Progress in Engineering Application and Technology Vol. 4 No. 2 (2023) 093-107

PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Fertilizer Measuring Machine for Hydroponic Growing Industry

Nathalie Tan Yhe Huan[1], Hazli Roslan[1]*, Suhaila Sari[2]

[1]Faculty of Electrical Engineering Technology,
University Tun Hussien Onn Malaysia Pagoh, 84600, Muar, Johor, MALAYSIA

[2]Faculty of Electrical and Electronic Engineering,
University Tun Hussien Onn Malaysia, 84600, Batu Pahat, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2023.04.02.010
Received 15 January 2023; Accepted 06 February 2023; Available online 06 February 2023

Abstract: In this era of globalization, most of the telecommunication systems in the industry are based on IOT. For a fertigation system that uses manual fertilizing methods, it has disadvantages such as requiring many workers and delays in fertilizing due to the problem of delays in fertilizing by workers. In the fertigation plant method, the fertilizer mixture ratio and fertilization time are the main factors in making plant growth to the maximum and best level. Errors in the fertilizer mixture ratio and delay in fertilizing will result in damaged plant growth and consequently causing serious losses to plant operators in terms of fertigation. To prevent this problem from happening, a tool was developed and applied. The ratio of fertilizer measurements can be provided accurately and appropriately according to the level of plant growth. Fertilizer mixture A and B are measured in tanks separately with the same ratio before being mixed in the mixer tank. These fertilizers are measured using a TDS (Total Dissolved Solids) sensor and the optimum level of reading is around 400ppm to 550ppm. The available measured fertilizer will be pumped to the plants. To ensure that the soil moisture level, temperature, and air humidity are always in the right range make sure that the plants are always in optimum situation, an application (Blynk) is applied and can work via Wi-Fi for the monitoring process using a mobile phone. This system is equipped with several other equipment such as a water level sensor as a gauge of the height of fertilizer and water, a water pump to pump fertilizer, an LCD as a system monitoring display and an Arduino Mega as a controller for the entire system. This system works well based on the test results and data that has been taken during the testing process and is suitable to be applied to the fertigation farming system.

Keywords: Fertilizer Measuring Machine, TDS Sensor, Blynk, Arduino

*Corresponding author: hazli@uthm.edu.my

1. Introduction

The traditional way of manual fertigation system has disadvantages such as requiring a large number of workers and delays in fertilization. Errors in the fertilizer mixture ratio and delay in fertilizing will result in damaged plant growth and consequently causing serious losses to plant operators. The lack of monitoring on TDS value and soil condition where the soil moisture, temperature humidity, and TDS level were unknown. The plants might have excessive moisture which will cause the fertilizer did not dissolve in the soil [1]. Therefore, the aim of this project is to develop a fertigation machine in controlling the fertilizer mixture ratio with the monitoring system. As agriculture sustainability was important to the world of the agriculture industry, an organic fertilizer mixture content have been a major concern related [2]. Appropriate fertilizer level is necessary pre-requisite for optimum plant growth therefore selecting and mixing of fertilizer must take into considerations. The application of modern technologies has tremendous potential to revolutionize the agricultural industry [3]. The vast efficiency of fertilizer ratio control has been proven may improve the soil by decreasing toxic effects associated with the over-application of fertilizers [4]. The sensor-based fertigation monitoring system able to provide a hopeful solution to farmers where farmers are not required to be in the field [5]. This fertilizer measuring machine will work to minimize the number of workers in a crop field, control and save water and electricity.

The objectives of this project will be developing a fertilizing tool that controls the ratio of fertilizer and monitor the soil moisture, temperature, and humidity in the vegetable plants. The fertilizer measuring machine will function by combining fertilizers A and B at the required ratio density and deliver to the vegetable plants. After that, there will be mainly two types of sensors which are the water level sensor and the TDS sensor. The water level sensors function as monitoring the sufficiency of the remaining water level and act as a signal detection to tell the system that the fertilizer reached the required level and automatically trigger the pump to deliver the measured ratio of fertilizers. Whereas the TDS sensor is used to monitor the condition of mixed fertilizer before deliver to the vegetable plants. Blynk platform was used to monitor the soil moisture, temperature, and humidity of the vegetable plants. In general, this fertilizer measuring machine can be used in many fields such as agriculture crop field, industry field, education field and so on. Since the fertilizing measuring machine was in small-scale, it even can function as a home-used machine.

2. Materials and Methods

The resources and methods applied in this project are fully presented in this section. The information will include all aspects related to the procedure of work for each stage such as block diagram, hardware and software used, and the overview on the system flowchart.

2.1 Materials

The design of this project was developed based on its functionality as a measuring machine. As we are measuring and mixing two types of fertilizers, therefore a total of five tanks were used to design the physical layout to resemble the machine. The tanks are classified into three categories which are main tank, measuring tank and mixer tank respectively. To develop a tool to measure the required fertilizer ratios, the system will use multiple water level sensors which will function in 2 ways. First set of water level sensor will act as monitoring tools whereas the other set of water level sensor will act as a signal detector, this is where the measuring progress will be done to measure the required fertilizer ratio. As delivering fertilizer was also a part of the main process when the system working, therefore DC water pump will be used as the primary motor in delivering the fertilizer from one tank to another tank. This delivery process will be divided into two different modes which manually controlled and automatically control the on / off switching of water pumps. Moreover, the system also used Blynk application platform to monitor the condition on surround the vegetable plants in terms of temperature, humidity, and soil moisture level. The list of components and software used for this project are listed below:

- Arduino Mega 2560 Microcontroller
- Water Level Sensor
- 2-channel Relay
- 5V DC Water Pump
- TDS (Total Dissolved Solids) Sensor
- DHT11 Sensor
- Soil Moisture Sensor
- NodeMCU ESP8266
- Push Button
- Arduino IDE
- Blynk Application

