Telecontrolling Microgreen Indoor Nursery Strawberry

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***Abstract*— Strawberry is a horticultural commodity that produces a high economy, but in 2014 strawberry production decreased by 34.83%. The reason for the decrease in production is the unstable temperature and humidity conditions due to global warming. Another factor that causes strawberries to fail is due to the slowness of farmers in knowing changes in temperature and humidity in strawberry. The method used in this study was to compare the results of special treatment on microgreen strawberry nurseries indoor using natural vegetative methods and outdoor. System telecontrolling strawberry nursery real time with temperature and humidity parameters using a DHT22 sensor, soil moisture using a soil moisture sensor, soil pH using a soil pH sensor, time using RTC and light intensity using a light intensity sensor BH1750. The results of strawberry nurseries with telecontrolling an indoor plant height of 9 cm and a plant width of 12 cm, results of strawberry nurseries without telecontrolling treatment outdoor with a plant height of 7.5 cm and a plant width of 7 cm.**

***Keywords*— Strawberry, Telecontrolling, Nursery, Microcontroller, DHT22, Microgreen.**

I. INTRODUCTION

Every year the human population in the world continues to increase rapidly. The binding of the population along with the increasing need for land as a place to live. The use of land as a place to live has an impact on the availability of land for agriculture. The problem of population nutritional needs is a challenge for all in the midst of population growth that continues to increase [1].

Microgreens are small in size, so they do not require a large area of land to grow [2]. Plants Microgreen best grown at an ambient temperature of 19-27°C depending on the type of plant. Growth process microgreen best placed in environmental conditions with air humidity of 40-60%. The process of watering the hydroponic planting system is best for microgreens, that is, flowing water only on the roots (bottom watering), because this watering process keeps the stems and leaves of microgreens dry to avoid disease [3]. Environmental factors that need to be considered in the growth of microgreens including temperature, humidity, pH, lighting, and irrigation systems must be maintained properly to accelerate the growth rate of microgreens and obtain the best quality yields. Strawberry is a horticulture that has high economic value, especially in subtropical climates. With the development of growing agricultural technology, strawberries can now be developed in the tropics [4]. Strawberry is a plant that grows well on highland land, because strawberry requires cold and humid environmental conditions with optimum temperature between 17ºC - 23ºC, 80-90% humidity, 8-10 hours of sunlight per day, pH 5.5 – 6.5; nutrient density is 1260 ppm -1540 ppm, and rainfall ranges from 600 mm – 700 mm per year [5].

Based on these problems, a system is needed that is able to monitor air temperature, air humidity, soil pH, light intensity and control of the irrigation system in strawberry. In this study, a system is proposed that can support telecontrolling research with the title "Telecontrolling Microgreen Indoor Nursery Strawberry Growing Media Cocopeat". Analysis of the results of the research on the telecontrolling of air temperature, air humidity, lighting, soil pH, the system control for *strawberry* superior seed.

When utilized as food supplements, microgreens are nutrient-dense functional crops with valuable nutritional components that have positive health effects [6]. Although microgreens have been recognized as valuable and nutritious functional crops, little is known about the consistency of each green's individual and collective influence. By enhancing the growth conditions, a number of ways have been devised to increase microgreen yield. As in research [7] the treatment of LED light spacing has a significant effect on fresh weight and chlorophyll content variables in microgreens. Meanwhile, the treatment of the growing media had a significant effect on the variables of plant height, fresh weight, and leaf chlorophyll, while the treatment of LED light spacing and the interaction between the two treatments had a significant effect only on the fresh weight and chlorophyll content of microgreens.

Strawberries require fertilizer just like other plants do to grow well. Fertilizer is a substance that provides plants with both macro and micronutrients. In general, there are two types of fertilizers: organic fertilizers and inorganic fertilizers. Manure, green manure, compost, shrimp waste, biological fertilizers, and others are examples of organic fertilizers. Inorganic fertilizers include urea, SP-36, KCl, NPK Ponska, NPK Mutiara, and others [8]. A fundamental criterion for success in boosting plant productivity is balanced fertilization. Finding the proper dose is one of the attempts. The most effective dose of NPK fertilizer to boost productivity has been determined by research [9] on the effects of combination doses of N, P, and K fertilizer on plant development and production.

