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| RESEARCH ARTICLE

Watering Strawberry (Fragaria X Anannasa) Plants in a Greenhouse Using IoT-Based Drip Irrigation

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| ABSTRACT
Strawberries are horticultural plants that are relatively sensitive to excess and lack of water; therefore, it is necessary to provide drip irrigation with an IoT-based control system to maintain the availability of water for plants to support good plant growth and facilitate the work of strawberry farmers. The purpose of using an IoT-based watering control system on strawberry plants (Fragaria X Annanasa) based on water needs in plants is used to support the development and progress of drip irrigation systems and smart farming system technology in modern agriculture. The research methodology is the preparation of tools and materials, assembling and testing the control system, placing sensors in three different scenarios, and observing the height and number of leaves of strawberry plants with different watering frequencies. The results of the design and testing show that the placement of the sensor on the planting media produces a reading value that is close to the actual volume of water by producing a volume of 51.6 ml of water, which is 79.51% of the weight of the growing media used. And for the growth of plants, watering every two days was better, with the average height and number of leaves for strawberry plants being 0.4 cm and 1.78 strands.

| KEYWORDS
Strawberry, IoT, soil moisture, smart farming, drip irrigation

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1. Introduction
In the field of agriculture and plantations play an important role in the source of income and source of food for some people in Indonesia. In some highlands in Indonesia, there are many types of plants that can grow and develop well, one of which is the strawberry plant. Strawberry is one of the fruit plants that have been known by the people of Indonesia, has high economic value, as well as good and attractive prospects for development [Asep, 2016].

Technically, strawberries require a growing environment with cold and humid temperatures, the height of the planting location, and the need for water supported by good soil moisture. In general, strawberry plants that are cultivated in greenhouses use rice husk charcoal, cocopeat, and soil mixed with compost. Strawberry plants are horticultural plants that are included in the type of fruit; horticultural plants are generally annual plants that are relatively sensitive to excess and lack of water. The vulnerability of horticultural crops is closely related to land use systems, soil properties, cropping patterns, soil management technology, water availability, and varieties. [Dwi, 2017].

Seeing this, it is very important to maintain soil moisture to meet water needs and maintain the temperature of strawberry plants [4]. Therefore, it is necessary to regulate a watering system with the application of smart farming technology in the hope that plant water needs can be met. Smart farming itself is a technology in agriculture that allows farmers to monitor the condition of the garden in real-time that is connected to several sensors without having to go directly to the land and can schedule exactly when the plants need to be watered and how much water the plants need.
However, in its implementation in the field, smart farming technology is widely used only as a monitoring tool for certain parameters without any control measures against these parameters, such as monitoring soil moisture without any action.

Watering is done to regulate soil moisture. It often happens that the installation and calibration of the soil moisture sensor are not appropriate, which results in the percentage value of the water content in the soil that is read by the sensor that is not in accordance with the expected value, which results in the provision of water being inconsistent with plant needs so that it can inhibit plant growth. [Hartanto, 2020].

Based on these problems, a system is designed that can monitor and control the value of soil moisture; By using several capacitive soil moisture sensors and an ESP32 microcontroller as the control center by implementing the internet of things concept in it and adding automatic control as an action to control watering by using drip irrigation techniques as a medium for water distribution to maintain soil moisture. The selection of the capacitive soil moisture sensor is intended so that the sensor probe does not corrode so that the period of use of the sensor is longer, and the use of drip irrigation is to maximize the use of water in watering. With the use of IoT in this system, it is hoped that monitoring and controlling activities can be carried out remotely via the internet using a smartphone so that it will cut all activities that require time and a large number of workers and large-scale agricultural activities can be carried out more quickly and efficiently.

