Monitoring and Control System Watering Orchid Plants Based on Weather Data

Rosih Ihwan[1], Unit Three Kartini[2], Tri Rijanto[3], Farid Baskoro[4]
[1,2,3,4]Jurusan Teknik Elektro, Fakultas Teknik, Universitas Negeri Surabaya, Surabaya, 60231, Indonesia
[1]rosihihwan.20042@mhs.unesa.ac.id
[2]unitthree@unesa.ac.id
[3]tririjanto@unesa.ac.id
[4] faridbaskoro@unesa.ac.id

Abstract

Orchid farming faces challenges in efficient water management, often relying on less accurate visual judgments. This research aims to design a weather data-based orchid watering system, monitored and controlled remotely via smartphone. Using a Research and Development (R&D) methodology, the system's performance was tested through soil moisture and temperature sensors. Sensor data were compared with measuring instrument data for accuracy and evaluated across different planting media: vermicompost, coconut fiber, and charcoal. Results showed the DHT22 sensor's temperature (average 33.87°C) was slightly higher than weather.com data (average 32.6°C). Both sources displayed similar humidity patterns, with higher humidity in the morning and lower in the afternoon. The DHT22 sensor recorded an average humidity of 52.58%, compared to 53.4% from weather.com, with a temperature standard deviation of ±0.59 and humidity of ±0.51, indicating good consistency. The soil moisture sensor closely matched the soil meter, with an average difference of 1.3% and a standard deviation of ±0.59. Orchid leaf growth in the first week increased from 10 cm to 10.2 cm in fertiliser and coconut fiber media and to 10.3 cm in charcoal media. In the second week, growth increased to 10.5 cm across all media. Charcoal media was the most effective in accelerating growth in the first week, making it the best choice among the tested media.

Keyword : *Monitoring and Control System, Plant Watering, Orchid Plant Growth.*

I. INTRODUCTION

Orchid farming has become one of the important sectors in the agricultural industry in many countries, not only as a source of income for farmers but also as a contributor to the national economy. However, just like in agriculture in general, orchid farming is also faced with a number of challenges, mainly related to efficient and timely water management. Watering orchid plants is one of the crucial aspects in maintaining plant health and productivity. In this case, weather factors play a very important role, as changing weather conditions can affect the plant's water needs and its impact on the growth and quality of the orchids produced Click or tap here to enter text..

Traditionally, growers rely on their experience and visual judgement to determine the watering schedule and volume required by orchid plants. However, this approach is often inadequate due to the lack of accuracy in estimating plant water requirements and is prone to human error . In the current era of information technology, there is a great opportunity to integrate existing technology with agriculture to improve efficiency and productivity. One promising solution is the development of a weather data-based monitoring and control system for watering orchid plants.

In addition to the direct benefits in watering management, the use of this system can also make a positive contribution to natural resource management and environmental sustainability. By being more efficient in the use of water, farmers can reduce negative impacts on the surrounding environment, such as soil and water pollution due to excessive use of fertilisers and pesticides . Furthermore, the system can also help reduce farmers' production costs, increase business profitability, and ultimately, contribute to improving farmers' welfare and the country's food security.

Previous research has developed an IoT system to monitor orchids using FC28 and DHT22 sensors. Soil temperature and humidity data are sent to a smartphone and displayed in a graph. Users can monitor conditions in real-time, and the system automatically waters when the soil is dry to maintain moisture. In developed an IoT-based Plant Monitoring System using Wireless Sensor Networks to monitor soil moisture. The data is sent to the server wirelessly. The system also monitors plant growth and has a pest and disease control programme. Then in discusses an intelligent watering system using fuzzy logic and blockchain. Sensors collect data on plant and environmental conditions, which are then processed with fuzzy logic on the server to determine the optimal watering schedule.

Thus, this research aims to develop and test the effectiveness of a monitoring and control system for watering orchid plants based on weather data. Through this approach, it is hoped that an increase in efficiency, productivity, and sustainability in orchid cultivation can be achieved, as well as making a positive contribution to the development of sustainable and environmentally friendly agriculture.