Arduino Mega 2560 will be used as the brain in this fertilizing measuring system which controls the process flow of fertilizer and monitor's process. NodeMCU ESP8266 will be used as a medium in collect data from Arduino Mega and send it to the Blynk server through Wi-Fi. because Arduino does not work wirelessly [6]. This monitoring system will be carried out by serial communicating Arduino Mega and NodeMCU with the Json Buffer [7]. This serial communication allows the data send from Arduino to NodeMCU by physical connection through the Tx and Rx pin of both boards [8], then the sets of data will be transmitted with the Wi-Fi module remotely from NodeMCU to the Blynk application platform. In the Blynk interface, the virtual gauge act as a visual indicator of the data reading of temperature, humidity and soil moisture received where the temperature and humidity value detection using a DHT11 sensor while the soil moisture detection using soil moisture sensor. As the optimal temperature range requirement in hydroponic crops is 50 °C to 70 °C whereas the humidity range is 40% to 70% RH, therefore DHT11 is suitable used for monitoring the temperature and humidity [9].

Figure 1 shows the block diagram of this project. The system utilizes the Arduino Mega 2560 microcontroller mainly controlling the fertilizer measuring process. The main components are the TDS sensor which was used to measure the total dissolved soluble solids in liquid [10], water level sensor in both measuring tanks and DC water pumps. The water level sensor in both measuring tanks will take responsibility on controlling the required percentage of fertilizer level pump from the main tank whereby the percentage of fertilizer in measuring tanks will greatly affect the TDS level in the mixer tank. The water pump located at the measuring tank will be programmed automated without any push button to trigger the on / off the water pump. The respective water pump relay will be triggered by receiving the signal from the respective water level sensors in the measuring tank, when the water level sensors detected required range reached, it will send signal to microcontroller to trigger and turn on the DC water pump. By monitoring the LED indicator of the TDS sensor, when the red LED turns on represents there's excess mineral nutrient in the mixer tank might cause plants unable to absorb nutrient due to oversaturation [11]. In addition, when the white LED turns on represents the mixer tank is lack of some mineral nutrients. Therefore, the ratio of fertilizer A and fertilizer B must be calculated and controlled in standard to maintain the appropriate TDS value. Generally, the appropriate TDS level for hydroponic vegetable plants and flowering is around 400ppm up to 500ppm where the TDS level less than 500ppm will cause insufficient nutrients for the vegetable plants to be absorbed [12][13] .

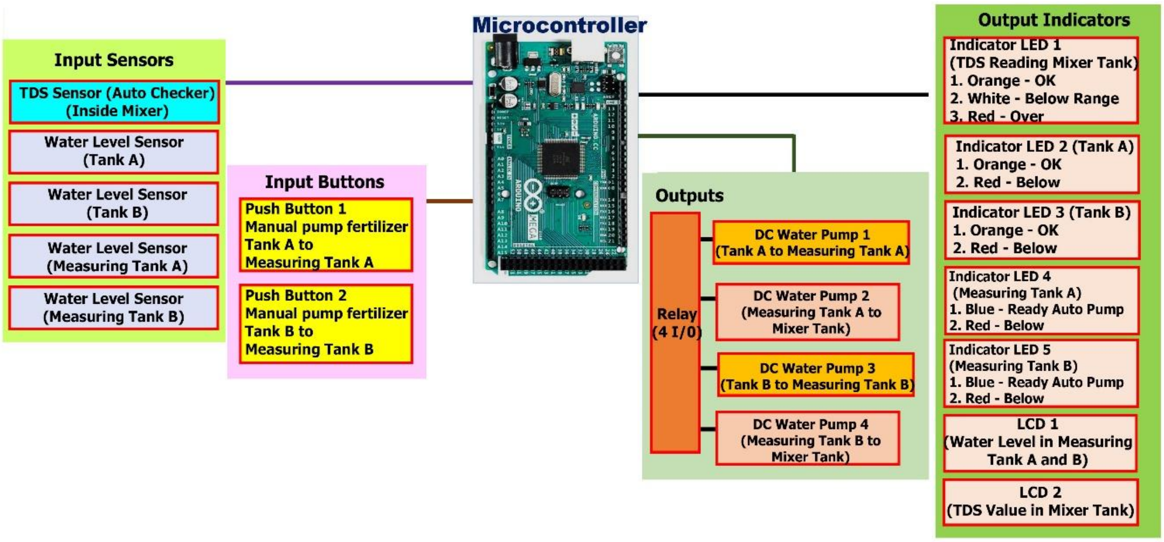

Figure 1: Block diagram of the system

2.2 Methods

Figure 2 represents an overview of how the system functions. After the initialization and starting up, both LCD 1 and LCD 2 are ready to display the respective water level sensor value and TDS sensor value. The DHT11 Sensor and soil moisture sensor located at the vegetable plants will read the moisture, temperature, and humidity. The value data collected from Arduino Mega will send to NodeMCU ESP8266 through serial communication, then send the value data through Wi-Fi to the Blynk. The serial communication will be carried out using the Arduino Json Object library, it is a method to store and exchange information which the data is written as value pairs [14].

The Millis functions will be applied here because it's a non-blocking function where any code that's located outside of that statement should work normally [15]. The Millis functions works as storing the current time (currentMillis) where the time in milliseconds started when user power up the microcontroller and starts the program. After storing the current time, it works by subtracting the previous stored time (previousMillis) from the current time. An interval will be declared for each millis functions to act as a compared value with the remainder of subtraction done just now.

