DESIGN AND IMPLEMENTATION OF AN AUTOMATION SYSTEM FOR A NUTRITION PUMP IN HYDROPONICS USING ARDUINO UNO

Composed as one of the requirements for completing Undergraduate Program at the Department of Electrical Engineering Faculty of Engineering

By:
LUTFI ARDHIANSYAH
D400 164 008

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by:

LUTFI ARDHIANSYAH
D400164008

This publication paper has been checked and approved by:

Supervisor

Dedi Ary Prasetya S.T., M. Eng.
NIK. 982

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D400164008

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LUTFI ARDHIANSYAH

D400164008

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Abstrak

Pada era teknologi seperti sekarang, pemanfaatan teknologi kian berkembang pesat. Hal ini juga dapat diterapkan pada sistem pertanian salah satunya pada sistem hidroponik. Pada penelitian kali ini, peneliti mengembangkan sebuah alat dengan menggunakan metode eksperimental dan pengujian data berupa pembuatan sebuah sistem otomasi pompa larutan nutrisi pada hidroponik menggunakan mikrokontroller *Arduino Uno* yang dapat diakses melalui internet. Dengan memanfaatkan beberapa sensor seperti sensor TDS, sensor waterfloat, sensor DHT21, dan sensor suhu DS18B20 yang diolah untuk keperluan menampilkan data seperti keadaan suhu, temperatur, batas jumlah air dan jumlah nilai PPM (Part Per Million) pada instalasi hidroponik. Pada sistem otomasi juga terdapat dosing pump 12 volt, yang digunakan untuk mengalirkan larutan nutrisi ke dalam sistem hidoponik secara otomatis. Pada penelitian ini penerapan sensor TDS yang berfungsi sebagai pemicu pergerakan pompa nutrisi melalui pembacaan sensor yang terdapat pada bak penampung air. Untuk mengetahui parameter data langsung, maka diperlukan sebuah sistem penyimpan data otomatis atau dikenal dengan istilah data logger. Pada sistem data logger digunakan modul RTC DS3231 sebagai penyimpan waktu. Sistem otomasi memanfaatkan *Internet of Thing (IoT)* yang dapat diakses melalui *smartphone* menggunakan aplikasi *Blynk* dengan menggunakan NodeMCU ESP 8266. Pendistribusian nutrisi dilakukan secara semi otomatis. Pada pengujian data pada pompa terdapat delay dengan rata-rata 7.43 detik saat pengiriman data.

Kata Kunci: Arduino Uno, Hidroponik, Sensor Level Air, Sensor Kelembapan, Sensor Suhu, Sensor TDS

Abstract

In this era of technology, the use of technology is growing rapidly. This can also be applied to agricultural systems, one of which is the hydroponic system. In this study, researchers developed a tool using experimental methods and data testing in the form of making a design and implementation of an automation system for a nutrition pump in hydroponics using Arduino Uno as microcontroller which can be accessed via internet. By utilizing several sensors such as TDS sensors, waterfloat sensors, DHT21 sensors, and DS18B20 temperature sensors which are processed for the purpose of displaying data such as temperature, temperature, water limit and total PPM (Part Per Million) values in hydroponic installations. In the automation system there is also a 12 volt dosing pump, which is used to drain the nutrient solution into the hydroponic system automatically. The focus of this research is on the application of the TDS sensor which functions as a trigger for the movement of the nutrient pump through the sensor readings contained in the water reservoir. To find out the direct data parameters, an automatic data storage system is needed or known as a data logger. In the data logger system, the RTC DS3231 module is used as a time saver. The automation system utilizes the Internet of Thing (IoT) which can be accessed via a smartphone using the Blynk application using the NodeMCU ESP 8266. The distribution of nutrients is carried out semi-automatically. In testing the data on the pump, there is an average delay of 7.43 seconds when sending data.

Keywords: Arduino Uno, Hydroponics, Humidity Sensor, Temperature Sensor, TDS Sensor,

Water Level Sensor

1. INTRODUCTION

Nowadays, the population in Indonesia is increasing. According to the Central Statistics Agency (BPS) the population in 2020 reached 269,603 million people. With the increase in population, this also affects the reduced availability of space and agricultural land. Conventional farmers who do not have land to grow crops are bothered by this. Hydroponics is an alternative to farming that can be developed on limited space. The hydroponic system itself allows people to grow crops without using soil media and can be done in a limited space, such as on the terrace of the house. Hydroponics is a cultivation of crops without using soil media (Roidah, 2014) which emphasizes efficiency in terms of both the use of nutritions, water use and limited land use so as to increase the yield of high-quality crop production (Rini & Nani, 2005). This is due to the hydroponic system, the oxygen content obtained by plants in the nutrition is more and nothing is wasted because the nutrition is directly absorbed by the roots so that the nutritional needs of plants are fulfilled and can grow optimally.