II. THEORY

A. Orchid Plants

Orchids are a beautiful and distinctive type of flower that is also one of the most diverse. Orchids are so popular as ornamental plants for indoors and outdoors. Moon Orchid (Phalaenopsis amabilis) is one of the natural orchid plants that still has many fans. It lives in humid conditions and likes little sunlight. It has a beautiful flower figure, pure white with yellow tongue, also has a long flower stalk. The ideal soil moisture for moon orchids ranges from 50% to 70%, which allows the roots to get enough water without running the risk of rotting. Excessive watering will trigger disease in the orchid plant, which can result in the death of the orchid plant .

Figure 1. Orchid Plants

B. Arduino Uno

Arduino Uno is a type of microcontroller developed by Arduino c.c.. Arduino has a USB port that can be connected to a computer and programmed using IDE software, or with Scratch for Arduino or Common coding. Arduino can also be connected to various sensors measuring physical quantities so that it can facilitate experimental activities.

Figure 2. Arduino Uno

C. NodeMCU ESP8266

NodeMCU ESP8266 is a microcontroller that has an ESP8266 wifi module that can connect or connect to the internet. Nodemcu has 16 digital pins, 1 analogue pin, 2 UART pins besides that Nodemcu ESP8266 also has SPI pins and I2C pins. The operating voltage of the Nodemcu ESP8266 is lower than the Arduino, the operating voltage is 3.3 volts while the input voltage is 7-12 volts.

Figure 3. NodeMCU ESP8266

D. Power Supply

Power supply is a device in the form of an electronic circuit to convert a large electric voltage into a smaller electric voltage, or a circuit to convert alternating current into direct current. Power supply is made to replace the function of the battery to make it more economical.

Figure 4. Power supply

E. Sensor DHT22

DHT22 sensor stands for Digital Humidity and Temperature sensor model 22. DHT22 DHT22 sensor is one type of sensor that is widely used to measure humidity and temperature in various applications. The DHT22 sensor can operate at temperatures ranging from -40°C to 80°C and has an accuracy of ± 0.5°C. This sensor is easy to implement in an Arduino type microcontroller because it has good stability.

Figure 5. Sensor DHT22

F. Sensor YL-69

The YL-69 sensor is a sensor capable of measuring moisture content in soil. This sensor uses two conductors to pass current through the soil, then the resistance value will be read as the moisture level. This sensor is called capacitive because the two coppers in the sensor are two capacitor plates Soil Moisture Sensor requires 5 volts of power.

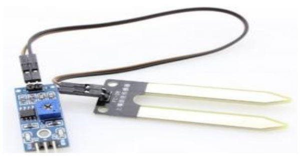

Figure 6. Sensor YL-69

G. Blynk

Blynk is a free-to-download iOS and Android application platform that controls microcontrollers such as Arduino, NodeMCU, and other microcontrollers over the internet. The Blynk platform is part of the IoT that serves to provide the ability to manage hardware remotely, such as displaying sensor data, storing data, viewing data, and performing various other advanced features.

III. METHODS

This research uses research and development methodology. Research and Development research methodology is a research method used to produce a certain product and test the effectiveness of the product. The necessary steps can be seen in the following figure.

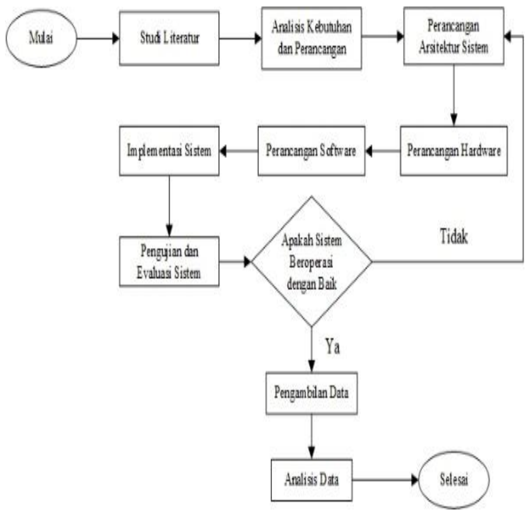

Figure 7. Research Stages

A. Research Design

Research design is made so that the performance process of the system or tool being made becomes clearer and more systematic. This will facilitate the process of designing the tool both in terms of making software and making hardware. The block diagram of the Monitoring and Control System for Watering Orchid Plants Based on Weather Data is as follows.

