic watering will be given to plants in the greenhouse so that the temperature does not increase and becomes stable again. Every

component that works on this air humidity and temperature control system is working properly and according to its function. If the temperature in the greenhouse reaches 35°C the fan and pump 1 turn on and off when the temperature reaches 32°C, if the humidity reaches 65% pump 2 turns on and will turn off when the humidity reaches ≥75%. Figure 9 shows data on temperature and humidity in the greenhouse for a period of 14 days. From Fig 9, it can be seen that the lowest average temperature in the greenhouse is 25.1 °C on day 9, while the highest temperature is 33.5 °C on day 10. Fluctuations in temperature and humidity are clearly shown in the following graph.

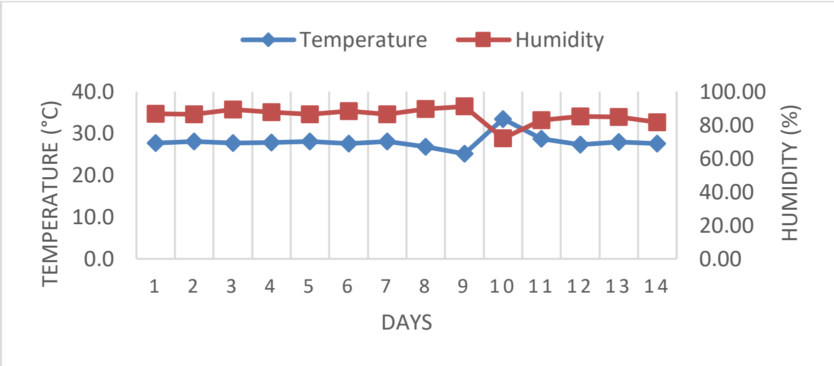

Fig. 9. Graph of Temperature and Humidity Fluctuations

In Fig. 9 it can be seen that the temperature and humidity reading system by the SHT10 sensor can monitor the tested parameters quite well. The influence of environmental conditions on the 10th day shows that the environmental conditions are hot with the optimal temperature value reaching 33.5°C but the lowest humidity is 72%. This happens because the high environmental temperature certainly affects the temperature in the greenhouse too high. Therefore, watering will automatically continue until the temperature drops in accordance with the temperature control settings that have been set, which is 32 - 35°C.

3.6 Error percentage

The percentage error value using linear regression method where the axis is the output value of the measuring instrument and the x-axis is the sensor output value. The way to find out the regression relationship is to compare the two output values. The method used to determine the percentage of errors using MAPE (Mean Absolute Percentage Error). MAPE is also used to determine the success rate of estimation. MAPE value can be calculated by the formula in Equation 1 below [23] [24] .

$$\text{MAPE} = \frac{\sum_{t=1}^{n} \left| \left(\frac{At-Ft}{At} \right) 100 \right|}{n} \qquad (1)$$

description:
At = Actual demand to t
Ft = Forecasting value to t
n = The amount of forecasting data

The following are the results of data analysis in determining the MAPE value for the temperature sensor, presented in Table 5 below.

Table 1. MAPE value for temperature sensor

Days to-	Average Temperature Sensor	AWS Average Temperature	Deviation (y-y')	(y-y')/y'
1	27.7	27.75	0.03	0.001146
2	28.1	28.78	0.69	0.024551
3	27.7	27.88	0.21	0.007685
4	27.8	27.78	0.00	0.000105
5	28.1	26.56	1.52	0.054141
6	27.5	27.82	0.29	0.010668
7	28.1	27.60	0.48	0.017068
8	26.8	26.81	0.05	0.001796
9	25.1	30.13	5.01	0.199546
10	33.5	26.29	7.19	0.214744
11	28.8	26.63	2.15	0.074628
12	27.3	27.46	0.19	0.006858
13	27.9	28.07	0.15	0.00545
14	27.6	26.05	1.53	0.055427
			MAPE value (%)	**4.8129**

From the results of data analysis in Table 1, the MAPE value obtained is 4.81%, which means that the interpretation of the MAPE value for the temperature sensor on the accuracy of the prediction model is very accurate including <10% [25]. While the results of data analysis in determining the MAPE value for the air humidity sensor are presented in Table 2 below.

Table 2. MAPE values for humidity sensors

Days to-	Average Humidity Sensor	AWS Average Humidity	Deviation (y-y')	(y-y')/y'
1	86.9	80.47	6.40	0.073661
2	86.4	78.47	7.91	0.091574

Days to-	Average Humidity Sensor	AWS Average Humidity	Deviation (y-y')	(y-y')/y'
3	89.4	84.29	5.08	0.056816
4	87.7	84.57	3.17	0.036159
5	86.5	79.67	6.80	0.078604
6	88.4	82.54	5.87	0.066409
7	86.5	83.28	3.18	0.036829
8	89.5	83.94	5.58	0.062305
9	91.1	73.77	17.28	0.189804
10	72.0	89.68	17.67	0.24547
11	83.1	84.90	1.83	0.021995
12	85.3	79.61	5.69	0.066699
13	84.8	78.93	5.92	0.069766
14	81.5	87.70	6.18	0.07575
			MAPE value (%)	**8.3703**

From the results of data analysis in Table 6, the MAPE value obtained is 8.37%, which means that the interpretation of the MAPE value on the accuracy of the prediction model is very accurate, including <10% [25].

4 Conclusion

Based on the results of the study, it can be concluded that the temperature and humidity outside the greenhouse can be monitored properly with an AWS (Automatic Weather Station) that functions properly. The average air temperature has increased starting at 06.00 am, from the lowest temperature at 22.3 to the highest point of 33.6 at noon around 12.00 noon. After reaching the peak, the air temperature slowly decreases followed by an increase in air humidity (RH). SHT10 sensor and display on the Nextion 3.2 HMI LCD screen used to collect temperature and humidity data in the greenhouse, the data display in Nextion was successfully set as desired in temperature and humidity data collection for 14 days. From the results of data analysis, the MAPE values obtained for the temperature and humidity sensors are 4.81% and 8.37%, respectively, which means that the interpretation of the MAPE value on the accuracy of the prediction model is very accurate (<10%).

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