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A Development of an Automatic Microcontroller System for Deep Water Culture (DWC)

M.F. Saaid, N.A.M. Yahya, M.Z.H. Noor, M.S.A. Megat Ali
Faculty of Electrical Engineering
Universiti Teknologi MARA
Shah Alam, Malaysia
mfarids@salam.uitm.edu.my

***Abstract*— Hydroponics method of growing plants is using mineral nutrient solution in water, without soil. Terrestrial plants may be grown with their roots in the mineral nutrient solutions only or in an inert medium. One of the hydroponic types was Deep Water Culture (DWC). Deep Water Culture (DWC) is a hydroponic technique that supplies water which contain nutrient direct to the roots of the plant continuously. This technique will ensure the roots of the plant always submerge in water and oxygen. The advantage of DWC system is highly oxygenated uses less fertilizer and low maintenance cost and monitoring time. In this research, pH value is automatically controlled by pH sensor where a sensor reads the value of water with nutrient in the reservoir and maintained to the requirements needed using solution mixer in the valve. Other than that, water in reservoir is continuously maintained through level control which triggers valve to control water flow into or out from the reservoir. The water level monitoring is important to maintain a suitable water level in reservoir. The methodology in this project consists of six stages namely details of study, hardware identification, software identification, hardware and software interfacing, analysis and troubleshooting, data and result collection. From the experimental test, there is a need of 5.64 ml changes in both acidity and alkalinity range in every 0.312 pH and 0.244 pH.**

***Index Terms*—Hydroponic, microcontroller, pH value, Deep Water Culture, temperature**

I. INTRODUCTION

Hydroponics is one of the subset of hydro-culture. Hydroponics method of growing plants is using mineral nutrient solution in water, without soil. Terrestrial plants may be grown with their roots in the mineral nutrient solutions only or in an inert medium, such as perlite, gravel mineral wool, expended clay or coconut husk. Hydroponic techniques are divided into six types, Wick, Deep Water Culture (DWC), EBB and Flow (Flood & Drain), Drip (recovery or non-recovery), Nutrient Film Technique (NFT) and Aeroponic [1, 2]. There are hundreds of variations on these basic types of systems, but all hydroponic methods are a variation and combination of these six types.

Deep Water Culture (DWC) is a hydroponic technique that supplies water which contain nutrient direct to the roots of the plant continuously. This technique will ensure the roots of the plant always submerge in water and oxygen. The advantage of DWC system is highly oxygenated uses less fertilizer and low maintenance cost and monitoring time.

The technology should auger well for the green consciousness in Malaysia. Other than that, this system also can achieve higher productivity per growing area which also translates to better land utilization [2]. In an DWC crops, absorption is usually proportional to the concentration of nutrients in the solution near the roots, being much influenced by environmental factors such as salinity, oxygenation, temperature, pH and conductivity of nutrient solution, light intensity, photoperiod and air humidity [3, 4].

The conventional method needs manpower to control needed to plant where everything should have to manually monitor. For the example to monitored pH, it took a time to read pH value which is needed periodically monitor and balanced a required value needs. Other than that addition on pH up and down solution could be waste because there is no specifications estimation enough for the pH solution must be adds to maintain a quality of the nutrients to plants.

In this research, pH value is automatically controlled by pH sensor where a sensor reads the value of water with nutrient in the reservoir and maintained to the requirements needed using solution mixer in the valve. Other than that, water in reservoir is continuously maintained through level control which triggers valve to control water flow into or out from the reservoir. The water level monitoring is important to maintain a suitable water level in reservoir. Pump is activated periodically by the microcontroller to supply of water and nutrients to the roots The application of automation in this system can provide advantages to production development for better control, being more accurate and safe and reduction of manpower, since an automatic microcontroller-based DWC system will need fewer people working, optimization in electricity consumption, improved product quality, as a completely controlled system will produce a better quality crop and provision of a record, which can be analyzed.

II. SYSTEM DESCRIPTIONS

A literature review discusses project information in a particular subject area within a certain time period. Collecting an information from others resources such journal, articles, books summarize the needed and objective of the project.