There are various kinds of hydroponic planting systems, one of those is the Deep Flow Technique (DFT) system. The DFT system is a hydroponic system where plant roots are placed in a layer of water with a depth of between 4-6 cm. The plant nutrition in the tank is pumped by a water pump to the planting tub pipe through pipe irrigation. Then the plant nutrition in the planting tub pipe is flowed back into the tank. The advantage of the DFT system itself is that it does not require electricity for 24 hours, so electricity consumption is more efficient. Even so, the plants will not wither even if the power goes out, because in this system the depth of the nutrition reaches a depth of 6 cm, so when there is no flow of nutritions, there is still a nutrition available in the planting tub pipe. The DFT system itself is an easy planting system and does not require large costs. The thing that needsto be considered in hydroponic planting is the provision of regular and monitored nutrition so that plant productivity can grow efficiently.

To support productivity and reduce the decline in plant quality, we can take advantage of technology which is now developing very rapidly so that we can monitor the condition of plants anywhere and anytime. Technology can help humans to process and do a job that is done by humans more easily, accuratelyand quickly, both in terms of time, cost, and space. Therefore, the development of this technology can also be used in hydroponic cultivation systems so that the quality of production remains optimal.

In this study, researchers designed an Android-based hydroponic automation system that is connected via internet. By utilizing several sensors such as TDS sensors, waterfloat sensors, DHT21 sensors, and DS18B20 temperature sensors which are processed for the purpose of displaying data such as temperature, humidity, water limit and total PPM (Part Per Million) values in hydroponic installations. In the data logger system, the RTC DS3231 module is used as a data logger. The automation system utilizes the Internet of Thing (IoT) which can be accessed via a smartphone using the Blynk application using the NodeMCU ESP 8266 with semi-automatic distribution.

This research uses the TDS sensor which functions as a trigger for the movement in nutrient pump through the sensor readings contained in the water reservoir. TDS (Total Dissolve Solid) or known as dissolved solids is a term for any mineral, salt, metal, cation or anion dissolved in water. While PPM (Parts Per Million) is the ratio of the weight of each ion in water.

The TDS sensor is a tool that can measure the amount of solids dissolved in the water in PPM units (mg/L) which is displayed in the form of digital numbers displayed on the LCD screen. The TDS sensor used in this research is the TDS DF robot sensor. This TDS sensor supports 3.3 ~ 5.5V wide voltage input, and 0 ~ 2.3V analog voltage output, which makes it compatible with a 5V or 3.3V control system or board. The excitation source is an AC signal, which can effectively prevent the probe from polarization and prolong the life of the probe, meanwhile, increase the stability of the output signal. The TDS probe is waterproof, it can be immersed in water for a long time measurement. TDS Measurement Range is 0 ~ 1000 PPM with an accuracy value is ± 10% F.S. (25°)

This TDS sensor triggers the movement of the pump that is used to drain nutrients in the water reservoir by how it works, the TDS sensor that has read the value contained in the water reservoir and has been given the minimum and maximum input values from the Blynk application will integrate the nutrition that are needed will be pumped so that the value of the solution contained in the water reservoir will be fulfilled.

2. METHOD

In this research, several methods were carried out, including the preparation of tools and equipments, then the tool design phase, if the design phase was successfullycarried out then continued at the testing stage. Data acquisition instrumentation design starts from programming as shown flowchart in figure 1.