Generally, section A and B are the water level sensor indication for Tank A and Tank B. The analog value of water levels will be displayed at LCD 1. The orange LED lights up when the water level is greater than 450 whereas the red LED will light up when less than 450. After that, the program will go back to section W which going back to the storing of the current time and search for the next function to execute. Section C and D are the automated water pump with the pre-programmed water level sensors at Measuring Tank A and B. When the water level sensors detected the water level reached or more than the analog value of 450, the blue LED will light up first and then wait for a delay timer, the relay will be triggered to turn on the water pump in the measuring tank deliver into the mixer tank. The water pump will be turned on for a period of delay timing then only turned off. Section E and F are the manually controlled water pump for Tank A and B. When the push button is pressed, the respective relay will be triggered and turn on the respective water pump. Lastly, section G is the indicator part for the gravity TDS sensor. The system will read the analog value of the TDS sensor and display it on LCD 2. There will be three scenarios which if the TDS value is less than or equal to 100, the white LED will light up which means the TDS is below range, or else if orange LED will light up which represents the TDS is within the range and if red LED will light up which means the TDS is over range.

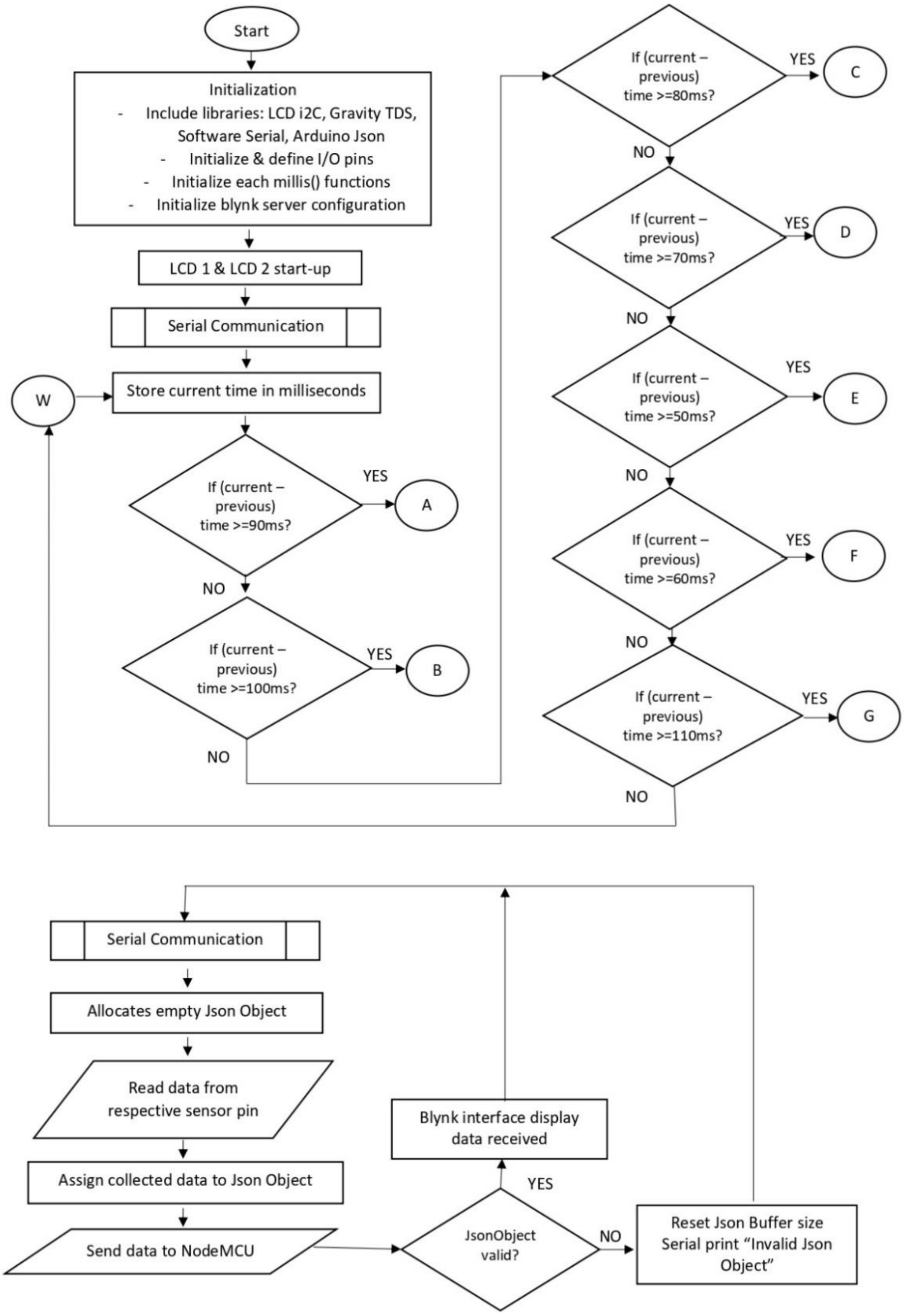

Figure 2: Flowchart of the system

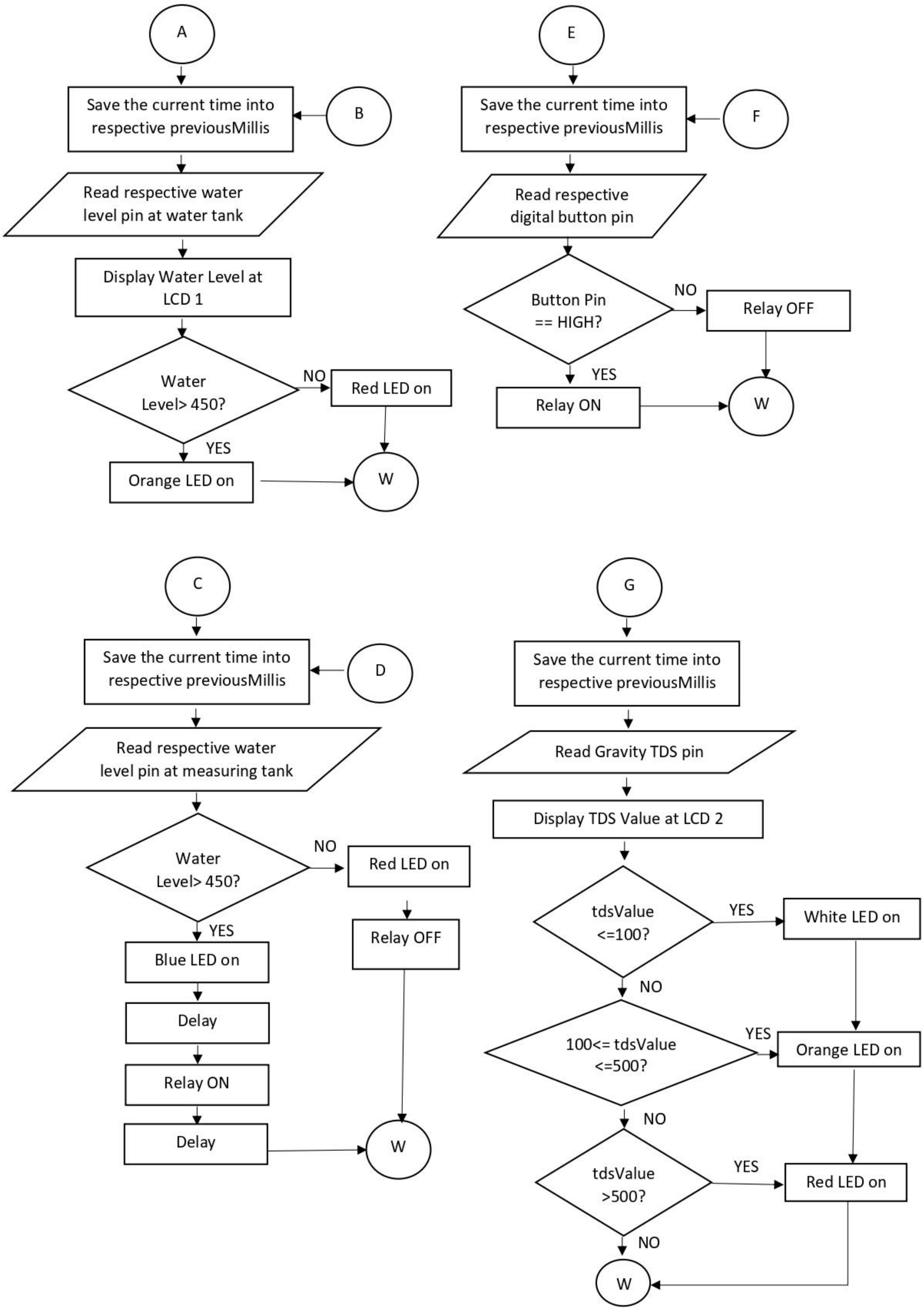

Figure 2: Flowchart of the system (continued)

3. Results and Discussion

