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Microcontroller-based Fertigation Farming Automation System

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Abstract

Fertigation is a technique that combines plant fertigation and irrigation that becomes most used by the commercial farmers as well as home growers. However, fertigation systems required a constant water supply and the exact amount of nutrient that plant needed as it changes depending on their growth. The paper aims to research, create, built, test and implement an automatic mixing fertilizer by implementing Total Dissolved Solids (TDS) monitoring system according to the plant's nutrient level needed. It is also exploring the potential of optimum water usage by constructing an automatic timer for watering the plants according to the routine schedule. The system used an Arduino UNO R3 as a microcontroller. TDS sensor sense and measure the dissolved solids in a nutrient solution which gives information on the number of nutrients or impurities in TDS value. In an automatic watering system, the pump is running according to the timer set by a microcontroller. The frequency of distribution and the concentration of the solution depends on the weather conditions and the level of the crop. Hot weather requires more amount and frequency of fertilizer but in dilute solution. As such, this system has demonstrated a cost-effective, sustainable, eco-friendly, and safe environment as a result it will produce fresh and healthy plants that can give benefits to living things.

Keywords: Fertigation System; Arduino Microcontroller; Automation

INTRODUCTION

In the agriculture field, water and nutrients are the crucial elements that contribute to the growth of plants and produce high income for the farmer. The effective way to feed with water and nutrient is that the soluble nutrient solution is mixed well with the water and feed to the crops via an automation irrigation system. This method is also known as fertigation.

Total Dissolved Solids (TDS) are the total amount of mobile charged ions, including mineral salts, metals dissolved in each volume of water, expressed in units of mg per unit volume of water (mg/L), also referred to as parts per million (ppm) [1]. TDS meter probe can determine the reading of concentration in the solution. Measurements of concentration can be made by the farmers in many ways. But most of the farmers will make an estimation based on the litre measurement. Nowadays, there are a lot of people who grow their crops at their house. TDS meter is one of the crucial components to buy. Plant growers keep looking at the tool to check the nutrient solution daily, adjusting it is necessary to maintain the proper levels for plant growth [2]. This shows that people already use the TDS meter for a long time in agriculture. TDS is a result of a calculation from Electric Conductivity (EC). Different plants have different needs for nutrients. EC value can be the indicator to refer to how much nutrients needed by the plants. Table 1 shows the EC value for different types of plants.

Table 1 EC value [3]

Plant	EC Value
Okra	2.0 - 2.4
Eggplant	2.5 - 3.5
Spinach	1.8 - 2.3
Broccoli	2.8 - 3.5
Onions	1.4 - 1.8
Sweet potato	2.0 - 2.5
Carrot	1.6 - 2.0
Cabbage	2.5 - 3.0
Tomato	2.5 - 5.0
Pumpkin	1.8 - 2.4
Parsley	0.8 - 1.8
Asparagus	1.4 - 1.8

The plant takes up several mineral elements in their ionic forms from the soil or any other growth medium for their metabolism and growth [4]. The EC value in the solution can affect the characteristics of the plants. For example, fruit flavour, texture, yield, firmness, plant appearance and water content of the tissue. That is why comparison can be seen either the user used fertilizer or not for their crops. Mixing fertilizer with water can help the growth of plants and the best fruits can be produced. Even the fertilizers consist of chemical substances, but it still good for plants. However, by increasing the EC level too much above the recommended range, the plant would not be able to reach maximum growth [5].

Next, watering time is another vital part of a farming routine. Water is important to the physiology of plants because of its crucial role in all physiological processes and because of the large quantities required [6]. The same concept as EC level, every type of plant has its watering schedule. Table 2 shows the watering time for some plants.