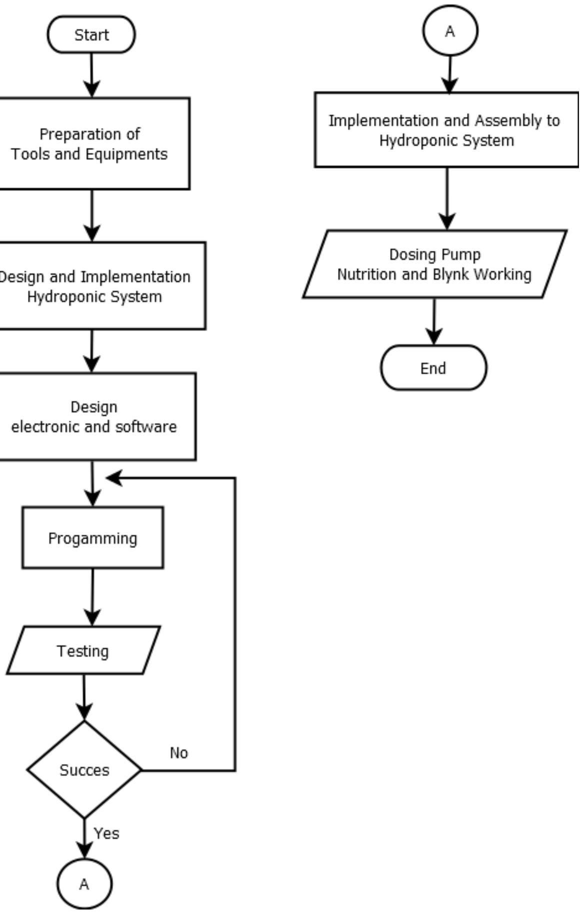

Figure 1. Flowchart

2.1 Diagram Block

The diagram block of the design and implementation of an automation system for a nutrition pump in hydroponics using Arduino Uno is shown as follows:

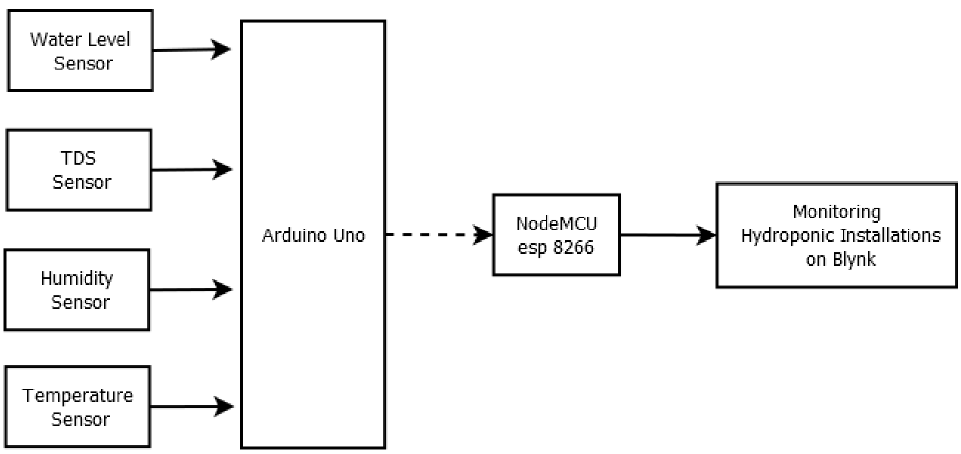

Figure 2. Monitoring Diagram Block

Figure 3. Automation Pump Diagram Block

There are 2 operating systems that can be performed on the device, namely the monitoring system and the nutrition automation system as shown in figure 2 and figure 3. In the input monitoring system, the sensor that is read through the Arduino Uno has been connected via the NodeMCU esp 8266, then sends a signal to the smartphone through the Blynk application so that the output value of each sensor can be seen in the Blynk application.

For the automation pump system, the smartphone used as an input values in the Blynk application so that the NodeMCU esp 8266 will send a command to Arduino Uno to read the TDS sensor and provide input values that have been sent via smartphone so that the dosing pump can provide nutritional values according to the commands that have been given.

A detailed explanation of the block diagram is presented as follows:

a. The water level sensor is used to determine the water limit from the reservoir so that the circulating water does not exceed a predetermined limit. The working principle of this tool is to connect the level sensor wire submerged in water with the other wire that has been connected to a +5V voltage.
b. The temperature sensor is used to measure the temperature of the water in the water reservoir. A good water temperature for plant growth is 25-27°C. The type of temperature sensor used is DS18B20. This sensor is capable of reading temperatures with an accuracy of 9-12bit with a range of -55°C to 125°C with an accuracy of ± 0.5°C.
c. Humidity sensor is used to determine the value of humidity around hydroponic plants. The type of sensor used is DHT21 with a temperature measurement of 4% and humidity of 18%.
d. The TDS sensor is used to measure the mineral nutrition content contained in the reservoir in PPM (Parts Per Million) units. The mineral content used in each type of hydroponic plant varies, depending on the type of plant and the nutritions used. The TDS sensor used in this tool is the TDS sensor DF robot with an accuracy value of ± 10% F.S. (25°C) and with a nutritional rating range of 0 – 1000ppm.
e. Arduino Uno functions as a controller for all the overall systems that will be made.
f. Water pump is used to pump nutrition water which is then flowed to the water reservoir. The water pump is driven using a relay that has been connected to the Arduino. The type of water pump used is a 12 volt dosing pump with an output of 1 ml/s.

g. The RTC (Real Time Clock) module is used for real-time notification of the operating system time. The RTC module used is DS3231.

h. NodeMCU esp 8266 is used as an additional device for the Arduino microcontroller so that it can directly connect to wifi and make a TDP/IP connection.

i. For the operating system and monitoring, the researcher uses blynk as a control module for the controller system via the internet on smartphone.