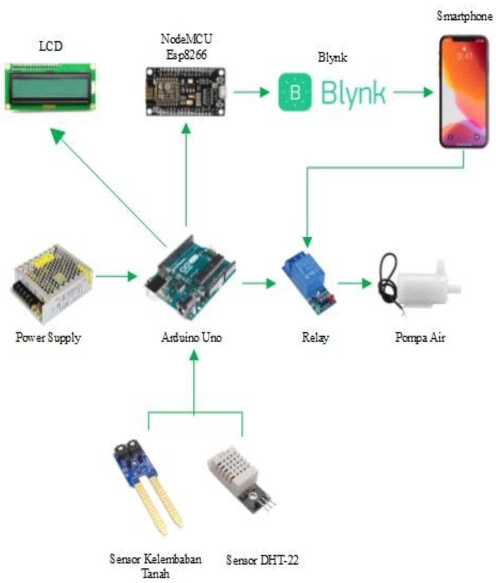

Figure 8. Diagram Block

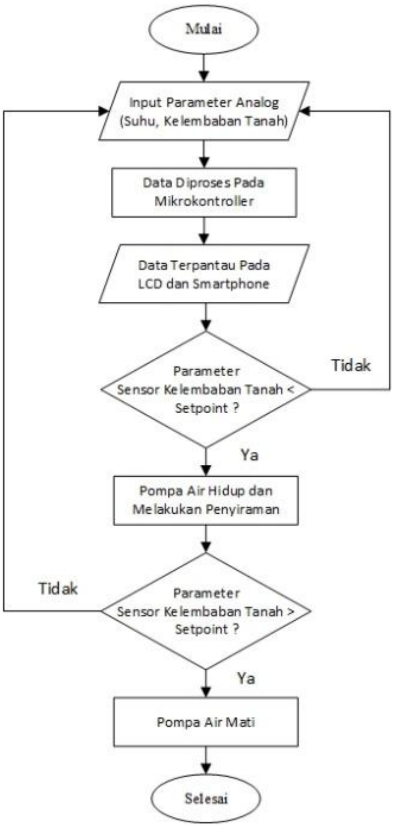

Figure 9. System Flowchart

B. System Design

In the research of Monitoring and Control System on Watering Orchid Plants Based on Weather Data, a prototyping method is used where the author makes a tool to monitor soil moisture in orchid plants. To identify how the systematic hardware circuit of the tool, the system design is carried out as follows.

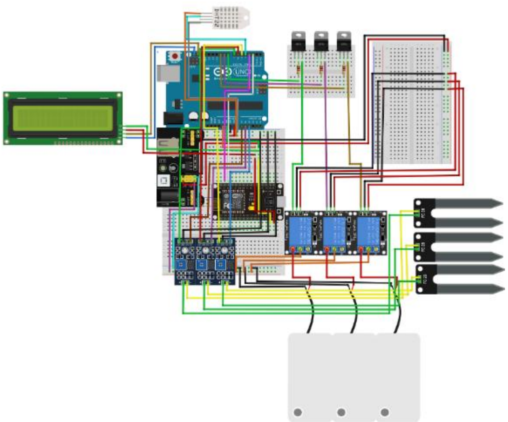

Figure 10. Draft System Design

C. Data Collection

The data collection method in this research is to test the performance of the Weather Data-Based Orchid Plant Watering Monitoring and Control System. Data is taken from soil moisture and temperature sensors. The sensor data value is compared with the actual data measured using the instrument to test the accuracy of the tool. Furthermore, the results of vermicompost, coconut fibre, and charcoal fertiliser planting media were compared to determine the best planting media for orchids.

IV. RESULTS AND DISCUSSION

A. System Design Results

The results of the research conducted are in the form of success in making a prototype that can monitor soil moisture, temperature and air humidity and can control relays to turn on the water pump to water the plants on the three types of planting media described in the figure below.