This section focuses on the analysis and discussion of collected results and findings that were obtained from several experiments conducted with reference to the aims of the project. The experiment performed targeted the functionality of the water pump, performance of automated water pump, effects of TDS level on mixing various ratio and monitoring system through Blynk platform. All the data obtained were presented and implemented into both table and graphical chart.

3.1 Project Layout

The figures below portray the layout of this entire project. Figure 3 shows the front view of the prototype whereas Figure 4 shows the top view of the prototype. Meanwhile, Figure 5 presents the monitoring system of vegetable plants and Figure 6 displays the Blynk Application interface.

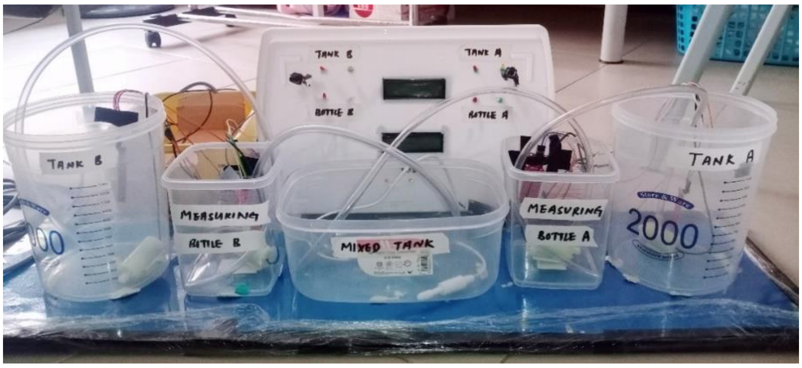

Figure 3: Front view of the prototype

Figure 4: Top view of the prototype

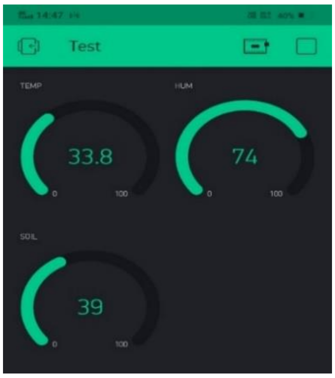

Figure 5: Monitoring System **Figure 6: Blynk platform**

3.3 Results

The first experiment conducted was on the functionality of the water pump. This is mainly checking on the consistency of Tank A and Tank B water pumps speed with respect to the fixed time duration. The push button will be pressed for 5 seconds, 10 seconds, 15 seconds, and 20 seconds on each water pumps in Tank A and Tank B. The test was repeated five times for each time duration and the original water level in both Tank A and B were fixed at 1100ml. The left-over amount in the tank will be compared with the amount in the measuring tank. Table 1 and Table 2 show the results obtained while the results are then implemented into a bar chart as shown in Figure 7 and Figure 8.