2.2 Design and Implementation of DFT (Deep Flow Technique) Hydroponic system

In the design of the DFT hydroponic system, it consists of a series of PVC pipes used for hydroponic media, buffer pipes, water reservoirs, nutrition tanks and also a control panel box as a control place for the components used.

a. A series of PVC pipes is used as a planting medium (Netpot) and nutrition circulation.

b. The buffer pipe is used as a buffer so that the planting media does not experience shocks.

c. The water reservoir is used as a container for raw water then flowed into the planting medium.

d. Nutrition tanks is used as a container for hydroponic nutrition . The nutrition used is AB mix.

e. The control box is used as a controller for all operating system components.

In this study, researchers used kale seeds with rockwool planting media with 2x2cm dice size. in one rockwool there are 5 seeds of kale. Seedling is done 7-10 days by watering using raw water. The kale plants that have passed the seeding phase are then transferred to the DFT (Deep Flow Technique) hydroponic system. This pipe will flow a different nutrition every week and there will be circulation every day to absorb the oxygen needs of the kale plant.

AB mix nutrition is needed byplants so that plants can grow optimally. There are 2 nutrition stocks for the AB mix nutrition , namely nutritions A and B with different micro and macro elements. A different place is needed for each nutrition with the provision of 1 liter of raw water and stored in a shady place.

2.3 Design Electrical and Schematic

Schematic circuit design using eagle software. This schematic is used to determine the layout and design of electronic systems. The figure 3 is the electronic circuit of a hydroponic automation system.

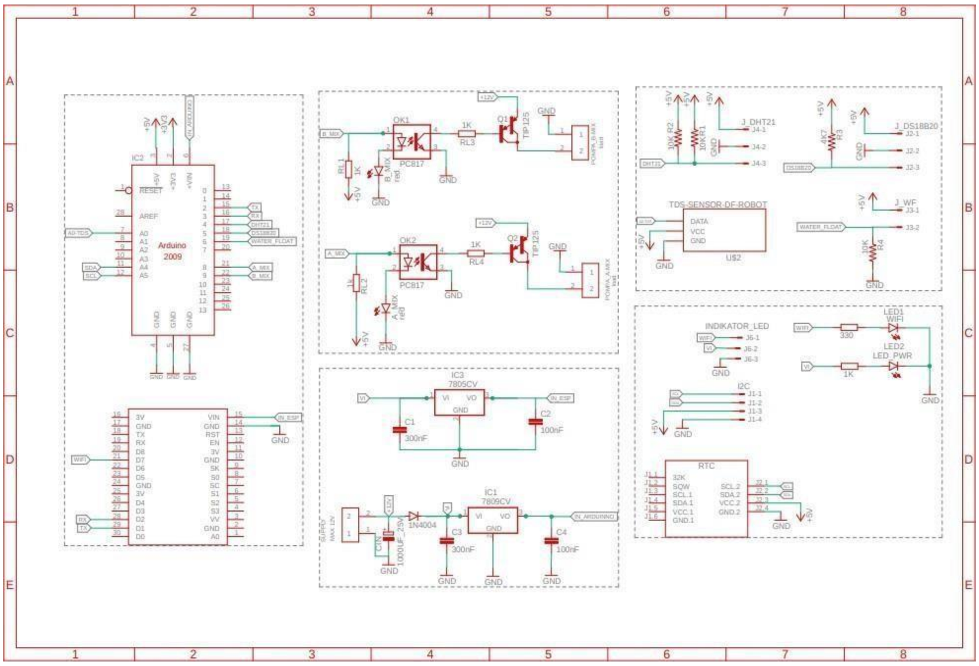

Figure 4. Design Schematic

In this study, an automation system was created for mixing AB mix nutrition and monitoring plants through blynk. The control system used in controlling the AB mix nutrition control system is Arduino Uno which is integrated with NodeMCU 8256 so that it can be connected to the Android operating system through blynk. For programming, the researcher uses the Arduino IDE application.

3. RESULT AND DISCUSSION

3.1. Hardware

In the results and discussion, several tests and data analysis will be carried out on all input and output sections. As seen in the figure 5 is the overall shape of the hardware that has been designed.

Figure 5. Hardware

On the mainboard there is an Arduino Uno which is used as a microcontroller which has been connected to several sensors such as temperature sensors, humidity sensors, TDS sensors, and also water level sensors. RTC (Real Time Clock) DS3231 is used as a data logger that is connected to the NodeMCU esp8266, and has integrated Arduino Uno. Before connecting to Arduino, the dosing pump is connected to Octocopler PC817 DIP and also Transistor TIP 125 so that the pump can work as a relay. For the voltage source, a 12 volt power supply is used which has been rectified with a 1N40004 diode. Then at the output there are probes for water level sensors, TDS sensors, and also temperature sensors which are then placed in a water reservoir. Then there is a humidity sensor probe that is placed on the wall of the hydroponic installation.