Research on the digitization of soil pH measurement is carried out with a microcontroller-based digital soil pH build design [10]. Electronic system design uses several components, namely LED, LCD, buzzer and pH sensor. These components are connected to the microcontroller according to the desired command.

A microcontroller is a miniature computer meant for controlling peripheral devices [11]. A microcontroller's usefulness lies in the fact that it is typically a system-embedded device with the job of analyzing inputs and producing appropriate outputs. The goal of the open-source Arduino project, which started in Italy in 2005, is to make microcontroller hardware and software simple to comprehend and use for students and tech enthusiasts. The open-source nature of the boards and software is one of the factors contributing to the success of the Arduino project. There is a sizable Arduino community, and many members communicate through blogs, forums, and websites to share projects and ideas.

The Arduino is programmed using an external computer, and when it operates independently, it focuses like a laser on a specific purpose. The Arduino is a very effective controller, and its specs are sufficient because of that. Here is a photo of one of the most well-known Arduino boards:

Figure 1. Arduino boards

The ESP32 is a modern, powerful, feature rich and low-cost Microcontroller Unit (MCU) [12]. It has integrated WiFi and Bluetooth. It can be programmed using the Arduino IDE and makes use of the libraries *available* for Arduino devices. The ESP32 can be successfully used in the data acquisition and control of various devices via wireless networks and it performs much better than its predecessor [13]. Due to integrated components such an antenna, oscillator, and flash, the module is incredibly simple to use despite its small size. Similar modules for various microcontrollers are frequently used for testing and prototyping.

The ESP32 microcontroller is built to work with the complete 802.11 b/g/n/e/i WLAN MAC specification, TCP/IP, and Wi-Fi Direct standards. Under the Distributed Control Function (DCF) protocol, the microcontroller can offer Basic Service Set (BSS) STA and SoftAP functions. Additionally, it supports P2P group operations that adhere to the most recent Wi-Fi P2P protocol. ESP32 was utilized to lessen network activity and the processing burden on the server [14].

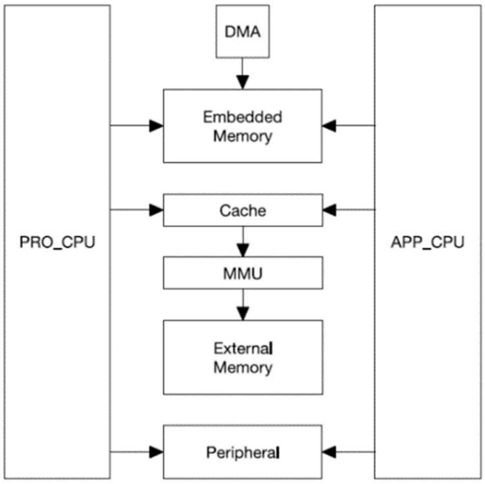


Figure 2. Arduino boards [13]

One of the most often checked parameters in many industrial and commercial applications is temperature. The chosen temperature sensor is connected to a microcontroller or microcomputer, such as the DHT22. The DHT22 sensor and other related sensors are typically used in temperature monitoring systems [15].

The DHT22 sensor is a sensor that controls humidity and temperature. Its analog voltage output can be further processed by a microprocessor. The DHT22 module has advantages in terms of reading the quality of *sensing* data that is more responsive and has speed in terms of detecting temperature and humidity. It is a module that is classed as a recessive element, such as a temperature measuring device.

Utilizing proprietary digital signal collection and humidity sensing techniques, the DHT22 ensures its dependability and stability. It has an 8-bit single-chip microprocessor coupled to its sensing components. Every sensor in this model has been temperature adjusted, calibrated, and saved in a type of program in OTP memory. When the *sensor* senses something, it will reference the calibration coefficient from memory. Small size, low power consumption, and a long transmission distance of 20 meters make the DHT22 suitable for use in a variety of challenging application scenarios [16].