Table 2 Schedule of watering time [3]

Weeks	[Number of times] x [time (min)]				
	Types of plant				
	Melon	Tomato	Chili	Cabbage	Spinach
1	4 x 5	3 x 5	3 x 5	3 x 5	3 x 5
2	4 x 5	3 x 5	3 x 5	3 x 5	3 x 5
3	5 x 6	4 x 5	4 x 5	4 x 5	4 x 5
4	6 x 6	4 x 5	5 x 5	5 x 5	5 x 5
5	7 x 6	6 x 5	5 x 5	5 x 5	5 x 5
6	7 x 6	6 x 5	6 x 5	6 x 5	6 x 5
7	7 x 6	6 x 5	6 x 5	6 x 5	6 x 5
8	6 x 5	6 x 5	6 x 5	6 x 5	6 x 5
9	6 x 5	6 x 5	6 x 5	6 x 5	6 x 5

Plants need water to make food and take in the water through their roots [7]. Some plants need much water at the beginning of the growth, and some might need it when the fruits/flowers start to produce. Plants make their food by a process called photosynthesis which takes place in the leaves [8]. Depending on the plants whether they are leafy plants or fruit-produced types of plants. Water is one of the important factors that lead to the growth of plants besides fertilizer as explained in the previous section. The amount and concentration of fertilizer for plants is also an important thing. It is to make sure the plants get enough nutrient. The suggestion for watered the plants is to use a drip irrigation system or sprinkler irrigation. But the drip irrigation system is an effective method of the irrigation technique that can be primarily [9].

In this work, an automatic mixing fertilizer system according to the plant's nutrient level is design and develop. It can help the plants grow well by constantly feeding them with the correct ratio of nutrients. This system also consists of an automatic watering system, where the pump is running according to the timer set by a microcontroller. The frequency of distribution and the concentration of the solution depends on the weather conditions and the level of the crop.

MATERIALS AND METHODS

Arduino Uno is used as a microcontroller that compiled with the coding and controlled the sensor function. The LCD display will show the real-time and value of the TDS meter that refer to the concentration of the fertilizer. Figure 1 shows the hardware of the project.

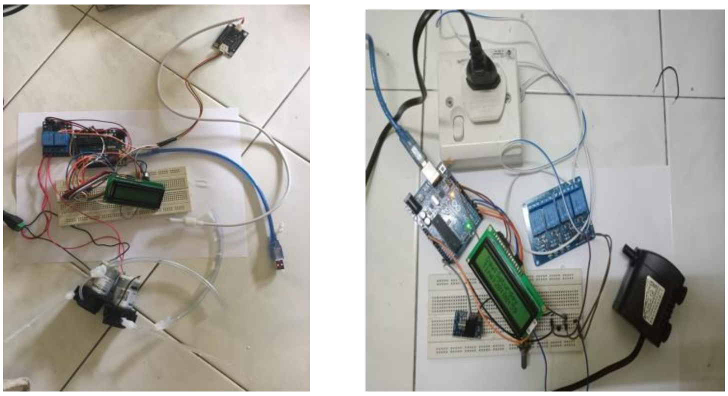

Figure 1 The project hardware

The TDS monitoring system works when the TDS sensor starts to sense and measure the number of dissolved solids in a nutrient solution. If the water in the tank contains no soluble materials (pure water), the input from the sensor will deliver the signal to the relay and the output of the controller is peristaltic pumps. The relay will activate the peristaltic pump and the peristaltic pump started pumping the fertilizer A and B to the water tank. This process will continue until the TDS sensor sense and measuring if the water is full of dissolved materials, the value of the mixing fertilizer with water is fixed according to the type of plants as in this project Okra (also known as lady's finger) plants are used and need 1000 ppm until 1200 ppm value [10]. When the display shows the TDS value is larger than 1000 ppm, the peristaltic pump will stop working immediately.

This automatic timer watering system is about the time that can be set on Arduino to water the plants. For this project, the pump is running according to the timer set in the Arduino which is 10 seconds the pump is ON and 5 seconds the pump is OFF. This time set is for the prototype but in the real product, the timer can be set on Arduino according to the routine schedule for watering plants. In the real product, the okra plant needs 5 times a day to watering this plant and the duration for the pump working is 5 minutes. The frequency of distribution and the concentration of the solution depends on the weather conditions and the level of the crop. Hot weather requires more amount and frequency of fertilizer but in dilute solution. Generally, a higher concentration of fertilizer solution is used as crop age increases. The LCD for the system is to display the real-time clock which is in day and time. Real-Time Clock (RTC) is used in this project to keep accurate time as these components can keep track of the current time and can be used in any device. Figure 2 shows the overall working system.