3.2. Hydroponic System

In the results and discussion, several tests and data analysis will be carried out on all input and output sections. This DFT (Deep Flow Technique) hydroponic system is formed by using PVC pipe as the frame with a size of 1 inch with a height of 95 cm, length 75 cm and width 55 cm. Then for plant planting media using 2.5 inch PVC pipes totaling 4 rods with a length of each pipe of 1 m as can be seen in figure 4. Each part of the pipe is given a hole for a netpot with a diameter of 4 inches in each hole, with a distance between holes of 18 cm. For the raw water reservoir, a tank with a water capacity of 20 liters is used.

Figure 6. DFT Hydroponic System

Figure 7. Automation System

The nutrition is placed in a separate place with each place containing of micro A and macro B, each place containing a 1 liter nutrition as shown in Figure 6. In order for the dosing pump to work more optimally, the circuit box is placed in a higher place than the dosing pump nutrition.

Figure 8. Nutrition Tank

Figure 9. Water Reservoir

This kale plant is given a different nutrition dose every week in order to produce quality plants. Kale plants can be harvested in the 3rd week or about 21-25 days after the seeding period. Can be seen in table 1 is the daily nutritional requirement.

Table 1. The dose of kale plant nutritions

Period	**Dose of nutrition in plant (PPM)**
Week 1	300 – 500
Week 2	500 – 750
Week 3 – Harvest	750 – 1100

3.3. Water Level Sensor Test

Water level sensor is used to detect the water level in the water reservoir. The water reservoir has a height of 40 cm with a diameter of 30 cm and is filled with 20 liters of raw water. The sensor is placed in a water reservoir as deep as 15 cm from the surface of the water pump. While the water level surface is 35 cm. When the sensor detects the water surface is less than the sensor, a notification will appear on blynk shown in figure 9. The following is a table of the results of testing the water level sensor in table 2.

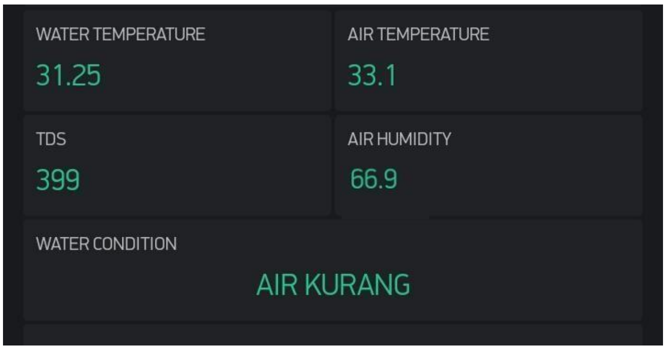

Figure 10. Water Condition Notification on Blynk

Table 2. Water level sensor test.

Day	Water level sensor position in water reservoir (cm)	Water level surface (cm)	Result
1	15	35	Notification off
2	15	29	Notification off
3	15	20	Notification off
4	15	11	Notification on

Based on the test results, it can be seen in table 2 that the daily water level decreases between 6 cm to 8 cm. On the fourth day it can be seen that the water surface is less than the water level sensor height limit, which is at a height of 11 cm, the water level sensor will send a notification to blynk that the water level has crossed the sensor limit.

3.4. Temperature Sensor Test

The temperature sensor is used to measure the temperature of the water in the water reservoir. The type of temperature sensor used in the system is the DS18B20 temperature sensor which is waterproof. This temperature sensor can measure from -10 °C to +85 °C with an accuracy of ±0.5 °C. Temperature sensor testing is done by comparing the results of the DS18B20 sensor measurements with the results of measurements made with an analog thermometer. The results of the temperature sensor test can be seen in table 3.

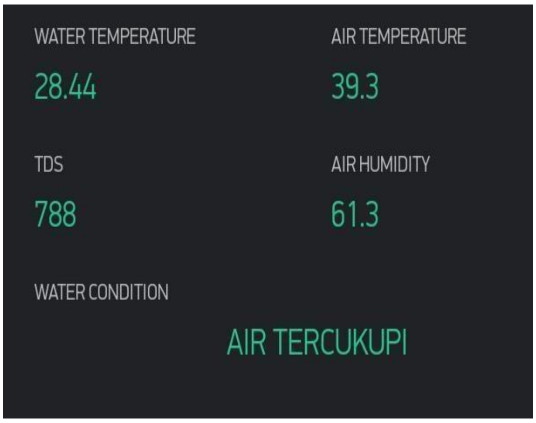

Figure 11. Water Temperature on Blynk

Figure 12. Water Thermometer test

Table 3. Temperature sensor test.