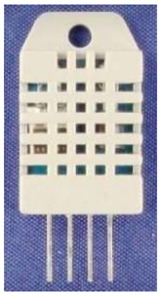
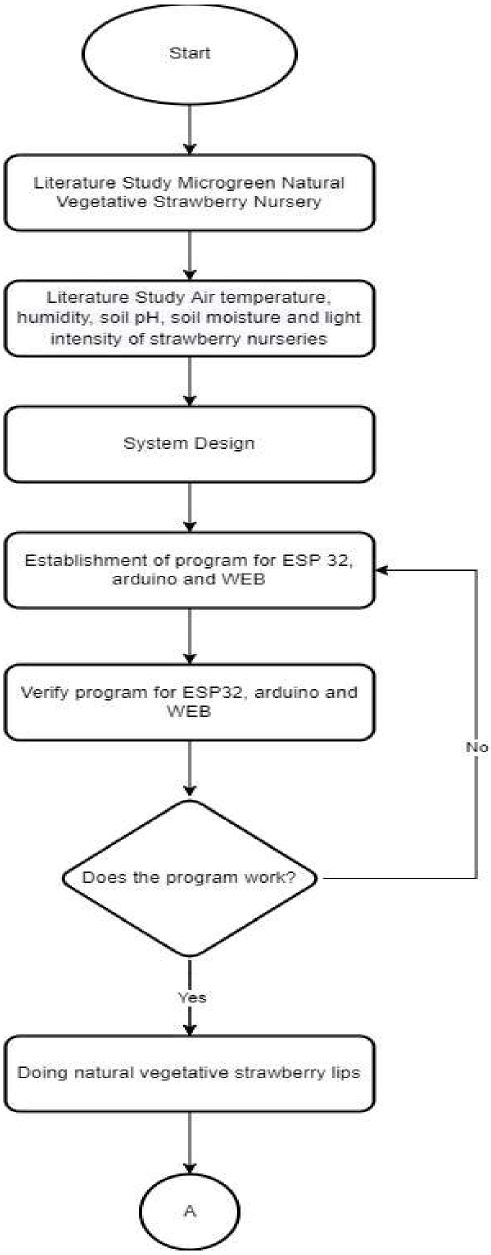


Figure 3. DHT22

II. METHOD

A. Stages of Research

The stages of research carried out as an initial stage in conducting research, are shown below. Everything related to research must be planned in advance, from searching for references to making reports.



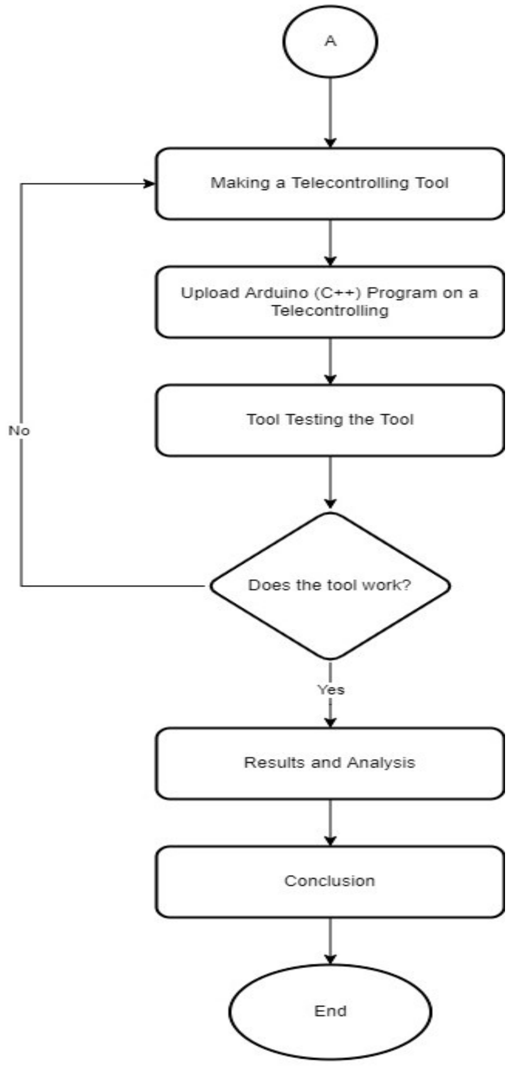


Figure 4. Stages of research

B. System Planning

Diagram block of the entire telecontrolling system of this research can be seen in Fig. 5.