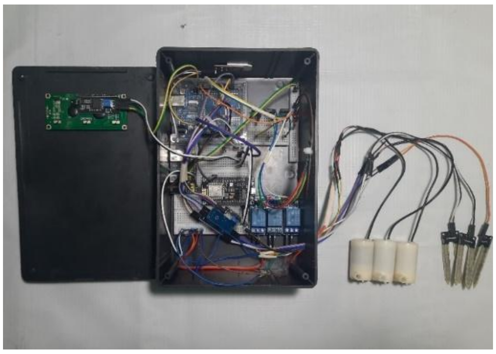

Figure 11. Prototype Instrumentation

The picture above is the final appearance of the orchid plant watering system that has been combined from several components starting from the Arduino as the centre of the microcontroller system that goes to the nodemcu so that it can be connected to a smartphone, DHT22 sensor as input for air temperature and humidity, YL-69 sensor as input for soil moisture, and also a water pump to pump water from the water reservoir to the soil to be watered.

Figure 12. Orchid Plant Watering System Prototype

B. System Testing Results

In this test, three types of growing media with different moisture conditions were prepared to assess the effectiveness of the orchid watering monitoring and control system. The soil conditions are divided into three moisture categories: dry (less than 50%), moist (51%-70%), and wet (more than 70%). If the sensor detects humidity less than 50%, the water pump will switch on automatically. If the humidity is greater than or equal to 50%, the water pump will switch off and no watering will be done.

Figure 13. Testing Soil Moisture Sensor and Water Pump on Fertiliser Kascing Planting Media

Figure 14. Testing Soil Moisture Sensor and Water Pump on Coconut Fibre Planting Media

Figure 15. Testing Soil Moisture Sensor and Water Pump on Charcoal Planting Media

Based on the figure above, the planting media with vermicompost fertiliser showed a soil moisture of 39% (dry), so the pump was turned on to meet the water demand. The coconut fibre planting medium has 68% moisture (moist), so the pump does not need to be turned on. The charcoal planting medium shows 63% moisture (moist), so the pump also does not need to be turned on.

At the next stage, to determine the accuracy of the data from the DHT22 sensor, a comparison is made with weather data from the weather.com website. This comparison is important to ensure that the DHT22 sensor provides accurate and reliable results.

Table I
Comparison of Temperature and Humidity Value of DHT22

Waktu	Sensor DHT22		Data Cuaca	
	Suhu (°C)	Humidity (%)	Suhu (°C)	Humidity (%)
07.00	30.9	66.6	30	68
08.00	32.8	59.3	31	60
09.00	33.1	57.5	31	59
10.00	34.6	50.2	33	52
11.00	35.1	50.4	33	53
12.00	35.2	47.6	35	48
13.00	35.1	47.2	34	48
14.00	35	46.6	34	47
15.00	35	47.4	33	49
16.00	32.9	50.2	32	51
Rata-rata	33.97	52.3	32.6	53.5

Table I shows the temperature and humidity data measured by the DHT22 sensor and the weather.com website. The temperature measured by the DHT22 sensor is higher, with an average of 33.97°C, compared to the weather data which averages 32.6°C. The air humidity measured by the DHT22 sensor and the weather data showed a similar pattern, being higher in the morning and decreasing until the afternoon. The average humidity measured by the DHT22 sensor was 52.3%, while the weather data showed an average of 53.5%.

Table II
Calculation of Standard Deviation of DHT22 Temperature

Data ke – (n)	Selisih (x)	$(x_i - \bar{x})$	$(x_i - \bar{x})^2$
1	0.9	-0.37	0.1369
2	1.8	0.53	0.2809
3	2.1	0.83	0.6889
4	1.6	0.33	0.1089
5	1.1	-0.17	0.0289
6	0.2	-1.07	1.1449
7	1.1	-0.17	0.0289
8	1	-0.27	0.0729
9	2	0.73	0.5329
10	0.9	-0.37	0.1369
Jumlah	12.7	-	3.161
Rata-rata	1.27	-	0.3161
STDV	$\pm$ 0.592640044		

From the table above, the standard deviation value of the DHT22 temperature sensor in Table II was obtained as ± 0.592640044. This shows that the variation or deviation of the temperature measured by the DHT22 sensor from its average value is relatively small, which indicates that the sensor has good consistency and accuracy in temperature measurement.

