NUTRIENT FILM HYDROPONIC SYSTEM TECHNIQUES FOR PID-BASED STRAWBERRY GROWTH

[1]MUHAMMAD AFIF ABDULLAH, [2]HARIANTO, [3]MUSAYYANA, [4]PAULADIE SUSANTO

[1,2,3,4] Universitas Dinamika, Department of Computer Engineering, Universitas Dinamika

Jln. Kedung Baruk No.98 Rungkut Surabaya

e-mail: [1]afifabdillah.aa@gmail.com, [2]hari@dinamika.ac.id, [3]musayyanah@dinamika.ac.id, [4]pauladie@dinamika.ac.id

ABSTRACT

Surabaya is an urban area with limited land for farming, because there are many buildings. Farming requires a large area and fertile soil. With the development of agricultural technology today, there is a new method of planting called Hydroponics. There are several types of hydroponic systems, namely Aeroponics (fog system) and Nutrient Film Technique (NFT). In this article, the writer uses NFT technique. NFT is a system that has a farming concept by channeling nutrients to plant roots in a film or thin so that plants get food nutrients, namely water and oxygen. The advantage of using this NFT system is that it makes it easier to control plant nutrients and plant growth is faster because plant roots are free to absorb nutrients to the maximum. From the results of the research conducted, the pH setpoint value was 6.0. From the results of the research conducted, set point pH values of 6.4 and 5.8. From the test results, the Ziegler Nichols method of type 1 for a setpoint of 6.4 gets a value of L=3 and T=22.44 and a setpoint value of 5.8 gets a value of L = 3 and T = 23.76. After that, the setpoint 6.4 got the value of Kp = 8.976 Ki = 1.496 Kd = 13,464 and the setpoint of 5.8 got the value of Kp = 9.504 Ki = 1.584 Kd = 14,256. 1. The setpoint value of 6.4 overshoot is 8.37% rise time 20 s, and settling time is 45 s. The setpoint value of 5.8 overshoot is 6.89% rise time 25 s, and settling time is 55 s.

Keywords: *Hydroponics, NFT System, Wemos D1 R2, Strawberry, PID*

1. INTRODUCTION

Surabaya is an urban area whose land is limited for cultivation, because there are many buildings in Surabaya. Farming requires a large area and fertile land. With development current agricultural technology, there are methods that new planting called Hydroponics. It is very suitable for farming in urban area [1].

Hydroponics is a method of using water without using soil. The need for water in hydroponic plants is less than the needs of plants that use soil. Hydroponics requires water efficiently which is suitable for narrow areas. There are several kinds of hydroponic systems, namely Aeroponics (fog system) and Nutrient Film Technique (NFT). In this article, the author uses the NFT technique [2].

NFT is a farming system by channeling nutrients to plant roots thinly so that plants get food nutrients, namely water and oxygen. The advantage of this NFT system makes it easier to control plant nutrients and plant growth is faster because plant roots are free to absorb nutrients optimally. In this NFT hydroponic system use strawberry plants of the type Fragaria sp. Strawberry seedlings need good nutrition through water. The pH of the water determines the nutrients for strawberry growth, around 5.8 to 6.5. If the pH is less or too much, it causes the strawberry taste to be less sweet [3]. In [4] conducted research related to the NFT hydroponic system with Fuzzy settings for nutritional pH parameters. This article uses the PID (Proportional, Integral, Derivative) method automatically because this method is considered a stable controller. In PID the error value comes from system feedback to determine the next control value [5]. In this study, a hydroponic system uses PID to control the mixing of nutrients from hydroponics and the pH sensor.

2. METHODS

The overall system of this research is shown in Figure 1 and the schematic circuit in Figure 2. The block diagram in Figure 1 is divided into several parts, namely the input, process, and output sections. The input consists of a pH sensor and an RTC module. The process is on the control of the microcontroller with the PID method. While the output consists of servo, LCD and relay.