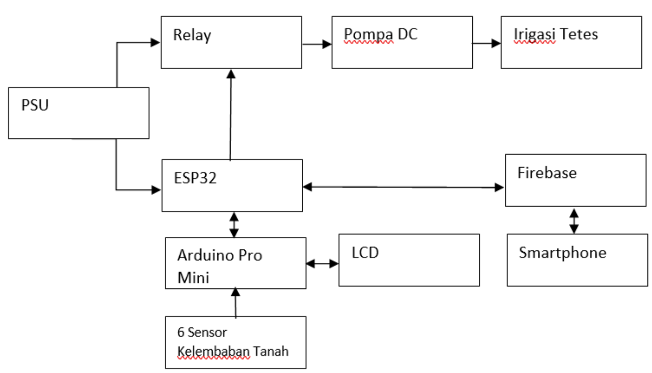
2. Methodology

This research was conducted in June – July 2021 at the Strawberry Nursery Cultivation Greenhouse located in Pancasari Village, Sukasada District, Buleleng Regency, Bali. The research method used in this research is a comparative experimental method with a quantitative approach. The research parameters that want to know are the effect of the voltage on the capacitive humidity sensor with soil moisture, the reading of the sensor value on the place where it is placed in polybags, the time and volume of water produced from drip irrigation, so that the humidity of the planting medium is uniform and the number of leaves and plant height of strawberries by comparing plant growth using different watering frequencies. The growing medium used was a mixture of husk charcoal and cocopeat with a ratio of 9:1. Based on the research method used, the number of samples in this study was 15 units (Borg and Gall, 2007)[Idrus, 2015].

3. Results and Discussion

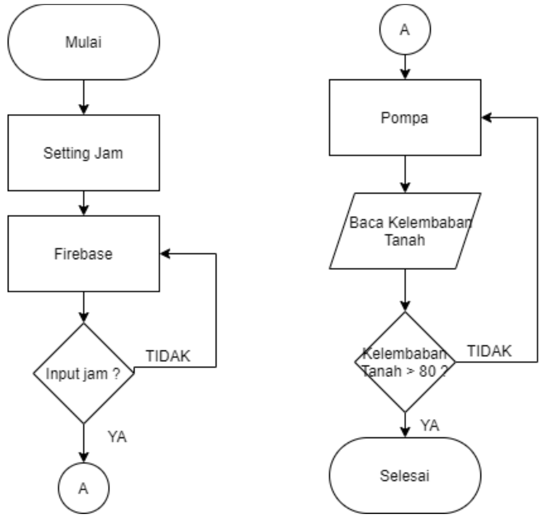
This watering control system with drip irrigation is based on the Internet of Things and is based on the working principle of a closed loop control system where the control system whose output signal has a direct influence on the control action. The closed loop control system is also a feedback control system. The actuating error signal is the difference between the input signal and the feedback signal, which can be a signal

output or a function of the output signal or its derivatives. It is fed to the controller to minimize errors and make the system output close to the desired value.

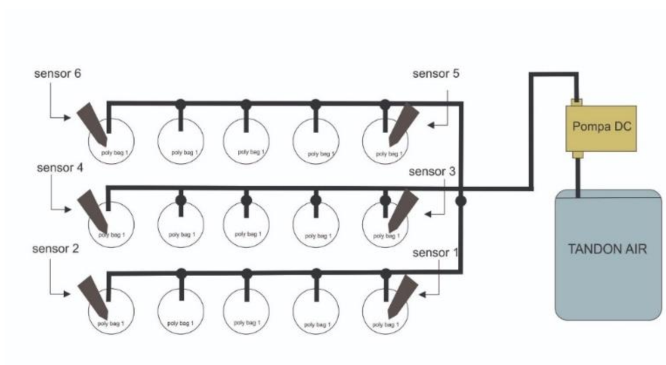


Picture 1. Block Diagram

This control system consists of several components, namely: a microcontroller, relay, sensor, LCD, and power supply, which are assembled into one system. By using multiple soil moisture sensors integrated with the board ESP32 Dev Module. To run the watering control system based on the diagram above, that is, by giving 5V power input to the ESP32 Dev Module, then the ESP32 module will automatically connect to the internet network which was previously programmed in the Arduino IDE software. The ESP32 microcontroller will read the value of the soil moisture sensor reading and will be sent to the google database to be displayed and read in the mobile application that has been created. In the application that has been made, a watering schedule will be determined and sent to the database. Then the microcontroller will retrieve data from the database; if the scheduling time is in accordance with the time on the microcontroller, the relay will be on to do watering. Watering time will be determined using the average sensor readings.



Picture 2. Flowchart Sistem



Picture 3. Drip irrigation circuit

4. Results and Discussion

4.1 Drip Irrigation Design Results

After all the design designs and their constituent components have been completed, the next step is to assemble the irrigation circuit according to the initial design that was previously made. The design of the drip irrigation circuit consists of pipes, L pipe connections, T penuematic connections, and emitters with a pipe diameter of 6mm. The number of pipes used is 1 main pipe, 1 divider pipe, and 3 lateral pipes, which are connected to 5 emitters in each lateral pipe. The pipe used in this drip irrigation network is LDPE pipe. Other supporting components that are no less important in this drip irrigation network are reservoirs and irrigation pumps. The reservoir is used to accommodate water used as irrigation water from a reservoir with a capacity of 1000 liters. While the pump used serves to drain water into the dividing pipe. Here is a picture of the drip irrigation circuit.