Table 1: Results of Water Pump Tank A Functionality Test

No. of Experiment	Push Button Pressed Time Duration (sec.)	Left-over amount in Tank A (ml)	Amount in Measuring Tank A (ml)
1		800	250
2		850	200
3	5	750	300
4		790	310
5		880	190
1		800	280
2		800	250
3	10	800	250
4		780	300
5		800	250
1		700	350
2		700	400
3	15	690	410
4		700	350
5		700	390
1		650	430
2		620	480
3	20	600	500
4		620	480
5		610	490

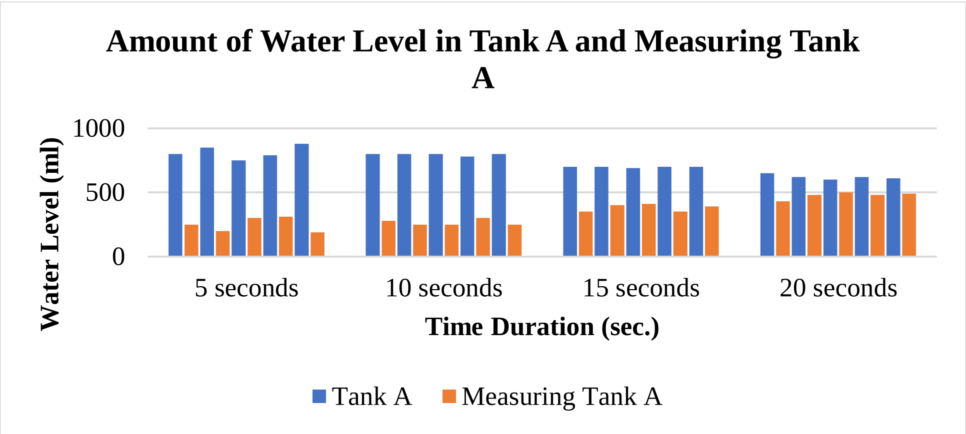

Figure 7: Comparison Chart for Water Pump Tank A

Table 2: Result of Water Pump Tank B Functionality Test

No. of Experiment	Push Button Pressed Time Duration (sec.)	Left-over amount in Tank B (ml)	Amount in Measuring Tank B (ml)
1		800	300
2		880	220
3	5	900	200
4		840	250
5		900	200
1		800	300
2		710	400
3	10	800	300
4		800	300
5		750	350
1		650	430
2		680	400
3	15	680	400
4		670	430
5		650	440
1		600	500
2		540	550
3	20	560	530
4		510	590
5		600	500

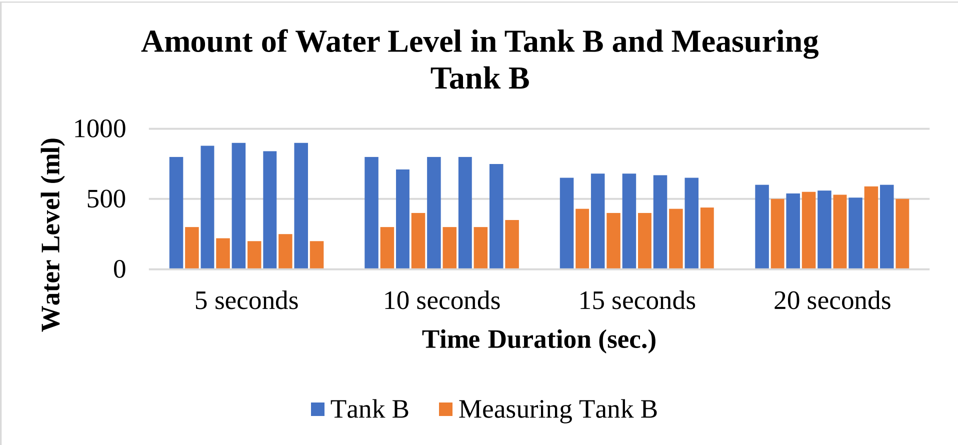

Figure 8: Comparison Chart for Water Pump Tank B

As a result, the functionality of water pumps was consistent where there are no huge fluctuations in one category of time duration. The similarity of both water pumps in tank A and tank B were at the first 5 seconds and 10 seconds, the speed of the water pump was not stable as compared to 15 seconds and 20 seconds of time duration pumping water. The possible explanation for this might be related to the power supply voltage where it will affect the water pump working current since the input of the 5v DC power supply also connects to another four-water pump. Other than that, this also could be explained by the pipework pressure loss as the pipe diameter and length will greatly affect the system pressure drop [16] and therefore this possibility should be taken into consideration when looking at the aspect of energy improvements. However, the minor difference that occurred will not give much impact to the whole system working where we could say that the water pumps in both tank A and tank B having high consistency to measure the fertilizer ratio accurately.

In the second experiment, the automated water pump located at Measuring Tank A and B were automated as when the water level sensor measuring tank detected the required water level amount, it will then trigger the relay to turn on the water pump in the measuring tank. In this experiment, time taken for the water pump in Measuring Tank A and B from 700ml to 200ml was recorded. When the water level sensor is detected, it will trigger the respective relay water pump and the time will be taken when the water pump in measuring tank turned on. Table 3 and Table 4 show the recorded results then implemented into a line chart as in Figure 9.

Table 3: Results of Time Taken for Water Pump Measuring Tank A

No. of Experiment	Time Taken (secs.)
1	22.67
2	22.49
3	22.22
4	22.64
5	23.29
6	22.57
7	22.83
8	23.26
9	27.55
10	22.38

Table 4: Results of Time Taken for Water Pump Measuring Tank B

No. of Experiment	Time Taken (secs.)
1	30.42
2	27.73
3	29.86
4	30.32
5	31.36
6	29.92
7	27.01
8	29.74
9	32.82
10	31.83