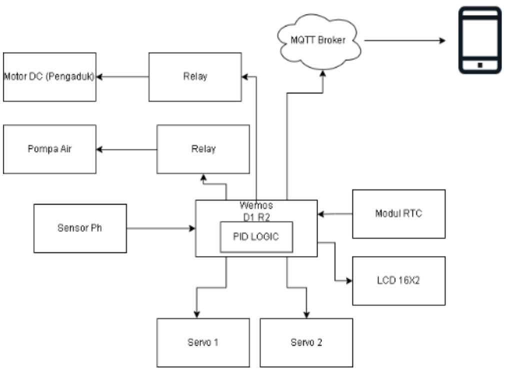


Figure 1. System Block Diagram

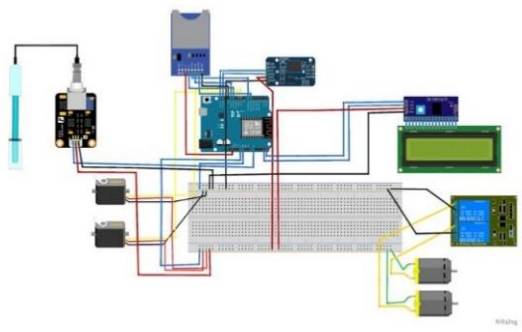


Figure 2. Schematic Circuit

2.1 Sensor pH

The level of acidity of a solution needs to be measured using a pH sensor. The pH sensor consists of electrodes that function to determine the number of H+ ions from a liquid. The pH sensor is a tool that functions to measure an acidity (pH) of a solution [6]-[7]. pH is defined as dissolved hydrogen ions (H+) with a value of 0 to 14. If pH < 7 means the solution is acidic, pH > 7 means the solution is alkaline, pH = 7 means the solution is neutral. The specifications of the pH sensor are presented in Table 1.

Table 1. pH sensor spesification

Voltage	5 +~ 0.2V (AC DC)
Current	5 – 10 mA
pH	PH 0 – 14
Temperature	0 – 80
Response time	5S
Stabilitation time	60S
Power	0.5W
Temperature	-10 ~ 50 (suhu nominal 20)
Humidity	95% RH (kelembapan nominal 65% RH)
Size of Modul	42mm 32mm 20mm
Output	analog

2.2 Sistem PID

The PID control system in this article, is to control the pH water parameters or nutrient solution in NFT hydroponics. The pH sensor as input with a pH range of 5.8 – 6.5 which will be controlled by the PID system requires the values of Kp, Ki, and Kd. After the setting process, the pH sensor will receive a pH value back if the pH is less than 5.8 then servo 1 will add a pH up solution (Base) so that the pH is stable, if the pH is more than 6.5 then servo 2 will add a pH down solution (acid) to stabilize the pH. Flowchart on the PID system in Figure 4.

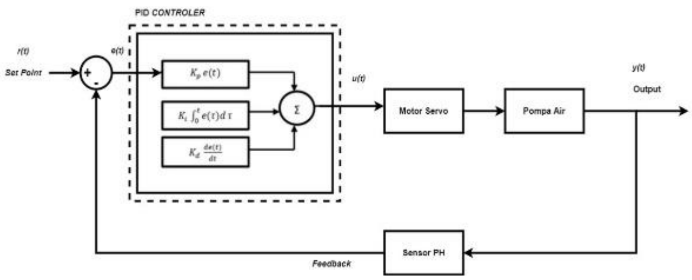


Figure 3. PID Logic System

will stabilize again, but if the pH condition is suitable from 5.5 – 6.5 then the stirrer will be off. After that the water pump is On and drains the water or nutrient solution to the strawberry plant hydroponics.