No	Temperature sensor (°C)	Thermometer (°C)	Value difference (%)
1	29.7	29	1.03
2	28.8	28	2.85
3	28.4	29	2.85
4	27.5	27	1.85
5	28.2	28	0.71

From the results of the temperature sensor test, it can be seen that the measurement value of the DS18B20 temperature sensor is not much different from the measurement results of an analog thermometer, with an average difference of 1.85% for measurements with a temperature sensor.

3.5. Humidity Sensor Test

In a hydroponic system, a humidity sensor is used to determine the humidity in the hydroponic environment. The type of humidity sensor used is DHT21 with a measurement of temperature values of -40 - ±80 °C and humidity of 0-100 RH ± 3 RH. The following are the results of testing the temperature sensor to determine the ambient temperature around the hydroponic system.

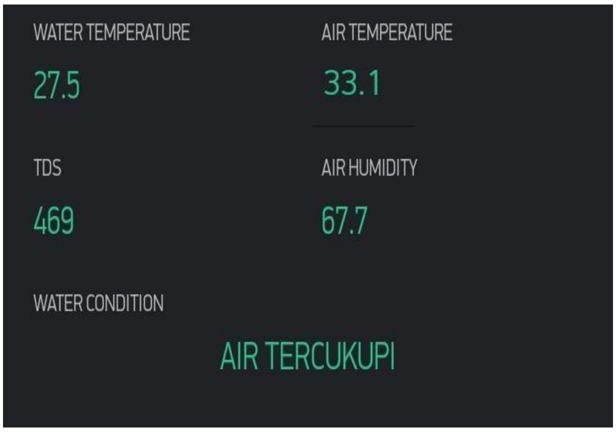

Figure 13. Air Temperature on Blynk

Figure 14. Air Thermometer

Test Table 4. Humidity sensor test data

No	Time	Air Temperature (°C)	Air humidity (%)
1	07.00	28.4	55
2	09.00	29.7	60
3	11.00	32.6	61
4	13.00	33.2	67
5	15.00	32.3	62
6	17.00	28.4	59

The results of the DHT21 sensor test can be seen in table 4 which shows the results of observing sensor readings. The DHT21 sensor can read temperature and humidity and can be displayed on blynk. Changes in temperature values at different times indicate that the sensor is working properly and can detect changes in temperature.

3.5 TDS Sensor Test

TDS sensor (Total Dissolve Solid) aims to determine the total value of the dissolved mineral in the water reservoir. The TDS sensor used in this tool is the TDS sensor DF robot with an accuracy value of ± 10% F.S. (25 °C) and with a nutritional rating range of 0 – 1000ppm. TDS sensor testing is done with a TDS meter as a comparison.

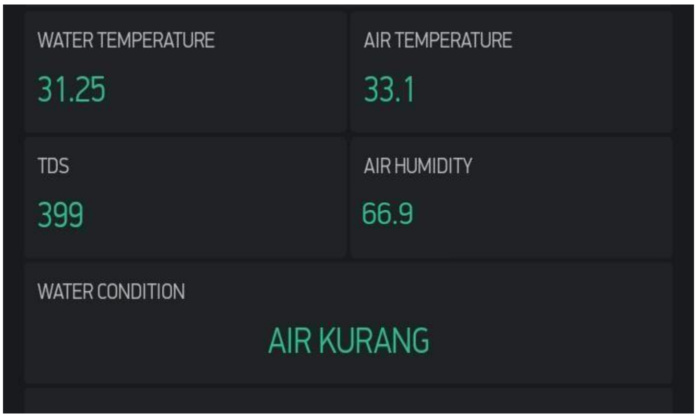

Figure 15. TDS Sensor on Blynk

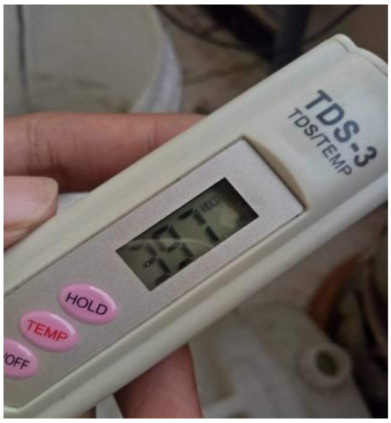

Figure 16. TDS meter

Table 5. TDS sensor test

No	TDS sensor (PPM)	TDS meter (PPM)	Value difference (%)
1	399	397	1.25
2	629	634	0.79
3	842	849	0.83

From table 5, the results of the TDS sensor test can be obtained that the TDS sensor measurement value is not much different from the TDS meter measurement results, with an average difference of 0.83% for measurements with the TDSsensor.