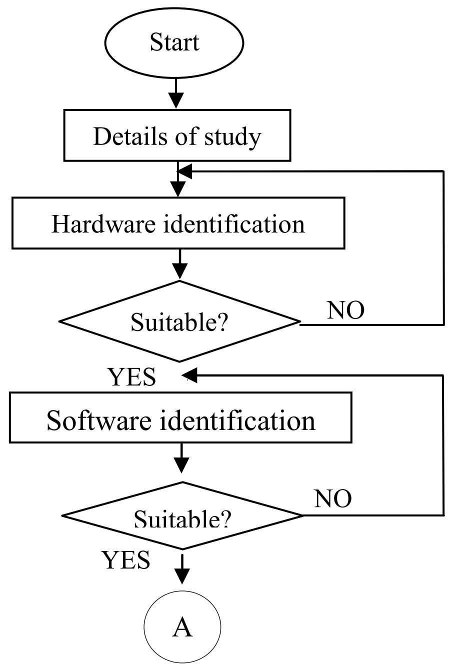
Deep Water Culture (DWC) is a viable alternative to other soilless culture systems for maintaining plants with a controlled root-zone atmosphere [5]. The important part to control for better production in plant was the roots where plant root absorb nutrients important for the crops growth.

The pH of plant root environment is an important factor affecting the uptake of many nutrients. The optimum range for many crops lies between 4.5 and 6.0, a narrow range near neutrality. Water used for DWC plant production must first be brought to the proper pH range [6]. By referring to this, briefly understand that pH nutrients deliver to the plants is one of the factors must be controlled in order to produce a good production for plants. If plant roots are exposed to a low pH for the example a pH range of 2-3 for only a few seconds, it immediately can damage the roots [6, 10]. Nutrient solution pH usually controlled by adding either dilute acid or base to maintain the desired value. It is known as pH up and pH down solutions. The pH controlled in the DWC system was found to provide a feasible alternative method of controlling nutrient solution for pH applications [7].

By resolving the problem based on the pH consideration inside nutrients. The production of the plant will contribute a lot of advantages. For the example the system which can contribute a quality production of the potato. The production of potato seed under conventional system has not been effective in avoiding or reducing the buildup of pathogens and has consequently led to reduced quality potato seed and low crops yields. Plants once cleaned through meristem culture and induction of tuberization under DWC system, produce high quality potato seed tubers rapidly that are free from contamination of pathogens [8].

III. METHODOLOGY

The methodology in this project consists of six stages namely details of study, hardware identification, software identification, hardware and software interfacing, analysis and troubleshooting, data and result collection. Figure 1 shows the flow chart of the methodology for this project.



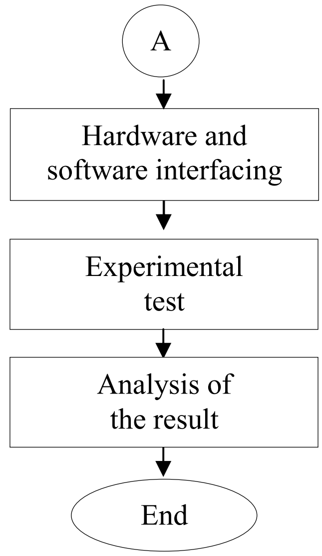


Fig. 1. Methodology Flowchart

To complete this development of the Deep Water Culture (DWC) system, systematic segregation of duties needs to be done to ensure the completion of these studies in the prescribed period.

A. Detail of the Study

In this section, details of study will aim the main objective and tackle the problem, then find the solution of the problem. This form contains important information for project and related to it. For the example, the importance of pH value in the nutrient required to maintain the quality needed by plants. There is a need to measure the value and balance the pH and responds the valve contains solution stabilizer. The pH values are continuously measured and adjusted until requires range achieve a need. Other than that, water level is always being monitor by a float sensor. This sensor will determine the discrete level required in the tank. The level of the water is important to maintain a suitable pressure to the sprinkler.