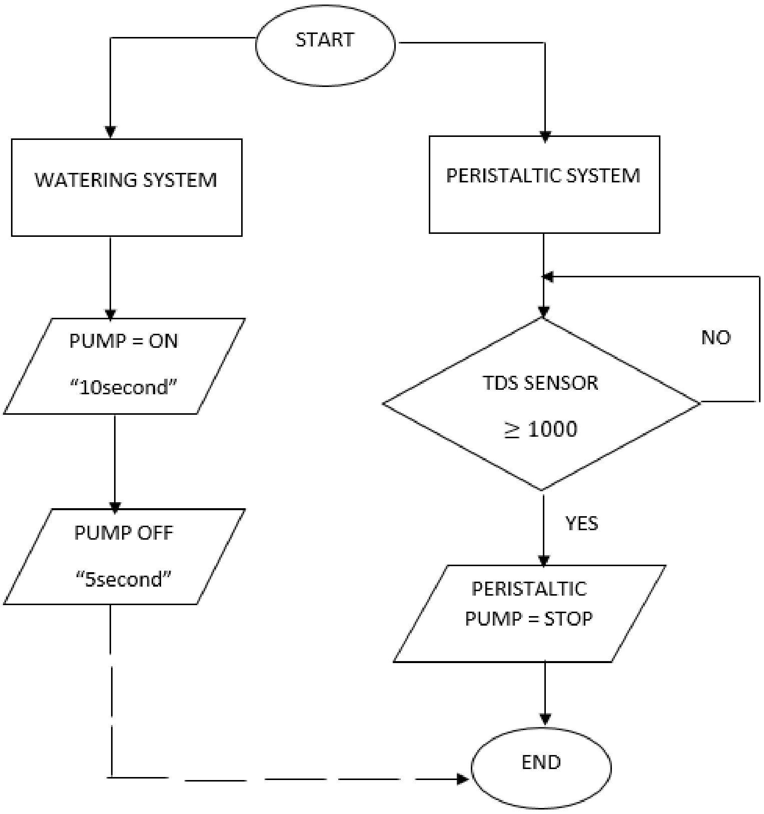

Figure 2 Microcontroller-based fertigation farming automation system flowchart

RESULTS AND DISCUSSION

The correct ratio of nutrients needed by the plant and watering routine has been done manually for the past few weeks [11]. Starting on 2nd May (week 8), the developed system is used and collecting data is carried out at the same time. Figure 3 below shows the Okra plants and Brazilian Spinach in week 7. Next, Brazilian Spinach is another type of plant used for this project. This type of vegetable took about 40 – 45 days from seed to harvest. This plant is easier to take care of as Brazilian Spinach is a low growing perennial leaf vegetable and does not produce fruits like the Okra plant.

Figure 3 Okra plants and Brazilian spinach (week 7)