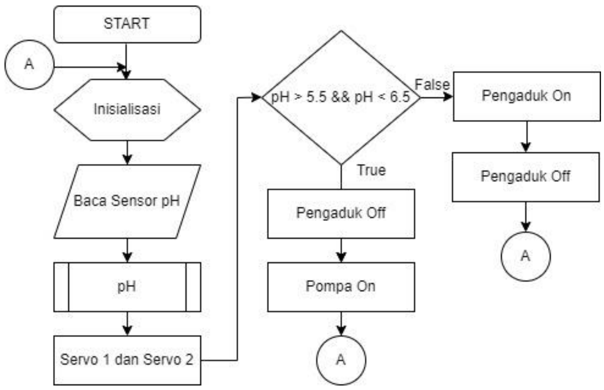
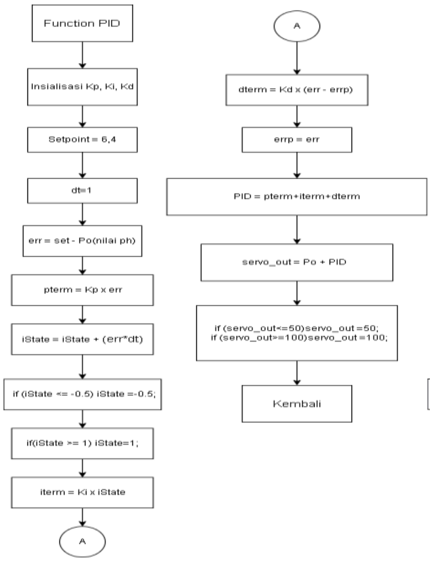
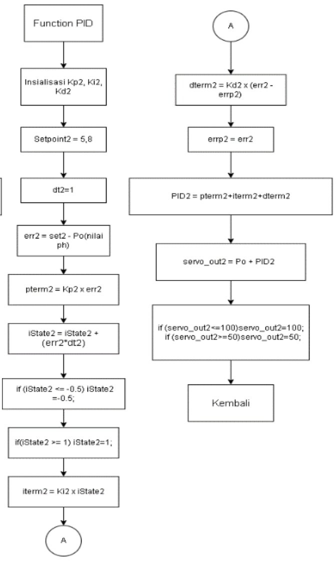


Figure 4. Control System Flowchart

Figure 5 is a flowchart of the PID setpoint 6.4 system, the first time is initialization, after that the pH sensor will read the pH value of the nutrient solution from the available tub which will then be sent to Wemos D1. After the sensor reads the pH value, the value will be stored in the available variables. After that the variables will be processed using the PID system. If the ph condition value is more than 6.5 then the PID setpoint value of 6.4 will be executed. For the servoout value less than 50 then servoout = 50 and if the servoout value is smaller than 100 then the servoout value = 100. So if the pH of the water matches the specified value, the water pump will turn on.

From Figure 6 is a flowchart of the PID system, the first time is initialization, after that the pH sensor will read the pH value of the nutrient solution from the available tub which will then be sent to Wemos D1. After the sensor reads the pH value, the value will be stored in the available variables. After that the variables will be processed using the PID system. If the ph condition is less than 5.8 then the PID setpoint value of 5.8 will be executed. For the setpoint value of 5.8 servoout2 can be known. If the value of servoout2 is less than 100 then servoout2 = 100 and if the value of servoout2 is greater than 50 then the value of servoout2 = 50. If the pH of the water matches the specified value, the water pump will turn on.





Figurer 5. 6.4 Setpoint PID Function Flowchart *Figure 6. 5.8 Setpoint PID Function Flowchart*

3. RESULT AND DISCUSSION

The tests in this article include testing a pH sensor on a solution that has been mixed with AB Mix nutrients, testing for strawberry growth starting from strawberry seeds, and testing the entire system including PID control.

3.1 Sensor pH

The initial condition of the water before mixing the nutrients measured pH 7.2. After being given AB nutrients, the water is mixed with nutrients so that it becomes a solution with a pH of 6.8 to 6.0 in Table 2. This test proves that the mixing of AB Mix nutrients is suitable for strawberries because the pH conditions of the solution are in accordance with the hydroponic needs of strawberry NFT.

Table 2. pH nutrition AB mix

No	Time (sec)	pH Sensor
1	0	7,2
2	3	7
3	6	6,8
4	9	6,4
5	11	6,4
6	13	6,2
7	15	6,0
8	17	6,0
9	20	6,0
10	22	6,0

3.2 Strawberry Plant Observation

In observation strawberry plants, the success rate is that it can grow to the maximum. Observation this plant using 3 pots, this plant observation was carried out for 4 days but every day was tested for 6 hours. Table 3 is a test of strawberry plants. In Table 3, the strawberry plants tested successfully grew from day to day during 4 days of planting. Pot 1 was 10.8 cm on the first day and grew to 11.4 cm on day 4. Pot 2 was 6.4 cm on the first day and grew to 7.4 cm on day 4. Pot 3 is 11.6 cm on the first day and grows to 12.2 cm on day 4. Plants can grow because of the pH that suits the needs of the plant and also the nutritional solution provided.