Fig. 5 explains that natural vegetative strawberry nurseries will monitor the development of plant photosynthesis, pH and humidity of the growing media, light intensity and temperature and humidity. The telecontrolling system uses an ESP32 microcontroller and Arduino Uno as the controlling centre and then uses a 16x2 LCD to display the reading values of all sensors. Soil moisture readings using a soil moisture sensor, Soil pH readings using a soil pH sensor, temperature and humidity readings using a DHT22 sensor, light intensity readings (lux) using a BH1750 sensor and water and fertilizer watering timers using Real Time Clock (RTC). To store data or as a database of sensor readings using firebase from google. A web application that is used to display sensor values as well as a graph of the progress of changes in values taken from firebase and a control centre created with HTML using the Visual Code Video application.

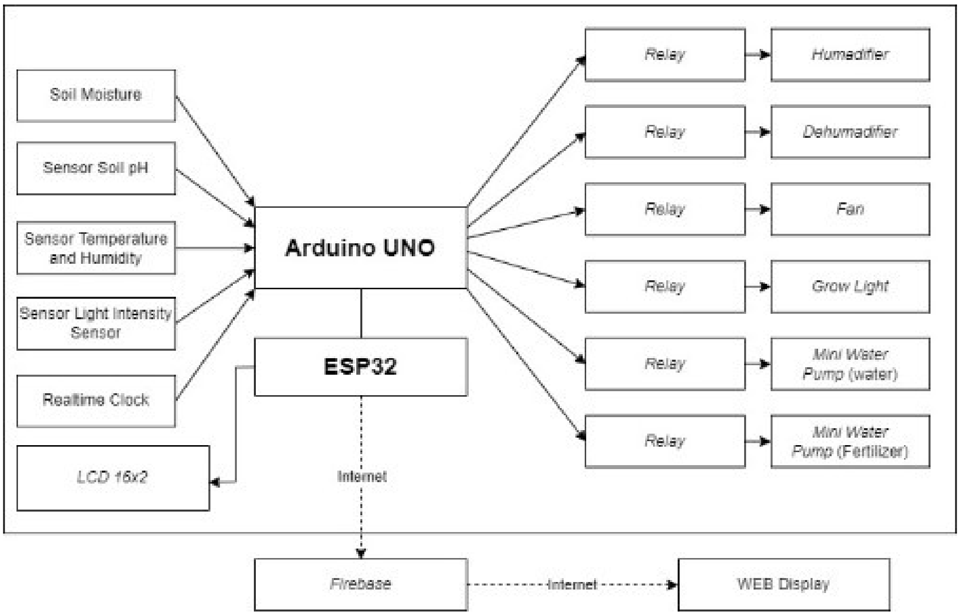


Figure 5. System planning

III. RESULTS AND DISCUSSION

A. *Measurement of the DHT22*

Microgreen growing medium indoor seedlings strawberry naturally vegetatively. The following is a table of the results of temperature measurements at 07.00 WIT and 17.00 WIT.

TABLE 1
DHT22 AIR TEMPERATURE SENSOR

Date	DHT22 Air Temperature Sensor (ºC)	
	07.00 WIT	**17.00 WIT**
15 June 2022	23ºC	22ºC
16 June 2022	22ºC	23ºC
17 June 2022	22ºC	21ºC
18 June 2022	21ºC	24ºC
19 June 2022	22ºC	25ºC
20 June 2022	20ºC	22ºC
21 June 2022	21ºC	23ºC
22 June 2022	22ºC	21ºC
23 June 2022	23ºC	20ºC
24 June 2022	20ºC	22ºC
25 June 2022	22ºC	23ºC
26 June 2022	21ºC	21ºC
27 June 2022	21ºC	26ºC
28 June 2022	20ºC	24ºC
29 June 2022	19ºC	24ºC
30 June 2022	21ºC	25ºC
01 July 2022	22ºC	24ºC
02 July 2022	25ºC	23ºC
03 July 2022	24ºC	22ºC
04 July 2022	23ºC	23ºC
05 July 2022	22ºC	23ºC
Average	21.71ºC	22.90ºC

Based on table 1, observations of changes in the temperature readings of the DHT22 temperature and humidity sensor at 07.00 WIT and 17.00 WIT on the 1st day to the 21st day with the lowest temperature at 07.00 WIT with a value of 19ºC on the 16th day and the highest temperature on July 02 with a value of 25ºC. At 17.00 WIT the lowest temperature is 20ºC on the 9th and the highest temperature on the 16th day is 25ºC. The average temperature at 07.00 WIT for 21 seeding days is 21.71ºC, and the average temperature at 17.00 West Indonesia Time (WIT) for 21 seeding days is 22.90ºC, so the average temperature at that hour is suitable for strawberry vegetative.

