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An Efficient Technique for Automation of The NFT (Nutrient Film Technique) Hydroponic System Using Arduino

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ABSTRACT

Hydroponic Nutrient Film Technique (NFT) is most widely applied on a home and industrial scale. One of the drawbacks of the NFT hydroponic system is that it is very dependent on electricity for 24 hours to power the water pump. The basic principle of the NFT hydroponic system is to flow nutrients to plant roots with a shallow and circulating nutrient layer so that plants get enough water, nutrients, and oxygen. Therefore, the role of the water pump in the hydroponic NFT system is crucial. This research makes the automation of the NFT hydroponic system more efficient using Arduino. There are two main parts to this automation system: the control of pH levels and nutrient distribution. The pH sensor is used to control the pH level of nutrients, and the ultrasonic sensor is used for nutrient distribution. Efficiency is emphasized more on the distribution of nutrients because it absorbs more electrical energy. The method used is to flow the nutrients in the reservoir to a storage tank that is located higher than the plant using a water pump with a large discharge. Nutrients are transported to each plant using the force of gravity. The nutrient volume is controlled automatically using an ultrasonic sensor in the storage tank. The water pump is only activated by the ultrasonic sensor readings on the storage tank. So that the need for electricity to turn on the water pump is reduced, based on tests carried out on the use of a 220-volt AC / 50 Hz / 125-watt water pump and the use of a 250-liter nutrient storage tank, it can be concluded that the system that has been created can save 70% of electricity consumption.

Keywords : Hydroponic; Nutrient Film Technique, Arduino

Article History

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I. INTRODUCTION

Naturally, humans need food to survive. The number of human populations is increasing from year to year. Population growth results in increased demand for food and reduced agricultural land. This problem, of course, must be resolved. The right solution is to apply hydroponics. Hydroponics is a method of cultivating plants by utilizing water and emphasizing fulfilling the nutritional needs of plants without using soil media. Therefore, hydroponics is also known as a soilless culture. So it is very suitable to be applied to limited land, extreme weather, even in areas with a limited water supply.

Hydroponics can be used in both agricultural and home environments to be used as an alternative to conventional farming. There are several hydroponic planting techniques hydroponic system, drip system, nutrient film technique, EBB & flow system, water culture, and wick system [1] [2]. However, farming using a hydroponic system also has its challenges to do. Farming with a hydroponic system requires special care regarding various parameters to provide good and satisfying yields. The main parameter that needs to be considered in the hydroponic system is nutrition. Furthermore, the distribution of nutrients to each plant is according to the hydroponic technique used.

The hydroponic system has both advantages and disadvantages. The problem that must be considered in a hydroponic system is the supply of electricity and nutrients that must be controlled continuously [3]. Nutrients must be maintained within the range required by the plant. The absence of electricity supply for a long time causes the roots of the plants to dry out, and the plants will die. People who are busy with various activities often find it difficult to monitor and control their hydroponic plants. Previous researchers have done various ways to solve this problem, namely: controlling pH levels [4] [5] [6] [7] [8] [9] [10] [11], hydroponic system automation [12] [13] [14] [15] [16], dan monitoring system [17] [18] [19].

This research specifically refers to the hydroponic system that is most widely used, namely Nutrient Film Technique (NFT). NFT are widely used because they are considered the most suitable for industrial-scale compared to other systems. The advantages of NFT are adequate water supply, uniform nutrient concentration can be adjusted according to plant age, and plants grow faster.

One of the drawbacks of the hydroponic NFT system is that it requires a full day of electricity to run the water pump to deliver water and nutrients to the plants. Many previous studies have attempted to automate hydroponic NFT systems [6] [9] [11] [20]. However, previous research has only limited automation of nutritional control and monitoring. Meanwhile, the automation of the NFT hydroponic system is still working for 24 hours.

This study has developed an integrated design for the hydroponic NFT system that is more efficient in consuming electricity using Arduino. This is important to save the operational costs of cultivating plants with the hydroponic NFT system. By saving on operational costs, the profits will be even greater. So that people are increasingly interested in farming with the NFT hydroponic system.

II. METHOD

This study consists of two stages. It consists design of hardware and software. Hardware design discusses NFT hydroponic installations and electronic control devices. The software design discusses the algorithm that is applied to a system built using the Arduino program code.