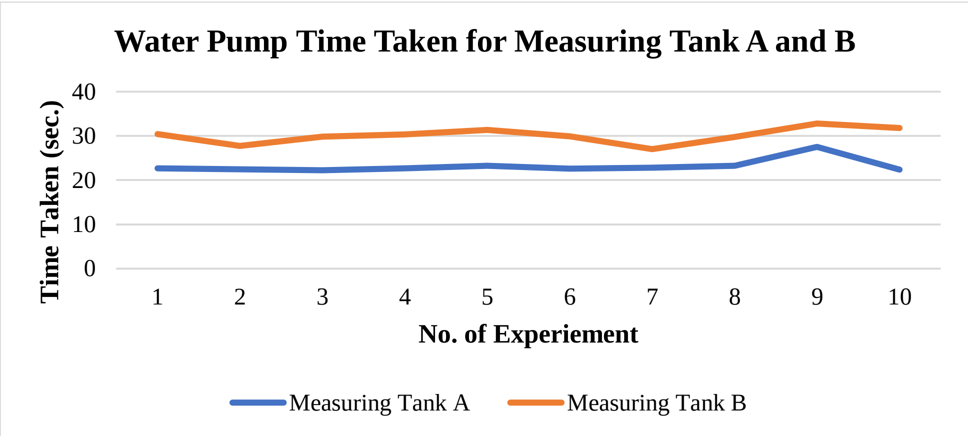

Figure 9: Comparison of Water Pump Time Taken for Measuring Tank A and B

In this experiment, we observed the time taken of the water pump for Measuring Tank A to reach the 500ml water level pumping was at an average of 30 seconds. Whereas the time taken for the water pump for Measuring Tank B to reach the 500ml water level pumping was an average of 20 seconds. As mentioned earlier, the automated water pump located in Measuring Tank A and B will be triggered with the pre-programmed water level sensors. This measure was important because we will take the time taken to set the delay timer for the water pump. The delay timer functioned as delay the water pump to keep the water pump on until the delay timing finished. As the water pump will be triggered by the relay, therefore the delay timer was inserted before digitally write the relay into low means turn off the water pump. This method greatly avoids the break off of delivering the measured ratio into the mixer tank which will in consequence affect the mixed fertilizer TDS value.

In the third experiment, we conducted on testing the effects on TDS level on mixing various ratios. Two scenarios experiment will be carried out which the first scenario will be preparing a 1000ml fertilizer A as the main fertilizer then slowly adding fertilizer B to mix them and check for the TDS value. Same in the second scenario, we prepared 1000ml fertilizer B as the main fertilizer then slowly add fertilizer A. Table 5 and Table 6 presented recorded results and Figure 10 shows comparison results.

Table 5: Mixing Fertilizer A at Constant Ratio

No of Experiment	Ratio A: Ratio B	Mixed TDS value (ppm)
1	10:0	680
2	10:1	640
3	10:2	625
4	10:3	609
5	10:4	594
6	10:5	582
7	10:6	582
8	10:7	579
9	10:8	562
10	10:9	550
11	10:10	547

Table 6: Mixing Fertilizer B at Constant Ratio

No of Experiment	Ratio B: Ratio A	Mixed TDS value (ppm)
1	10:0	440
2	10:1	479
3	10:2	482
4	10:3	492
5	10:4	513
6	10:5	527
7	10:6	531
8	10:7	539
9	10:8	547
10	10:9	549
11	10:10	556

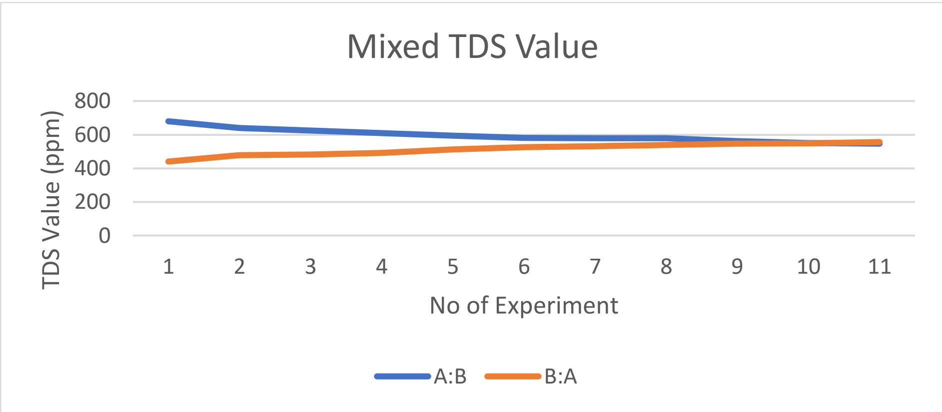

Figure 10: Mixed TDS Value of Fertilizer A and Fertilizer B in Different Ratios

From the line chart implemented as shown in Figure 10, the concentration points of both fertilizer A and B at the ratio of 1:1 is around 550ppm which is within the vegetable leafy plants optimum TDS range. Even though we were able to mix both fertilizers in different ratio to reach the optimum range, but a balanced nutrient contents delivered to the vegetable plant more considerable.

Lastly, the final test conducted was to check on the monitoring system surrounding the vegetable plant through the Blynk platform. These readings were taken twice per day for 1 week which presented in Tables 7 and 8 respectively. The aim of the experiment is to observe the soil moisture level, temperature, and humidity during the day and nighttime. From the results implemented as shown in Figures 11,12, and 13, the temperature and soil moisture during daytime were higher than at nighttime. The reason could be explained temperature was higher during daytime was because of the daytime sunlight and the lack of humidity causing the temperature high. To explain the huge fluctuation difference in soil moisture level, this is because after undergoing a day of absorption and evaporation, the soil moisture during night time significantly showed less than in daytime which left around only 10% of moisture level.