Picture 4. Emitter Placement

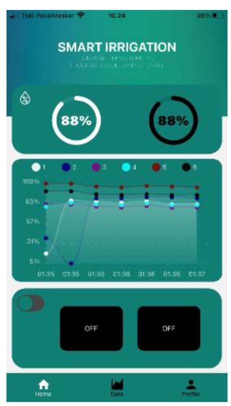
4.2 Hardware Assembly

Hardware manufacture includes assembling a control system with a relay circuit assembly, soil moisture sensor, LCD, ESP32 Dev Module circuit, and arduino pro mini. The results of the control system assembly are as follows: ESP32 and arduino pro mini as a control center on the system, where ESP32 has a role as a controller that exchanges data with the database and arduino pro mini as a control center to process data from soil moisture sensor readings and display it on a layer LCD. This control system is connected to six soil moisture sensors, while the output of the system uses a relay that is connected directly to the GPIO pin of the ESP32. The relay here functions as a switch to turn the pump on and off. The results of the control system assembly can be seen in the image below.

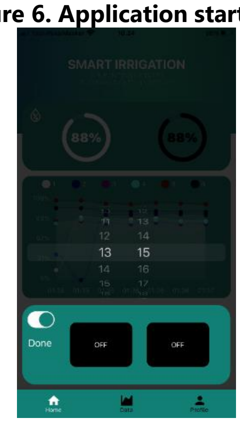
Picture 5. Outer View of the Tool

4.3 Software Development

Software development includes writing programs using the Arduino IDE application, which is software for program writing, compiling, and uploading programs to the microcontroller board, As well as making mobile applications using the JavaScript programming language using the React Native library. Then ESP32 will send data from the soil moisture sensor readings and take the input value of the watering time to the firebase, which functions as a data storage area where the value of the sensor readings and the clock input time will be displayed and can be seen on the mobile application that has been made. The following is the result of making the software.



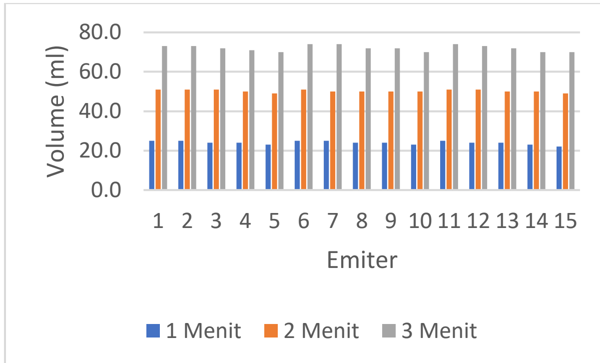
Picture 6. Application start page



Picture 7. Scheduling View

4.4 Drip Irrigation Circuit Test

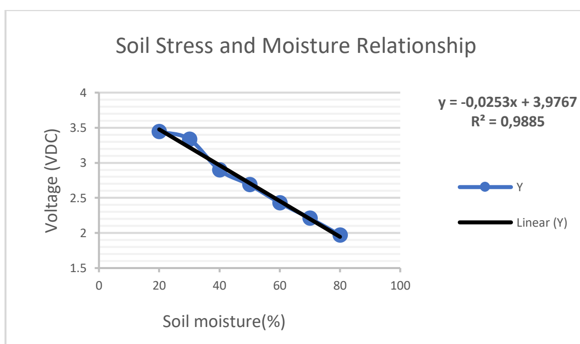
This irrigation circuit test was carried out to determine the even distribution of water or uniformity of emissions and to determine the ratio of the volume of water in each polybag, with an interval of 1 minute, 2 minutes, and 3 minutes of testing. The results of this test can be seen in Figure 4 below.



Picture 8. Volume of Water Produced by Each Emitter

Based on the graph in the image above, it can be seen that the highest water volume is found in polybags 1,7 and 11 or in the first polybag on each lateral pipe, while the lowest water volume is found in polybags 5,10 and 15 or in the last polybag on each lateral pipe, which can be seen in Figure 4. The difference in water volume is due to the water flowing through the first emitter in polybag 1 faster than in polybag 5. Other things can also cause the difference in volume, such as water used for dirty watering, resulting in blockage of the dropper used so that the flow of water through the emitter is blocked. It is also seen that there is a relatively small difference in the volume of water produced by the emitter in each polybag used. This can indicate that the distribution of water throughout the polybags is good so that there is an even distribution of water throughout the plant.