B. Hardware Identification

There are details of study discuss about the problems, to overcome the problem one of the most important part is the hardware declaration to solve the problem. In practice, pH value inside the reservoir is manually measured by farmer and to achieve intended trial and error approach seems prevalent solution.

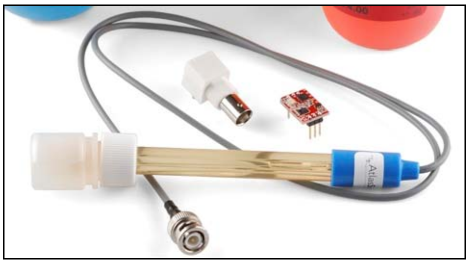


Fig. 2. pH Sensor

Figure 2 show pH sensor is known as a glass electrode pH sensor. The portable pH meter provides the maximum degree of operating comfort, reliability and measuring certainty for this project. With pH: -2.00 to 19.99 measures range and Temperature: 23.0 to 221°F it display pH/temperature or mV/temperature simultaneously, which makes taking pH readings easy

Other than that, this project needed the SK 40C as shown in Figure 3. It is a controller to control a DWC system such as to control the actuator and pH sensor. The pH sensor sends the information to trigger either one of the valve for adjusted the pH value. SK 40C Microcontroller as a brain to execute the action must be done in the system. SK 40C with 40 pins PIC microcontroller will attached with LCD display to indicate the status happen in the system such the pH value, Water level condition and the action which need to respond for the system.

Fig. 3.Microcontroller

C. Software Identification

To operate the controller SK 40C need software. This project needs MPLAB IDE to runs the operation as a command to the controller to runs the system automatically. MPLAB IDE is a software program that runs on a PC to develop applications for microchip microcontrollers. It is called an Integrated Development environment, or IDE, because it provides a single integrated “environment” to develop code for embedded microcontrollers.

D. Hardware and Software Interfacing

There is a need for interfacing to demonstrate the functionality of the project. Where software as instruction to hardware act with what we need. UIC00B programmer is use to connect with SK40C where there is an Integration with MPLAB IDE for auto-loading programming to the circuit.

E. Experimental Test

Main purpose of experimental test as a series of steps used to test theory or an idea. Other than that from the experimental test is as an act or operation for the purpose of discovering something unknown or of testing a principle. There is an experimental test for testing the pH value change due to the two solution reaction which is pH up and down solution.

i. Measurement of pH Value in the Reservoir

This test was aim to measure the pH value in the water that contain nutrient. The water has been placed in the reservoir that has a capacity of 300ml water.

ii. Measurement of Changes on pH Value in Reservoir using pH Down

The objective of this experiment was to measure how many pH changes in every 0.2 ml of droplet for pH down in the vessel contains water. In this experiment, 300 ml of pure water was put in a reservoir. A pH value in the first reading was recorded and determine as an initial value. An experiment was started by dropped a 0.2ml of pH down solution first in the vessel. Stir the solution with a stick stirrer and after a second the value of pH condition in the vessel was recorded. After a reading was taking, another 0.2ml pH was dropped again; stirring again and the value were recorded. The same procedure was repeated again until it reached minimum value of pH

iii. Measurement of Changes on pH Value in Reservoir using pH Up

A procedure as in the first experiment was repeated. 300ml of water now is in the acidity condition was measured. The measures including temperature value is recorded. By using the syringes with the small range 0.2ml pH up solution is drop into the 300ml water and the changes in pH value was recorded.

IV. RESULTS AND DISCUSSIONS

A. Measurement of pH Value in the Reservoir

TABLE I. MEASUREMENT OF PH VALUE IN 300 ML WATER.

No. of measures	pH Value	Temperature (°C)
1	7.46	24.90
2	7.41	25.00
3	7.50	25.00
AVERAGE	**7.46**	**24.97**

Table I show an average result of pH value in 300ml water. The 300ml water was choosing because of the size of the reservoir used in this research. After three reading has been made, the average value of pH was about 7.46 with temperature 24.97 °C. This value has been used as a reference (initial value) before experiment using pH solution has been conducted.