B. *Measurement of the Light Intensity Sensor The light*

Intensity sensor BH1750 is used to determine the light intensity for photosynthesis of microgreen indoor strawberry nurseries naturally vegetatively. BH1750 is an digital Ambient Light Sensor IC for I^2C bus interface. The LCD and keypad backlight power of a mobile phone can be adjusted using ambient light data obtained by this IC. Wide range detection is achievable with high resolution.

Changes in sensor sensitivity are available with the BH1750. Furthermore, by utilizing this function, the optical window influence (difference with vs. without optical window) can be eliminated. Adjustment is made by adjusting the measurement time. For instance, when the optical window's transmission rate is 50% (the measurement result changes to 0.5 times if the optical window is set), the optical window's influence is ignored by increasing the sensor's sensitivity from the factory setting of default to 2.

TABLE II
LIGHT INTENSITY BH1750 SENSOR

Date	Light Intensity BH1750 Sensor (lux)	
	07.00 WIT	**17.00 WIT**
15 June 2022	250 lux	180 lux
16 June 2022	250 lux	180 lux
17 June 2022	245 lux	175 lux
18 June 2022	243 lux	175 lux
19 June 2022	239 lux	178 lux
20 June 2022	240 lux	174 lux
21 June 2022	242 lux	173 lux
22 June 2022	241 lux	176 lux
23 June 2022	239 lux	178 lux
24 June 2022	235 lux	179 lux
25 June 2022	234 lux	181 lux
26 June 2022	235 lux	175 lux
27 June 2022	236 lux	170 lux
28 June 2022	239 lux	172 lux
29 June 2022	238 lux	176 lux
30 June 2022	235 lux	172 lux
01 July 2022	235 lux	172 lux
02 July 2022	238 lux	173 lux
03 July 2022	235 lux	176 lux
04 July 2022	238 lux	172 lux
05 July 2022	238 lux	176 lux
Average	239.29 lux	175.38 lux

Based on table 2, observations were made of changes in the light intensity readings of the BH1750 light sensor at 07.00 WIT and 17.00 WIT on the 1st day to the 21st day with the lowest intensity at 07.00 WIT with a value of 234 lux on the 11th day and the highest intensity on the 11th day. 1 and 2 are worth 250 lux. At 17.00 WIT on the 13th day the lowest light intensity is 170 lux, the highest light intensity on day 1 and 2 is 180 lux. The average temperature at 07.00 WIT for 21 nursery days was 239.29 lux, and the average light intensity at 17.00 WIT for 21 nursery days was 175.38 lux. So at 07.00 for 21 days the grow light nursery turns off because the intensity value is above 200 lux and at 17.00 the grow light turns on because of the light intensity because the intensity value is below 200 lux to help the growth of strawberry.

C. Measurement of Soil Moisture

Soil moisture sensor is used to determine the water content contained in the planting media as a reference standard for the quality of the planting media. These sensors can either be fixed or mobile, like handheld probes. Portable soil moisture probes may monitor soil moisture at many sites, in contrast to stationary sensors, which are installed in the field at specified depths and locations. Sensors placed at several different depths and locations. Typically, sensors are placed in pairs at one-third and two-thirds the depth of the crop root zone and at two or more locations in the field, preferably in the representative soil type away from high points, depressions and slopes.

The design of the sensor will determine how it is installed. Observe the manufacturer's installation instructions. The two most common methods for installing soil moisture sensors are using an auger or soil sampling probe to bore a hole and installing the sensors vertically, or excavating a hole or trench and placing the sensors horizontally at various depths.