Table III
Calculation of Standard Deviation of DHT22 Air Humidity

Data ke – (n)	Selisih (x)	$(x_i - \bar{x})$	$(x_i - \bar{x})^2$
1	1.4	0.4	0.16
2	0.7	-0.3	0.09
3	1.5	0.5	0.25
4	1.8	0.8	0.64
5	0.7	-0.3	0.09
6	0.4	-0.6	0.36
7	0.8	-0.2	0.04
8	0.4	-0.6	0.36
9	1.6	0.6	0.36
10	0.8	-0.2	0.04
Jumlah	10	-	2.39
Rata-rata	1	-	0.239
STDV	± 0.515213009		

From Table III above, it can be seen that the DHT22 air humidity sensor has a standard deviation value of ± 0.515213009. This result shows that the variation in air humidity measurements by the sensor is quite consistent. This relatively small standard deviation indicates that the DHT22 sensor has a good level of accuracy in measuring air humidity.

Furthermore, to determine the accuracy of the soil moisture sensor, a value comparison is carried out with the soil meter measuring instrument. The comparison of the soil moisture sensor value with the soil meter is shown in the figure below.

Based on the three tables above, the comparison between the sensor and the soil meter shows that both provide consistent and similar soil moisture measurement results throughout the day, with small differences. The sensor tends to show a slightly higher moisture drop than the soil meter, but the difference is not significant. Both tools gave a good picture of changes in soil moisture over time, although the sensor results were slightly higher than the soil meter at some times. Overall, the sensor and soil meter were effective in measuring soil moisture and provided reliable data for monitoring moisture conditions in all three types of growing media.

Table IV
Comparison of Soil Moisture Sensor Values for Planting Media with Vinegar Fertiliser

Waktu	Pupuk Kascing	
	Sensor (%)	Soil Meter (%)
07.00	80	80
08.00	79	80
09.00	79	78
10.00	78	76
11.00	78	77
12.00	76	74
13.00	76	77
14.00	75	76
15.00	75	76
16.00	74	75
Rata-rata	77	76.9

Table V
Comparison of Soil Moisture Sensor Values in Coconut Fibre Planting Media

Waktu	Serabut Kelapa	
	Sensor (%)	Soil Meter (%)
07.00	77	75
08.00	77	76
09.00	76	75
10.00	76	75
11.00	75	76
12.00	74	75
13.00	73	74
14.00	72	74
15.00	71	73
16.00	71	73
Rata-rata	74.2	74.6

Table VI
Comparison of Soil Moisture Sensor Values in Charcoal Planting Media

Waktu	Arang	
	Sensor (%)	Soil Meter (%)
07.00	74	72
08.00	73	71
09.00	73	70
10.00	72	70
11.00	71	70
12.00	70	68
13.00	70	69
14.00	69	68
15.00	69	68
16.00	68	67
Rata-rata	70.9	69.3

Table VII
Calculation of Standard Deviation of Soil Moisture Sensor in the Cultivation Media of Fertiliser Kascing

Data ke -	Selisih (x)	$(x_i - \bar{x})$	$(x_i - \bar{x})^2$
1	0	-1.1	1.21
2	1	-0.1	0.01
3	1	-0.1	0.01
4	2	0.9	0.81
5	1	-0.1	0.01
6	2	0.9	0.81
7	1	-0.1	0.01
8	1	-0.1	0.01
9	1	-0.1	0.01
10	1	-0.1	0.01
Jumlah	11	-	2.9
Rata-rata	1.1	-	0.29
STDV	± 0.567646		

From the table above, it can be concluded that the soil moisture measured by the sensor and soil meter on the planting media of vermicompost fertiliser shows similar results with insignificant differences. The average difference between the two tools is 1.1% with a standard deviation of ±0.567646, indicating that the difference in soil moisture measurements by sensors and soil meters is quite small and consistent.