B. Measurement of Changes on pH Value in Reservoir using pH Solution

TABLE II. MEASUREMENT OF PH VALUE BY APPLIED PH DOWN SOLUTION

pH Down (ml)	pH Value		Difference	Temperature (°C)
	before	after		
0.2	7.13	6.40	0.73	25.40
0.2	6.40	6.20	0.20	25.40
0.2	6.20	6.00	0.20	25.40
0.2	6.00	5.80	0.2	25.50
0.2	5.80	5.67	0.13	26.60
0.2	5.67	5.37	0.3	25.60
0.2	5.37	5.00	0.37	25.8
0.2	5.00	3.69	1.31	25.9
0.2	3.69	3.30	0.39	26.0
0.2	3.30	3.14	0.16	26.1
0.2	3.14	2.97	0.17	26.1
0.2	2.97	2.86	0.11	26.1
0.2	2.86	2.78	0.08	26.1
0.2	2.78	2.72	0.06	26.1
0.2	2.72	2.45	0.27	26.2
Average			**0.312**	

In this experiment, Table I shows that the average of changes in pH approximately to acidity 0.312 pH changes needs 0.2 ml of pH Down solution in 300 ml water. Where one tank of water contains 37843.75 ml, by comparing with 300 ml of water, how many times 300 ml of water is achieve a same volume of one tank of water. So,

$$(37843.45\ \text{ml})/\ (300\ \text{ml}) = 25.23\ \text{times}$$

Therefore, by choosing a droplet pH down solution of 0.2ml, for one tank of water there is

$$0.2\ \text{ml} \times 25.23 = 5.046\ \text{ml}$$

So, 5.046 ml of pH down solution needed to changes 0.312 pH value near to acidity.

TABLE III. MEASUREMENT OF PH VALUE BY APPLIED PH UP SOLUTION

pH Up (ml)	pH Value		Difference	Temperature (°C)
	before	after		
0.2	2.45	2.54	0.09	26.1
0.2	2.54	2.60	0.06	26.0
0.2	2.60	2.68	0.08	25.9
0.2	2.68	2.78	0.1	25.9
0.2	2.78	2.86	0.08	25.9
0.2	2.86	2.96	0.1	25.9
0.2	2.96	3.09	0.13	25.9
0.2	3.09	3.40	0.31	25.9
0.2	3.40	3.93	0.53	25.9
0.2	3.96	4.89	0.93	25.9
0.2	4.89	5.38	0.49	25.9
0.2	5.38	5.65	0.27	25.9
0.2	5.65	5.84	0.19	26.9
0.2	5.84	5.96	0.12	26.1
0.2	5.96	6.12	0.16	26.1
0.2	6.12	6.23	0.11	26.10
0.2	6.23	6.31	0.08	26.10
0.2	6.31	6.40	0.09	26.2
0.2	6.40	7.06	0.66	26.2
Average			**0.244**	

For average of changes in pH approximately to alkalinity 0.244 pH changes needs 0.2 ml of pH Up solution in every 300 ml water. One tank of water contains 37843.75 ml, by comparing with 300 ml of water, how many times 300 ml of water is achieve a same volume of one tank of water. So,

$$(37843.45\ \text{ml})/\ (300\ \text{ml}) = 25.23\ \text{times}$$

Therefore, by choosing a droplet pH up solution of 0.2ml, for one tank of water there is

$$0.2\ \text{ml} \times 25.23 = 5.046\ \text{ml}$$

So, 5.046 ml of pH up solution needed to changes 0.244 pH value near to alkalinity.

V. CONCLUSION

In conclusion, the development of Automatic Microcontroller System for Deep Water Cultivation has been done. To control the pH value in the reservoir is important to ensure the plant received a sufficient nutrient through water. From the experimental test, there is a need of 5.64 ml changes in both acidity and alkalinity range in every 0.312 pH and 0.244 pH. An automatic valve feeder must act accurately in order to respond value needed in every pH changes. The accuracy of both solution triggers when it is received respond from pH sensor important in order to monitor pH value need by system.

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