TABLE III
SOIL MOISTURE OF SOIL MOISTURE SENSOR

Date	Soil Moisture of Soil Moisture Sensor (%)	
	07.00 WIT	**17.00 WIT**
15 June 2022	90%	80%
16 June 2022	92%	82%
17 June 2022	91%	83%
18 June 2022	91%	81%
19 June 2022	89%	77%
20 June 2022	90%	78%
21 June 2022	90%	79%
22 June 2022	92%	78%
23 June 2022	93%	80%
24 June 2022	92%	81%
25 June 2022	90%	79%
26 June 2022	91%	80%
27 June 2022	89%	81%
28 June 2022	92%	81%
29 June 2022	91%	78%
30 June 2022	89%	81%
01 July 2022	90%	82%
02 July 2022	92%	81%
03 July 2022	93%	80%
04 July 2022	92%	79%
05 July 2022	91%	80%
Average	90.95%	80.04%

Nurseries soil at 07.00 WIT and 17.00 WIT on the 1st day to the 21st day. The lowest soil moisture at 07.00 WIT was 92% on the 2nd day and the highest soil moisture was 92% on the 21st day. At 17.00 WIT the lowest soil moisture is 77% on the 5th day and the highest soil moisture is 83% on the 3rd day. The average soil moisture at 07.00 WIT for 21 seeding days was 90.95%, and the average soil moisture at 17.00 WIT for 21 seeding days was 80.04%. So at 07.00 for 21 days the nursery period, humidity is above 80% because the system automatically waters at 06.30 WIT with the help of RTC (Real Time Clock) to keep soil moisture above 80%, at 17.00 WIT there is a decrease in soil moisture due to water content. absorbed by plants to help the growth process.

D. Measurement of Soil pH

Soil pH sensor is used to determine the level of acidity contained in the planting media as a reference standard for the quality of the planting media. The term "soil ph" refers to the soil's current pH, which is significant to plant growth. Although there is a vast range where plants can grow normally, each species has its ideal pH. Crops can grow healthily when the pH level of the soil is moderately controlled. The used soil sensor is highly accurate, measures data quickly, produces output that is steady, and is applicable to a wide range of soil types. The weather, fertilizer, type and quantity of irrigation, soil type, nearby plants, and nutrient availability are the most frequent factors that affect soil pH.

TABLE IV
OIL PH OF SOIL PH SENSOR

Date	Soil pH of Soil pH Sensor	
	07.00 WIT	17.00 WIT
15 June 2022	6.2	6.2
16 June 2022	6.2	6.2
17 June 2022	6.2	6.2
18 June 2022	6.2	6.2
19 June 2022	6.2	6.2
20 June 2022	6.2	6.2
21 June 2022	6.2	6.3
22 June 2022	6.3	6.3
23 June 2022	6.3	6.3
24 June 2022	6.3	6.3
25 June 2022	6.3	6.3
26 June 2022	6.3	6.3
27 June 2022	6.3	6.3
28 June 2022	6.3	6.3
29 June 2022	6.3	6.3
30 June 2022	6.3	6.3
01 July 2022	6.3	6.4
02 July 2022	6.4	6.4
03 July 2022	6.4	6.4
04 July 2022	6.4	6.4
05 July 2022	6.4	6.4
Average	6.28	6.29

Based on table 4, observations of changes in soil pH readings from the soil pH sensor at 07.00 WIT and 17.00 WIT from day 1 to day 21. The lowest soil pH at 07.00 WIT was 6.2 on day 1 to day 7 and the highest soil pH was 6.4 on day 18 to day 21. At 17.00 WIT, the lowest soil pH was 6.2 on day 1 to day 6 and the highest soil pH was 6.4 on day 17 to day 21. The average soil pH at 07.00 WIT for 21 nursery days was 6.28, and the average soil pH at 17.00 WIT for 21 nursery days was 6.29. So during the planting period the quality of the strawberry meets the standard where the value is between 5.5 - 6.5 so that it supports the growth of strawberry seedlings well.

E. Test Packet Loss

The success rate of data transmission can be done by calculating the packet loss sent from ESP32 to firebase. Packet loss testing as one of the QoS parameters is carried out to determine network performance. The transmission of data was tested 15 times. Wireshark is used for testing. The following table contains the findings of the packet loss tests.

TABLE V
TEST PACKET LOSS

Delivery of Packages to Firebase	Firebase Status
1	Updated
2	Updated
3	Updated
4	Updated
5	Updated
6	Failed
7	Updated
8	Updated
9	Updated
10	Updated
11	Updated
12	Updated
13	Updated
14	Updated
15	Updated

Based on table 5 of the 15 packets sent, there was 1 failed package and 14 succeeded with a success percentage of 93.3% with a packet loss of 6.7% where the quality of package delivery was good.