Table 3. Strawberry Plant Test Results

Date	POT I	POT II	POT III
14 – 12 – 2021	10,8 cm	6,4 cm	11,6 cm
15 – 12 – 2021	11 cm	6,9 cm	11,8 cm
17 – 12 – 2021	11,4 cm	7,4 cm	12,2 cm

3.3 Overall System Test

In Figure 7 is a 6.4 pH set point test, this component runs as desired. Testing the pH sensor using the Zichler Nicholas Open Loop PID got an L (dead time) of 3 and a T (delay time) of 22.44. After getting the values of L and T, then look for the values of Kp, Ti and Td the formula is as follows:

Kp = 1,2 x ($\frac{T}{L}$)→Kp = 1,2 x ($\frac{22,44}{3}$)
Kp = 1,2 x (7,48) = 8,976
Ti = 2L→Ti = 2(3) = 3
Td = 0,5L→ Td = 0,5(3) = 1,5

Next, for Kp = 8,976 Ti = 6 Td = 1,5. To find the value of Ki and Kd the formula is as follows:
Ki = Kp / Ti → Ki = 8,976 / 6 = 1,496
Kd = Kp x Td→ Kd = 8,976 x 1,5 = 13,464

In Figure 8 is a 5.8 pH setpoint test, this component runs as desired. Testing the pH sensor using the Zichler Nicholas Open Loop PID got an L (dead time) of 3 and a T (delay time) of 23.76. After getting the values of L and T, the next step is to look for the values of Kp, Ti and Td, the formula is as follows:

Kp = 1.2 x (T/L) → Kp = 1.2 x (23,76/3) → Kp = 1.2 x (7,92) = 9,504

Ti = 2L → Ti = 2(3) = 6
Td = 0.5L →Td = 0.5(3) = 1,5

After getting the value of Kp = 9.504 Ti = 6 Td = 1.5. To find the value of Ki and Kd the formula is as follows:
Ki = Kp / Ti → Ki = 9,504 / 6 = 1,584
Kd = Kp x Td → Kd = 9,504 x 1,5 = 14,256

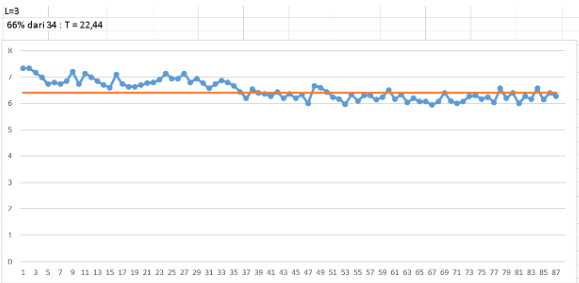


Figure 7. pH setpoint 6,4

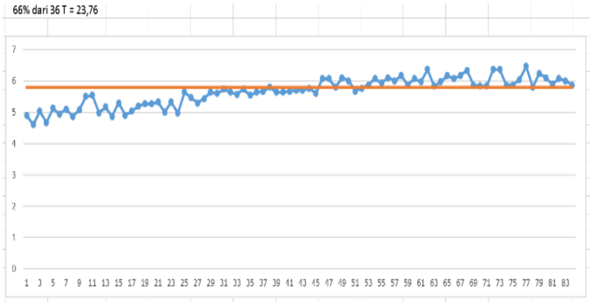


Figure 8. pH setpoint 5,8

From the values in Figure 9 and Figure 10, it can be seen the resulting response to achieve a stable pH value using Kp, Ki, Kd which has been obtained by the Ziegler Nichlos type 1. In this test the setpoint 6.4 was given a value of Kp = 8.976, Ki = 1.496, Kd = 13,464 and setpoint 5.8 given the value of Kp = 9.504 Ki = 1.584 Kd = 14,256. The test was carried out by adjusting the pH setpoint values of 6.4 and 5.8. The way it works is that if the ph value is more than 6.5 then the PID setpoint 6.4 will work and if it's below 5.8 then the PID setpoint 5.8 will work. In Figure 9-10, the graph is blue (pH value), orange (setpoint value is 6.5), and gray (setpoint value is 5.8).