3.6 Nutrition Pump Output Test Data on Blynk

The output of this automation system is monitoring blynk to sontrol the nutrition value so that the nutrition pump can drain nutritions to the reservoir. In blynk, there are also output values for the DHT21 humidity sensor, DS18B20 temperature sensor, and also the water level sensor as shown in figure 5.

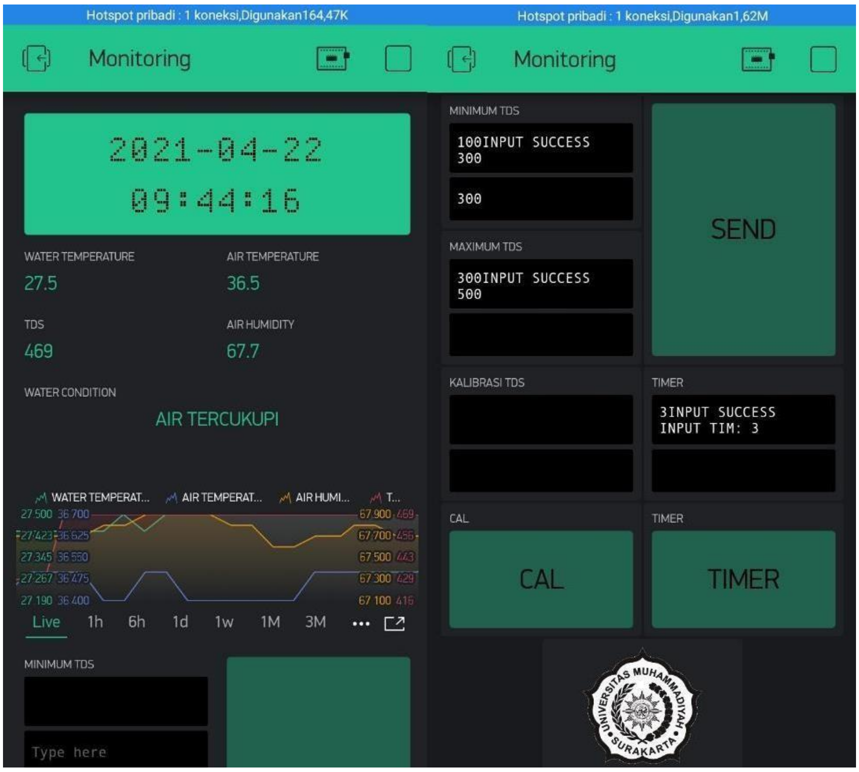

Figure 17. Blynk Interface System

As known in table 1 that kale plants require different amounts of nutritions each week. Nutrition is given automatically according to the number of nutrition doses used each week using blynk by inputting the value on the Min and Max input value buttons on the application so that the nutrition pump can move. In blynk there is also a timer input value button that functions to input the variable for how long the pump will pump the nutrition into the water reservoir. The dosing pump can drain 1 ml/s of nutrition water into the water reservoir. In the application there is also a calibration for the TDS sensor so that the variable value is not much different from the value on the TDS meter. The following are the results of testing the data in table 6.

Table 6. Nutrition pump output test data on blynk

No	Minimum nutrition (PPM)	Maximum nutrition (PPM)	Nutrition value in water reservoir (PPM)	Timer (s)	Nutrition dosing pump On (ml/s)	Delay (s)	Notification Water level
1	300	500	324	1	1/1	1.12	Off
2	300	500	397	3	1/3	3.34	Off
3	300	500	469	5	1/5	5.09	Off
4	500	750	540	1	1/1	2.25	Off
5	500	750	629	3	1/3	4.76	Off
6	500	750	826	5	1/5	6.08	On

7	750	1000	783	1	1/1	1.24	Off
8	750	1000	842	3	1/3	3.41	Off
9	750	1000	1180	5	1/5	6.25	On

Figure 18. Monitoring Data on Blynk

Figure 19. Notification on Blynk

3.7 Discussion

In this research, the tool works semi-automatically, this is to reduce the risk of errors that occur when giving nutrition. To activate the nutrient pump so that it can turn on automatically, the first thing to do is to provide a variable input value in the Min and Max input coloum. The minimum and maximum value for the nutrient pump is carried out on blynk application by adjusting the number of doses each week. Then assign a variable to the timer column. Blynk also provides a calibration column for calibrating the TDS sensor so that the TDS sensor value and the TDS meter are not too farapart.