F. Test Delay

Delay testing is needed to see if the communication system in this final project is running well or not. Wireshark can display several packets when doing live streaming, because the protocol used is TCP and therefore must be filtered first. Do a filter according to the IP used. The IP used by ESP32 on the access point used is 192.168.43.72 and the Website IP 114.125.67.226.

TABLE VI
TEST DELAY

Delivery of Packages to Firebase	IP ESP32 (src)	IP Website Monitoring (dst)	Delay (ms)
1	192.168.43.72	114.125.67.226	0.0029
2	192.168.43.72	114.125.67.226	0.0024
3	192.168.43.72	114.125.67.226	0.0025
4	192.168.43.72	114.125.67.226	0.0028
5	192.168.43.72	114.125.67.226	0.0037
6	192.168.43.72	114.125.67.226	0.0016
7	192.168.43.72	114.125.67.226	0.0023
8	192.168.43.72	114.125.67.226	0.0025
9	192.168.43.72	114.125.67.226	0.0014
10	192.168.43.72	114.125.67.226	0.0029
11	192.168.43.72	114.125.67.226	0.0022
12	192.168.43.72	114.125.67.226	0.0017
13	192.168.43.72	114.125.67.226	0.0025
14	192.168.43.72	114.125.67.226	0.0015
15	192.168.43.72	114.125.67.226	0.0017
Average Delay			0.0023

Table 6 is the result of the packet calculation with the average delay obtained is 0.0023ms, it can be seen that the delay calculation result is very small. The smaller the delay, the better the quality of a call because there is no information delay.

IV. CONCLUSION

After doing the research and getting the results and then doing the analysis, the next step is to make conclusions from the analysis. The following are some conclusions obtained from this research: (1) Making a strawberry nursery telecontrolling device with cocopeat planting media is used to monitor air temperature conditions, humidity, light intensity, soil moisture and soil pH can be monitored remotely based on the internet. (2) The DHT22 air temperature and humidity sensor reads the air temperature of the strawberry nursery planting medium, if the air temperature is more than 23℃ the fan turns on, when the humidity is less than 80% the humidifier turns on to increase the humidity, when the air humidity exceeds 90% the dehumidifier turns on to reduce the humidity. The BH1750 light intensity sensor reads the light intensity of the room, if the light intensity is less than 200 lux, the Grow Light turns on to help the nursery photosynthesis process. The soil ph sensor reads the soil ph condition of the strawberry, if the ph condition is not between 5.5 – 7.3 liquid fertilizer is applied to the strawberry plants. The soil moisture sensor reads the soil moisture of the strawberry planting medium, if the soil moisture is less than 80%, the water will flow to the plants. (3) The results of the measurement of the temperature and humidity sensor readings DHT22 on average at 07.00 WIT are worth 21.71 C and at 17.00 the value is 22.90ºC, while the average humidity at 07.00 WIT is 82.74% and at 17.00 WIT is 80.76%. The average soil pH sensor reading at 07.00 WIT is 6.28 and at 17.00 is 6.29. The average light intensity sensor reading at 07.00 WIT is worth 239.29 lux and at 17.00 is 175.38 lux. The success rate of sending data from ESP32 to the webserver is 93.3 % and the average delay in sending data is 0.0023 ms. (4) The results strawberry natural vegetative indoor with telecontrolling had a plant width of 12 cm and a plant height of 12 cm with an average growth of 0.425 cm per day and plant height of 0.3 cm per day. nurseries strawberry of natural vegetative outdoors have a plant width of 7 cm and a plant height of 7.5 cm with an average plant width growth of 0.175 cm per day and a plant height of 0.225 cm per day. These results can be concluded that strawberry natural vegetative indoor with telecontrolling have slightly better seeds based on plant height and width compared to strawberry natural vegetative outdoors. (5) Based on the results obtained from this study, suggestions can be given, namely to determine soil fertility more accurately, it is better to add an NPK sensor and this telecontrolling research can be developed for strawberry fruit quality, not limited to nurseries.

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