4.5 Effect of Sensor Voltage Relationship on Soil Moisture



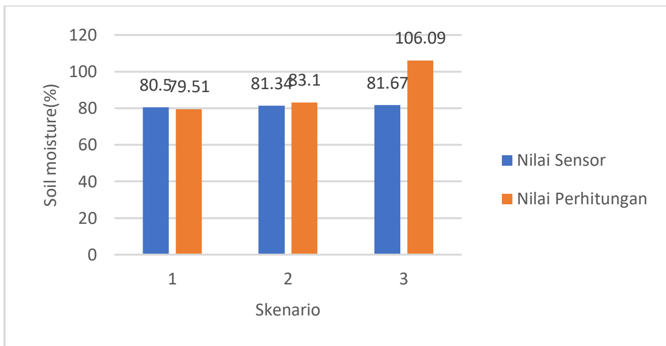
Picture 9. Graph of the Relationship of Soil Stress and Humidity

Based on Figure 4.11, looking for linear regression values is carried out to determine the relationship between the output voltage on the sensor with different soil moisture values , and the equation $y = -0.0253x + 3.9767$ is obtained. Where the x variable is the soil moisture value, and the y variable is the output voltage on the sensor, while the number 3.9767 states the sensor's initial voltage value when the read soil moisture value is close to zero. The negative sign (-) means that the output voltage on the sensor decreases when there is an increase in the percentage value of soil moisture. The degree of linear correlation on the graph is expressed by R2, and the value is 0.9885. The magnitude of the value in this degree of correlation indicates that there is a linear relationship between the sensor output voltage and the soil moisture value.

This voltage change occurs because wet soil has a different dielectric constant from dry soil; this change in capacitance value is caused by dielectric changes that occur in the planting medium caused by the decomposition of ions formed by the planting medium and water. The dielectric value of the capacitive soil moisture sensor is directly proportional to the resistance value of the resistive soil moisture sensor; the amount of change in the resistive value is influenced by the number of percentages between the water and air content in the soil pores. While the resistance value of the resistive soil moisture sensor increases with increasing air content in the soil pores, this is because air is a poor conductor of electricity. So it can be concluded that the capacitive value is directly proportional to the amount of air content in the pores and inversely proportional to the amount of water contained in the soil; thus, the electrical impedance value in the soil increases with the less water content contained in the surroundings. the sensor. [Mareta, 2019].

4.6 Strawberry Plant Growth Comparison Test

In this test, an experiment will be carried out by placing the sensor in a polybag with 3 experimental scenarios; first, the sensor will be plugged in from above at a distance of 5cm from the emitter, and the second sensor will be plugged in from the middle side of the polybag, and the last one will be plugged in from the bottom of the center of the polybag and parallel to the emitter. With the depth of sensor placement in the three scenarios is 7cm according to the recommended limit on the sensor datasheet, then watering will be carried out using drip irrigation until the humidity value read by all sensors is 80% according to the value of the field capacity of the growing media. From the three experiments above, we will look for the volume of water produced in each polybag placed by the sensor by weighing the weight of the soil sample after watering and reducing the weight of the initial sample of the soil that has been dried.



Picture 10. Comparison of Soil Moisture Value

The difference in soil moisture values in the three test scenarios above was due to the limited movement of water in the planting medium in the horizontal direction of drip irrigation, also due to the varying ability of the planting media in each polybag to absorb water. In the rice husk charcoal planting medium with a mixture of cocopeat, although it has a high water absorption capacity, the vertical movement of water is still ongoing, but the water movement in the horizontal direction will reach a certain maximum distance, and it will take some time to reach the bottom of the polybag with the help of gravity. This is in accordance with the opinion expressed by Pairunan (1997), which states that the amount of water obtained by the soil partly depends on the ability of the soil to absorb water quickly and continue the water received on the soil surface [9]. In general, the area of the wetted growing media resembles a light bulb, and the area of the wetted growing media from drip irrigation with a certain volume but given different flow rates is almost the same as shown by Roth. (1974)[Pratiwi, 2017].

4.7 Control Circuit Test

Testing of the scheduled watering control system was carried out for two simulations by observing the time on the relay and off the relay to determine the accuracy of the system based on the time input on the control system used.