Table 7: Observation Results of Surrounding Condition on Vegetable Plant in Daytime

	Temperature	Humidity	Soil Moisture
Day1	34.7 °C	58%	29%
Day2	37.5 °C	69%	30%
Day3	27.1 °C	92%	30%
Day4	33.8 °C	74%	39%
Day5	33.8 °C	78%	35%
Day6	32.8 °C	70%	28%
Day7	32.3 °C	77%	33%

Table 8: Observation Results of Surrounding Condition on Vegetable Plant in Night-time

	Temperature	Humidity	Soil Moisture
Day1	26.7 °C	77%	6%
Day2	29.8 °C	89%	4%
Day3	27.6 °C	93%	11%
Day4	27.1 °C	90%	10%
Day5	28 °C	84%	9%
Day6	27.1 °C	89%	11%
Day7	26.3 °C	91%	2%

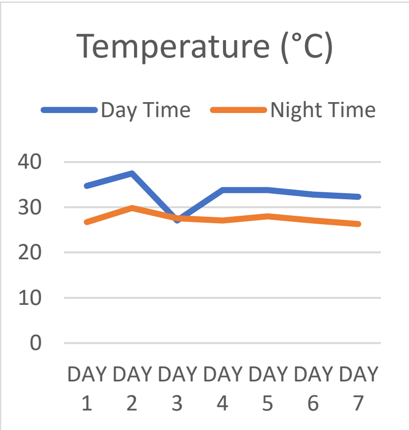

Figure 11: Comparison of Temperature

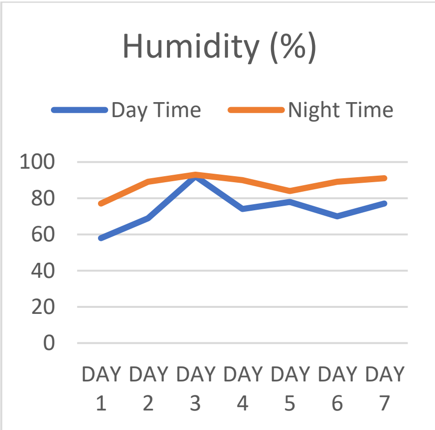

Figure 12: Comparison of Humidity

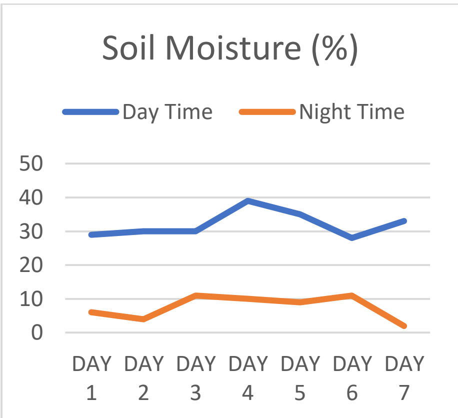

Figure 13: Comparison of Soil Moisture

Generally, the aim of those experiments was to determine the functionality of actuators with respects to the sensors. The first experiment on testing the functionality of the water pump in Tank A and B as a result the rate of the water pump motor in both Tank A and B is constant. After that, the results of the experiment in testing the time taken for the water pump in Measuring Tank A and B showed that the time taken for the water pump in Measuring Tank A was at average of 30 seconds while in Measuring Tank B was at average of 20 seconds. This measure was important because we will take the time taken to set the delay timer for the water pump. Besides that, the results testing mixing various ratios of fertilizer A and B proved that with a ratio of 1:1 can provide the optimum range of TDS value required by the vegetable plants. The final experiment conducted was about testing the monitoring system of the surrounding condition of vegetable plants through Blynk platform. The sensor values were updated every 1 second therefore user was able to monitor the condition from time to time. The device that uses Blynk applications must connected to the same Wi-Fi as configured in the NodeMCU ESP8266 microcontroller for Blynk server to connect with NodeMCU through the authentication code.

4. Conclusion

Based on the finding of the experiments, the Fertilizer Measuring Machine can optimize its functionality in the vegetable plant growing industry. As most of fertigation systems used only a tank of fertilizer and a water pump to distribute the solution, this measuring machine will be able to provide convenience for users to measure the ratio of fertilizer automatically using only water level sensors and a water pump. This kind of simple actuator and sensor will greatly reduce the cost of the vegetable growing industry field especially for fresh entrepreneur in agriculture. Other than that, the monitoring system was developed to help in monitoring the soil moisture, temperature, and humidity. It optimized the works to enable user to monitor wirelessly through mobile phone. The features make these research sustainable option to be considered to improve the agriculture and fertigation efficiency.

All objectives were successfully achieved where the fertilizing tool was developed by using a water pump, water level sensor, LED indicator and program to control the ratio of fertilizer. The water pump deliver fertilizer from the tank to measuring tank, stop pressing the water pump once LED indicator turns from red to blue. This means that the ratio of fertilizer reached the required level according to the program. The monitoring system for observing the humidity and moisture level surrounding the vegetable plants was developed using various sensors and the Blynk platform for wireless monitoring purposes. The notification system was built simply using an LED indicator to observe when the conditions of water level and TDS value in the mixer tank are detected out of the required range. LCD was also built in together with an LED indicator to monitor the current water level in the main tank and the TDS level in the mixer tank.

4.1 Impact of Engineering Technology Solutions

There are a few impacts of fertilizer measuring machine in the factor of social, economic sustainability, public health and safety, industry, and environment. In the factor of social, this fertilizer measuring machine could be used as a home-use machine because of the small-scale size and simple operation. After that, this fertilizer measuring machine able to maintain economic sustainability which increases the efficiency usage of water and fertilizer, therefore reduce the fertilizer inputs and reducing production costs. Other than that, the crops produced will have sufficient nutrients which leads to healthy public health and safety because the ratio of fertilizer pump to the vegetable plants were measured. Furthermore, with the use of fertilizer measuring machine in the industry field, it will greatly reduce the cost of hiring manpower but therefore increase the cost of electricity because the system needs to be powered by electricity. Finally, the impact on environmental factors is by having this kind of machine, we could reduce foliar disease which can minimize the leaf wetness which caused by too much contact between plant leaves and wet dirt; therefore, an automated irrigation water system will treat this disease.