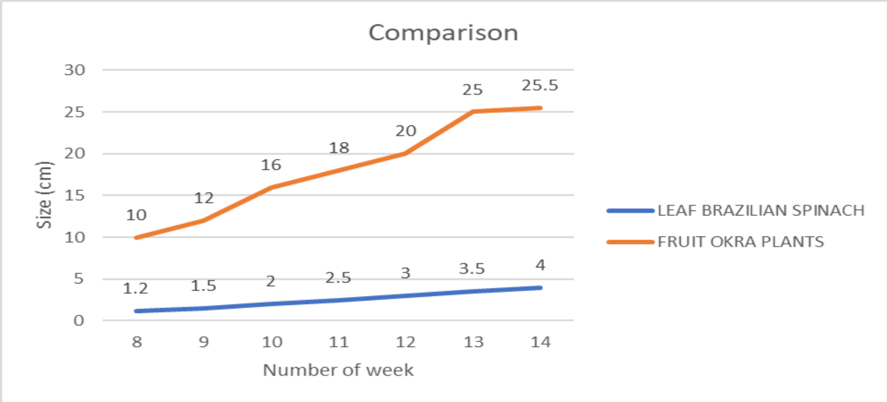

Figure 4 Progression growth of two different plants

Figure 4 shows the comparison between two plants: the Okra plant and Brazilian Spinach. Both plants managed to grow healthy and bigger. The fruit/vegetable size become bigger week by week. The measurement is taken starting from week 8 until week 14. Week 1 until week 7 is the time taken for the plants to produce leaf/fruit.

Values of TDS will appear at the serial monitor of Arduino IDE as shown in figure 5 once the TDS meter is dipped into the solution. The higher the conductivity, the more dissolved solids in the solution. The conductivity is used to measure the strength of the nutrient solution while the dissolved solids are the mixture of two fertilizers (A+B). Then, peristaltic pumps will stop operate after the TDS reading reached the desired value. The TDS Sensor and peristaltic pumps are functioning well as when the TDS Sensor measure the TDS Value larger than 1000 ppm in the mixing water tank, the peristaltic pumps stop working to pump the fertilizer.

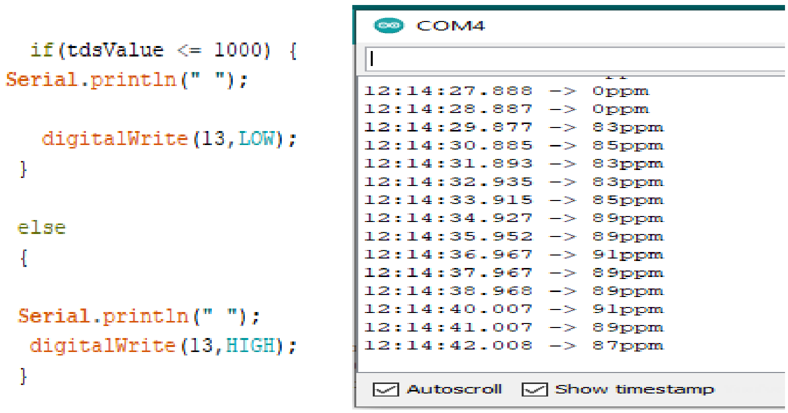

Figure 5 Result of TDS value in Arduino IDE

In this part, the serial monitor shown in figure 6 is the real-time clock and day. The purpose of doing that is to make user's work easy by keeping an updated track of current time. The submersible pump continuously operates for 10 seconds and stop for 5 seconds at the same time. This time set is shorter as it is a prototype but in the real product, the timer can be set according to the routine schedule for watering plants.

```
// the loop function runs over and over again forever
void loop() {
  digitalWrite(RELAY_PIN, HIGH); // turn oFF pump 5 seconds
  lcd.begin (16,2);
  lcd.print("  OFF WATERING  ");
  delay(5000);
  lcd.clear();
  digitalWrite(RELAY_PIN, LOW);  // turn ON pump 5 seconds
  lcd.print("   ON WATERING  ");
  delay(10000);
}
```