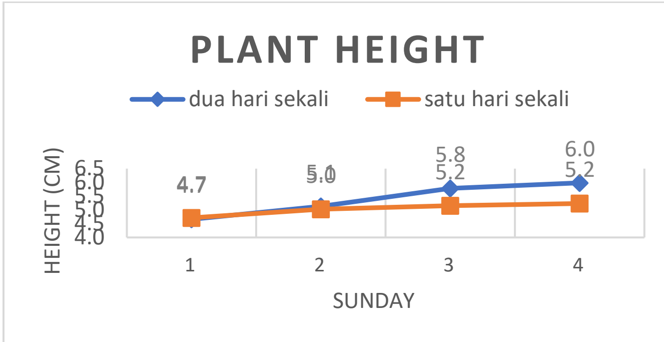
Table 1. Control System Testing Simulation Results

No	Time		Soil moisture (%)		Difference (s)
	Input	On system	On	Off	
1	09:00:00	09:00:02	43,83	80,67	2
2	16:00:00	16:00:06	37,34	81,17	6

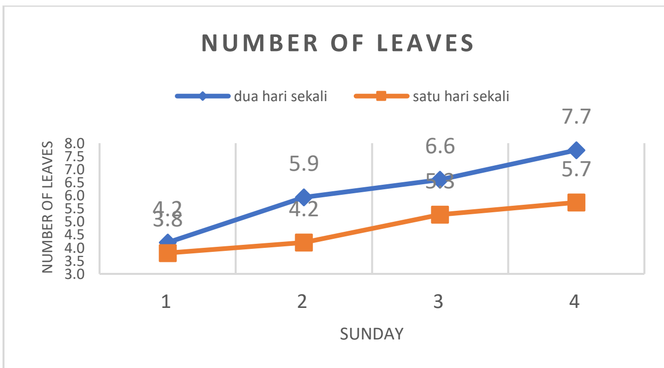
Based on the results of testing the control system and sensor readings above, it can be seen that the system response when turning on the relay and running the pump there is a delay of 2 seconds and 6 seconds from the input time on the mobile application that has been made, this is due to the speed of the internet connection at the test site and several blocks program that takes time to run by the microcontroller. As for the response of the soil moisture sensor, when all sensor readings are above or equal to 80%, the relay will turn off and turn off the pump. It can be seen in Table 4.2 that the readings of the soil moisture sensor are 80.67% and 81.17%, respectively. So it can be concluded from the results of testing the watering control system on the drip irrigation network that it is used to running well and working according to the specified scheduling time value and the percentage of soil moisture obtained in accordance with the desired value.

4.8 Strawberry Plant Growth Testing With Different Watering Frequency

This test was conducted to determine the comparison of strawberry plant growth using an automatic watering control system using a drip irrigation circuit with different watering frequencies, with the sensor placement location according to the results of the sensor placement study above. This test is carried out by observing and recording the number of leaves produced and the height of strawberry plants for one month of observation, with a frequency of watering once a day and every two days.



Picture 11. Plant Height Growth Comparison



Picture 12. Comparison of the Number of Plant Leaves

In the test results shown in the Figure above, the average growth of plant height and the number of leaves produced at the frequency of watering twice a day is better, while in this once a day watering, there is growth inhibition, as well as some plants that begin to wither and some strawberry plants begin to die in the fourth week. This is because the plant media used is always moist, which results in fungal growth on the roots of strawberry plants, where the planting medium with a mixture of cocopeat has a high water absorption capacity, which is 69% [Rizka, 2020]. From the results of the picture above, it is known that watering carried out using a control system that has been made with a frequency of watering every two days produces a higher height and number of leaves than the frequency of watering once a day.

5. Conclusion

Based on the research results obtained, it can be concluded that this watering control system works by entering the watering time through a mobile application that has been made. The microcontroller will adjust the clock time that has been entered; after the input value is appropriate, the system will turn on the relay to turn on the pump; the length of watering depends on the value of the soil moisture sensor reading, the pump will turn off when the value of all sensors is above or equal to 80%. The application of a watering control system using drip irrigation produces a fairly high time accuracy and provides a response that is almost in accordance with the input given to the application. As well as the placement of a good soil moisture sensor is the sensor is positioned on top of a polybag. The placement of this sensor provides a sensor response that is in accordance with the volume content of the water in the planting media used, namely the water content in the planting medium of 79.74% of the weight of the soil sample or 51.83 mL so that there is no excessive water supply to plants. And on the use of rice husk charcoal and a mixture of cocopeat with a ratio of 9:1 used as a planting medium for strawberry plant nurseries, the results of watering with a frequency of once every two days using a control system resulted in a better average plant height and number of leaves, namely 0, 4 Cm and 1.78.

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Conflicts of Interest: The authors declare no conflict of interest

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