4.2 Recommendations

Even though all the objectives of this project were reached and achieved, there are still several limitations and suggested improvements to enhance the functionality of the measuring machine. For instance, we can modify the measuring system into a fully autonomous measuring machine which all the motors will automatically deliver and mix the fertilizer using the timer techniques. In another way, this measuring system can also be modified into wirelessly control the mixing process through various platforms which user able to trigger the mixing process by using a mobile phone. Other than that, replacing the water level sensor with an ultrasonic sensor will be able to increase the efficiency of water level amount detection in the tank as water level sensor not suitable for huge and deep tank [17]. Another replacement will be replacing the water pump in measuring tank with a solenoid valve to avoid the problem in such the minimum water level that for the water pump to function normally will create fertilizer wastage problem. Finally, the monitoring platform can be modified into storing data and data analysis rather than only real-time monitoring. The benefits of storing data and data analysis were users able to refer to the data of previous times so that the conditions of vegetable plants can be known through analysis of previous data.

Acknowledgement

The authors would like to thank the Faculty of Engineering Technology, Universiti Tun Hussien Onn Malaysia for its support.

References

[1] D. F. Jacobs and V. R. Timmer, “Fertilizer-induced changes in rhizosphere electrical conductivity: Relation to forest tree seedling root system growth and function,” *New For.*, vol. 30, no. 2–3, pp. 147–166, 2005, doi: 10.1007/s11056-005-6572-z.

[2] Sisay Assefa, "The Principal Role of Organic Fertilizer on Soil Properties and Agricultural Productivity -A Review," Agri Res& Tech: Open Access J. 2019; 22(2):556192, doi: 10.19090/ARTOAJ.2019.22.556192.

[3] P. Vejan, R. Abdullah, T. Khadiran, S. Ismail, and A. Nasrulhaq Boyce, “Role of plant growth promoting rhizobacteria in agricultural sustainability-A review,” *Molecules*, vol. 21, no. 5, pp. 1–17, 2016, doi: 10.3390/molecules21050573.

[4] Prasad, R., Jain, V.K., & Varma, A, "Role of nanomaterials in symbiotic fungus growth enhancement," *Current Science*, 99(9), pp. 1189-1191.

[5] M. Kumari, “iot-enabled-smart-irrigation-system-monitoring-and-water-harvestingin-different-soils-IJERTV10IS030261,” vol. 10, no. 03, pp. 545–552, 2021.

[6] Nur Fatiehah Iylia Binti Muhamad Ilias, “a Web Based System for Lost and Found Items System Using Rfid and Email Notification,” no. July, 2020, [Online]. Available: https://ir.uitm.edu.my/id/eprint/45937/1/FullText 45937.pdf

[7] L. Raju, A. Swetha, C. K. Shruthi, and J. Shruthi, “IoT based Demand Side Management using Arduino and MATLAB,” *Proc. - Int. Conf. Smart Electron. Commun. ICOSEC 2020*, no. Icosec, pp. 823–829, 2020, doi: 10.1109/ICOSEC49089.2020.9215314.

[8] S. Pasha, “Thingspeak Based Sensing and Monitoring System for IoT with Matlab Analysis,” *Int. J. New Technol. Res.*, vol. 2, no. 6, pp. 19–23, 2016.

[9] P. Kronenberg, P. K. Rastogi, P. Giaccari, and H. G. Limberger, "Relative humidity sensor with optical fiber Bragg gratings," *Opt. Lett.*, vol. 27, no. 16, p. 1385, 2002, doi: 10.1364/ol.27.001385.

[10] S. F. Mujiyanti, S. N. Patrialova, M. F. Febrian, and M. Kartika, "Design and Implementation of Nutrition Control System for Optimization of Hydroponic Plant Growth," *2021 Int. Conf. Adv. Mechatronics, Intell. Manuf. Ind. Autom. ICAMIMIA 2021 - Proceeding*, pp. 52–57, 2021, doi: 10.1109/ICAMIMIA54022.2021.9807772.

[11] D. Eridani, O. Wardhani, and E. D. Widianto, "Designing and implementing the arduino-based nutrition feeding automation system of a prototype scaled nutrient film technique (NFT) hydroponics using total dissolved solids (TDS) sensor," *Proc. - 2017 4th Int. Conf. Inf. Technol. Comput. Electr. Eng. ICITACEE 2017*, vol. 2018-Janua, no. January 2018, pp. 170–175, 2017, doi: 10.1109/ICITACEE.2017.8257697.

[12] A. Nursyahid, H. Helmy, A. I. Karimah, and T. A. Setiawan, "Nutrient Film Technique (NFT) hydroponic nutrition controlling system using linear regression method," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1108, no. 1, p. 012033, 2021, doi: 10.1088/1757-899x/1108/1/012033.

[13] "Temperature and Humidity Sensor on an Arduino".

[14] M. Soliman, T. Abiodun, T. Hamouda, J. Zhou, and C. H. Lung, "Smart home: Integrating internet of things with web services and cloud computing," *Proc. Int. Conf. Cloud Comput. Technol. Sci. CloudCom*, vol. 2, pp. 317–320, 2013, doi: 10.1109/CloudCom.2013.155.

[15] R. Olomo and O. Osemwegie, "Arduino Based Traffic Light System with Integrated LED Advertising Display," *J. Phys. Conf. Ser.*, vol. 1378, no. 4, 2019, doi: 10.1088/1742-6596/1378/4/042079.

[16] V. Savić, D. Knežević, D. Lovrec, M. Jocanović, and V. Karanović, "Determination of pressure losses in hydraulic pipeline systems by considering temperature and pressure," *Stroj. Vestnik/Journal Mech. Eng.*, vol. 55, no. 4, pp. 237–243, 2009.

[17] S. L. Mohammed, A. Al-Naji, M. M. Farjo, and J. Chahl, "Highly Accurate Water Level Measurement System Using a Microcontroller and an Ultrasonic Sensor," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 518, no. 4, 2019, doi: 10.1088/1757-899X/518/4/042025.