For testing the output of the nutrient pump, it is carried out with different timer.

Comparison of nutritional values was carried out by giving different timer inputs starting from 1,3, and 5 seconds with 1 ml of each nutrient solution pumped into the reservoir. It can be seen in table 6 that there is a difference in the amount of nutrition that is given to the reservoir every second. From the research that was tested, the average number of delays on the timer for pumping nutrients every 1 second was 1.54 seconds. Every 3 seconds the average number of delays is 3.83 seconds. And the average number of delays every 5 seconds is 7.43 seconds. 5 At the 5 second timer input, the nutrient dose tends to exceed the maximum specified limit. This is because the internet connection used in blynk application can affect the flow of the given nutrient pump.

As can be seen in Figure 9 the graphs contained in blynk are monitored directly tto the RTC sensor. The monitoring shows the results of the temperature sensor, humidity sensor, and TDS sensor. The displayed graph can be viewed as long as the device is connected to the internet.

When the nutrients have exceeded the limit of the maximum input, the TDS sensor will send a signal to blynk that the nutrients have exceeded the limit shown by the monitor on blynk application as shown in figure 10. This can be a problem if the pump pumps too much nutrients so that the nutrient solution will be wasted and the plant will cause yellowing leaves. Therefore, the Min and Max column inputs in blynk application are given a wide range so that if there is a problem with the internet connection, nutrients are not pumped too much into the reservoir. The TDS sensor in this experiment serves as a unit value reader in the water reservoir to drive the nutrient pump. If the TDS sensor value reads a unit value that is less than the minimum input result on Blynk, the TDS sensor will send a command to the nutrition pump to fill the water in the water reservoir in accordance with the existing command.

In the automation system, the tool works as expected and is quite helpful in monitoring the surrounding environment and filling the pump automatically, although there are still error because blynk depends on the internet connection. When compared to without the use of automation system tools, the comparison from plant is not different, starting from the seeding process to harvesting can be done manually because plant growth needs are influenced by many other factors, such as plant type, type of seed, nutrition, planting site, and pest.

4. CLOSING

4.1 Conclusion

Based on the results of research and testing that have been carried out, the following conclusions can be drawn:

a. The monitoring and automation system for hydroponic plant nutrition pumps uses several sensors, namely temperature sensors, humidity sensors, water level sensors, and TDS sensor using an Arduino Uno microcontroller which can be connected via Android via blynk. For connection in blynk, the NodeMCU ESP8266 is used which is connected via internet, using a smartphone wifi hotspot that can be monitored directly using the RTC module.

b. From the test results, it can be seen that the water level sensor detects when the water is less than the water sensor on the fourth day with the water level above 11cm. for the water temperature sensor has an average difference of 1.85% compared to the thermometer. As for the humidity sensor, it can detect properly according to changes in time that occur. The TDS sensor has an average difference of 0.83% compared to the TDS meter.

c. In testing the output of the nutrition flow pump, it is done by giving different timer inputs startingfrom 1 second, 3 seconds, and 5 seconds with a reference to the predetermined nutrition dose. In the test, it can be seen that the timer with 5 seconds of input tends to exceed the limit of the specified dose, this is due to the delay in reading between the hardware and blynk that utilizes the internet network, namely wifi hotspot from a smartphone, with a delayof 5 seconds of timer input is 7.43 seconds. This can affect the plant if the nutritions exceed the predetermined nutrition levels. However, blynk has been notified on monitoring that if the dose has exceeded the limit a reminder will appear on blynk. The TDS sensor in this experiment serves as a unit value reader in the water reservoir to drive the nutrient pump. If the TDS sensor value reads a unit value that is less than the minimum input result on Blynk, the TDS sensor will send a command to the nutrition pump to fill the water in the water reservoir in accordance with the existing command.

d. In the automation system that has been created, this automation system helps to monitor the conditions around the hydroponic environment with nutrition pump automation that utilizes existing technology. When compared with ordinaryhydroponic planting, there are not so many changes in the planting process. This is because there are several factors that affect plant growth in hydroponic systems such as weather factors, pest, planting sites, types of plant seeds, raw water used and types of AB mix nutritions used.

4.2 Suggestion

The suggestions of researchers in the tests that have been carried out are as follows :

a. To improve communication between applications and hardware, use a network that has agood internet network so that there will not be a lot of delay.
b. Further researchers can develop systems by utilizing several types of sensors, controllers, and types of application software that are more suitable for hydroponic systems.
c. In this study using a dosing pump that pumps nutritions as much as 1ml/s. for further development, it can be done with a dosing pump that releases a smaller amount of water so that there is no waste of nutritions.

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