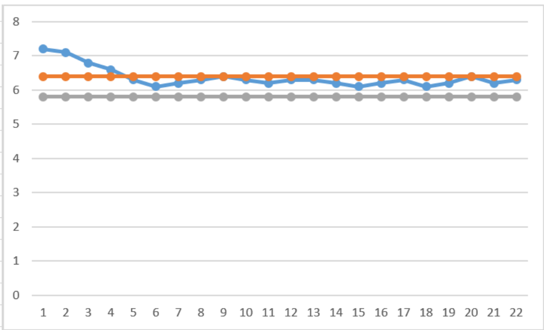


Figure 9. 6.4 setpoint PID result

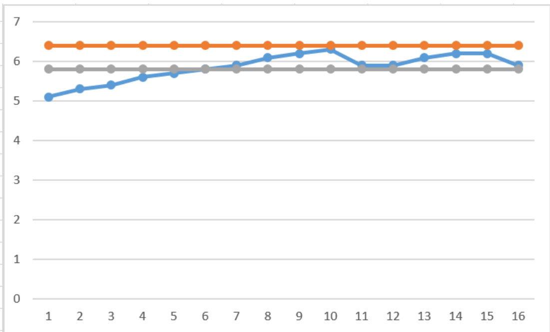


Figure 10. PID setpoint result 5.8

Table 4. PID setpoint result 6.4

No	Time (sec)	Ph	*Down*	Up
1	00:00:05	7.2	50	0
2	00:00:10	7.1	50	0
3	00:00:15	6.8	50	0
4	00:00:20	6.6	50	0
5	00:00:25	6.3	0	0
6	00:00:30	6.1	0	0
7	00:00:35	6.2	0	0
8	00:00:40	6.3	0	0
9	00:00:45	6.2	0	0
10	00:00:50	6.3	0	0
11	00:00:55	6.2	0	0
12	00:01:00	6.3	0	0
13	00:01:05	6.3	0	0
14	00:01:10	6.2	0	0

15	00:01:15	6.1	0	0
16	00:01:20	6.2	0	0
17	00:01:25	6.3	0	0
18	00:01:30	6.1	0	0
19	00:01:35	6.2	0	0
20	00:01:40	6.3	0	0
21	00:01:45	6.2	0	0
22	00:01:50	6.3	0	0

Table 5. PID setpoint result 5.8

No	Waktu (detik)	Ph	*Down*	Up
1	00:00:05	5,1	0	100
2	00:00:10	5,3	0	100
3	00:00:15	5,4	0	100
4	00:00:20	5,6	0	100
5	00:00:25	5,7	0	100
6	00:00:30	5,8	0	0
7	00:00:35	5,9	0	0
8	00:00:40	6,09	0	0
9	00:00:45	6,2	0	0
10	00:00:50	6,3	0	0
11	00:00:55	5,9	0	0
12	00:01:00	5,9	0	0
13	00:01:05	6,09	0	0
14	00:01:10	6,2	0	0
15	00:01:15	6,2	0	0
16	00:01:20	5,9	0	0

4. CONCLUSION

After being calibrated, it was tested using a pH buffer of 4.0 and 6.8. The value of the pH sensor and pH meter measurements resulted in an average error of 0.02% and 0.01%, respectively. The ph sensor will check whether the ph value is more than 6.5 or less than 5.8. If it is more than 6.5 then servo 2 (down) will be active and the stirrer is active and if it is less than 5.8 then servo 1 (up) will be active and the stirrer is active. When the conditions are as desired or according to the setpoint, the pump will turn on servo 1, servo 2 and the stirrer does not turn on.

The application of the PID control system with the Ziegler Nichols method of type 1 for a setpoint of 6.4 gets a value of L= 3 and T=22.44 and a setpoint value of 5.8 gets a value of L = 3 and T = 23.76. After that, the setpoint of 6.4 got the value of Kp = 8.976 Ki = 1.496 Kd = 13,464 and the setpoint of 5.8 got the value of Kp = 9.504 Ki = 1.584 Kd = 14,256. The setpoint value of 6.4 overshoot is 8.37% rise time 20 s, and settling time is 45 s. The setpoint value of 5.8 overshoot is 6.89% rise time 25 s, and settling time is 55 s.

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