Table VIII
Calculation of Standard Deviation of Soil Moisture Sensor in Coconut Fibre Planting Media

Data ke -	Selisih (x)	$(x_i - \bar{x})$	$(x_i - \bar{x})^2$
1	2	0.6	0.36
2	1	-0.4	0.16
3	1	-0.4	0.16
4	1	-0.4	0.16
5	1	-0.4	0.16
6	1	-0.4	0.16
7	1	-0.4	0.16
8	2	0.6	0.36
9	2	0.6	0.36
10	2	0.6	0.36
Jumlah	14	-	2.4
Rata-rata	1.4	-	0.24
STDV	± 0.516397		

Based on the data obtained in the table above, it shows that the average difference between sensor and soil meter readings on coconut fibre planting media is 1.4% while the standard deviation results in ± 0.516397.

Table IX
Calculation of Standard Deviation of Soil Moisture Sensor in Charcoal Planting Media

Data ke -	Selisih (x)	$(x_i - \bar{x})$	$(x_i - \bar{x})^2$
1	2	0.4	0.16
2	2	0.4	0.16
3	3	1.4	1.96
4	2	0.4	0.16
5	1	-0.6	0.36
6	2	0.4	0.16
7	1	-0.6	0.36
8	1	-0.6	0.36
9	1	-0.6	0.36
10	1	-0.6	0.36
Jumlah	16	-	4.4
Rata-rata	1.6	-	0.44
STDV	± 0.699205		

From the table above, it can be seen that the average difference between sensor and soil meter readings on charcoal growing media is 1.6%, with a standard deviation of ± 0.699205. The small standard deviation value indicates that the soil moisture measurement data by the sensor is quite consistent and indicates its reliability in measuring soil moisture under the conditions tested.

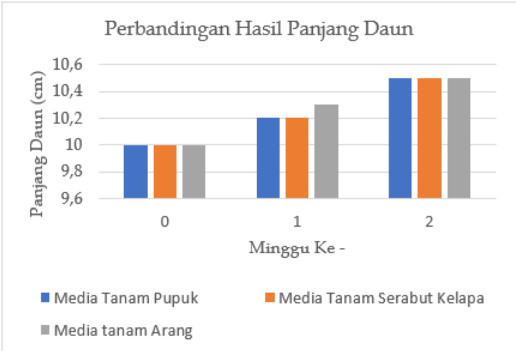

Figure 16. Comparison of Orchid Leaf Length Results with 3 Types of Planting Media

From the comparison of the results of orchid leaf length growth in the figure above, it is known that in the first week, leaves on fertiliser and coconut fibre media grew to 10.2 cm, while charcoal media grew to 10.3 cm. In the second week, leaves on fertiliser and coconut fibre media grew to 10.5 cm, while leaves on charcoal media also grew to 10.5 cm. Overall, although in the second week the leaf length of the three media showed similar results, the charcoal media proved to be the most effective in accelerating the growth of leaf length in the first week, making it the best choice among the three media tested.

V. CONCLUSIONS

Based on the test results on each part and the whole system, the following conclusions can be drawn:

a. The design of Monitoring and Control System for Watering Orchid Plants Based on Weather Data consisting of air temperature and humidity is applied to three different types of planting media, namely vermicompost, coconut fibre, and charcoal. Three pumps and four sensors are used, consisting of three YL-69 soil moisture sensors and one DHT22 air temperature and humidity sensor.
b. The monitoring system performance results show the temperature from the DHT22 sensor (average 33.87°C) is higher than the weather data from weather.com (average 32.6°C). Humidity from both sources shows a similar pattern, higher in the morning and decreasing towards the afternoon. The average humidity from the DHT22 sensor is 52.58%, while the weather data shows 53.4%. The DHT22 sensor has a standard deviation of temperature ±0.59 and humidity ±0.51, indicating good consistency and accuracy. The soil moisture sensor showed good agreement with the soil meter, with an average difference of 1.3% and a standard deviation of ±0.59, indicating small and consistent measurement differences. Orchid leaf growth in the first week increased from 10 cm to 10.2 cm in fertiliser and coconut fibre media, and 10.3 cm in charcoal media. In the second week, leaf growth on all media increased to 10.5 cm. Charcoal media proved to be the most effective in accelerating growth in the first week, making it the best choice among the three media tested.

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