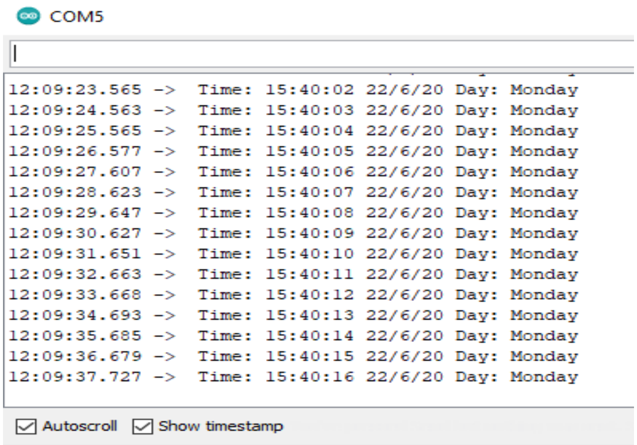

Figure 6 Result of watering time in Arduino IDE

In a typical fertigation system, the plant that places at the back always wilt because the pipe in the first line is not connected with the second line. So, the water is either cannot reach until the end or become slower. That is why the plant at the back always need to change position to fulfil the need of nutrient. But in this project, connecting the pipe in line one and line two could solve the problem. Water will regulate back and forth as the end pipe is connected and formed a ‘circle flow’.

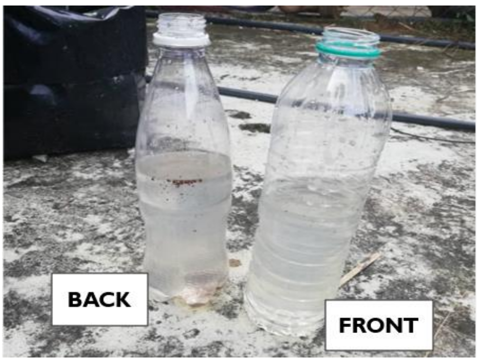

Figure 7 Equal quantity of water

Since both plants grow well as expected, another alternative is taken to strongly prove that back and front plants got the same quantity of water. The solution that comes out from the dripping pipe is taken out and Figure 7 illustrates the quantity of water obtained from it. It shows that all plants managed to get the same quantity of water even the position is different either near the water tank or far from the water tank. This thing should not be a problem anymore since a solution has been found is by doing a looping method, the water will keep on circulating.

CONCLUSION

In conclusion, the objective of the project has been achieved in creating an automatic mixing fertilizer system according to their nutrient level needed and constructing an automatic timer for watering the plants according to the routine schedule without the user interferences. This project also is an eco-friendly project that contributes to sustainability and safe for the environment as a result it will produce fresh and healthy plants that can give benefits to living things. Most importantly the microcontroller-based fertigation farming automation system project can be operated by a non-technical person.

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REFERENCES

[1] Purendra Singh. (2019). Laboratory Instrumentation and Technique. Dwarka, New Delhi.
[2] Michael I. Rich. (2018). Gardening: Hydroponics Ð Learn the "Amazing Art" of Growing: Fruits, Vegetables, & Herbs, without Soil. *Lulu.com*
[3] Ashwikumar Marimuthu. (2015). Kaedah Menyediakan Baja Fertigasi. Jabatan Pertanian Negeri Terengganu.
[4] M. Naeem, Abid A. Ansari, Sarvajeet Singh Gill. (2017). Essential Plant Nutrients: Uptake, Use Efficiency, and Management. *Springer.*
[5] Tom Alexander. (2000). Best of Growing Edge: Popular Hydroponics and Gardening for Small Commercial Growers. *New Moon Publishing, Inc.*
[6] Hans Lambers, F Stuart Chapin III, Thijs L. Pons. (2008). Plant Physiological Ecology. *Springer Science & Business Media*
[7] Bobbie Kalman. (2007). Living Things Need Water. Crabtree Publishing Company.
[8] Jackie Clegg, Jason White. (2008). *Science. Letts and Lonsdale.*
[9] Adegboye, M. A., Ajao, L. A., Folorunso, T. A., Mamudu, A. Y., & Isah, A. S. (2017). Automatic fertilized-irrigation control and management system. *FUW Trends in Sci. & Techn. J*, *2*(2), 801-805.
[10] Abd, M. K. I., Buyamin, S., Abidin, M. Z., & Mokji, M. M. (2018). Development of Automatic Mixing Process for Fertigation System in Rock Melon Cultivation. International Journal of Electrical and Computer Engineering, 8(3), 1913.
[11] Pretty, J.N. (1995) Participatory Learning for Sustainable Agriculture. World Dev. 23, 1247–1263.