A. Hydroponic Nutrient Film Technique (NFT) Installation Design.

The design of the NFT hydroponic installation is in the form of a prototype, which includes a 5-liter capacity nutrient tank, reservoir, irrigation system, hydroponic plant growth, tray/channel, and some electronic devices. Modul dimensions of 1 meter high, 0.5 meters wide, and 1 meter long with four plant holes. This hydroponic installation prototype uses Rockwool as a growing medium for lettuce plants. The nutrition tank and reservoir are made of Poly Vinyl Chloride (PVC) plastic with the same capacity. In the reservoir, there is an air pump that functions to increase oxygen levels in nutrients. When the reservoir is fully filled with nutrients, an AC current water pump is used to distribute the nutrients to a higher storage tank than the plants. The use of an AC current water pump is intended so that the nutrient liquid can be distributed in large enough quantities. Then the nutrients will automatically flow to each plant due to the force of gravity. Fig. 1 is a schematic diagram of hydroponic NFT installation.

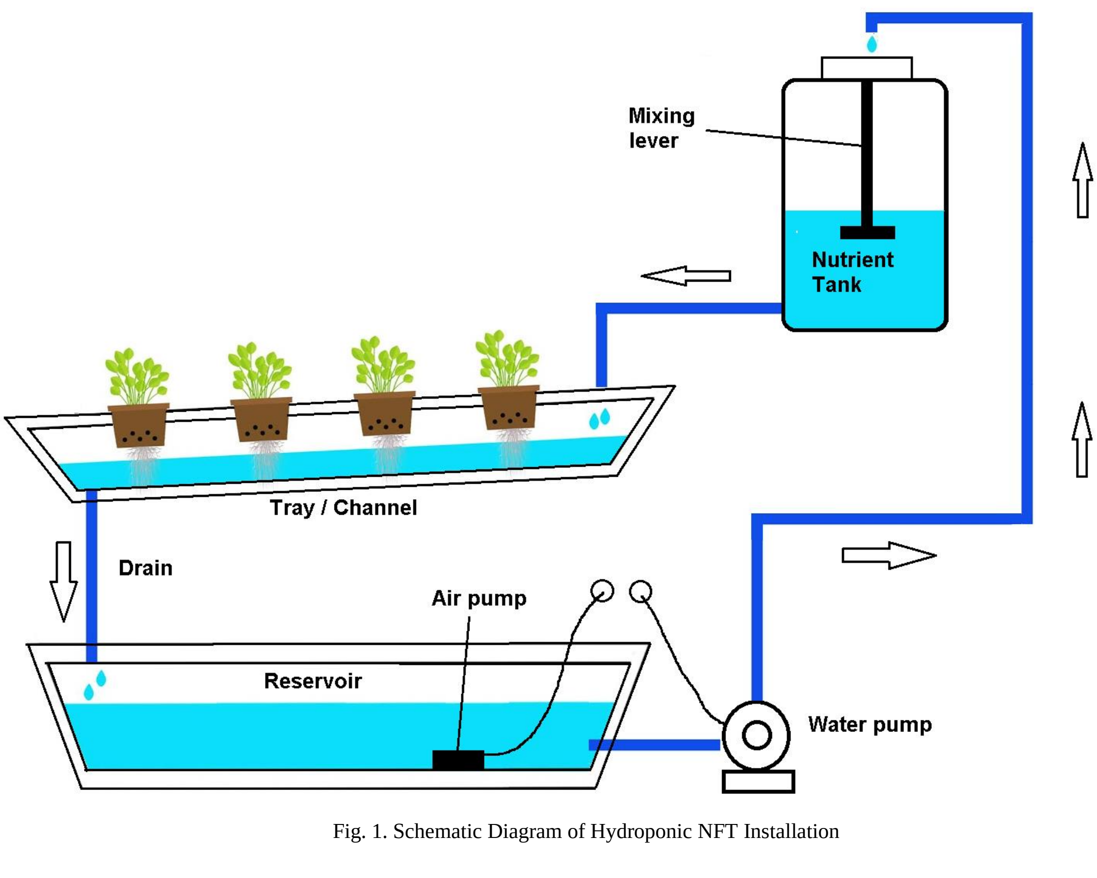

Fig. 1. Schematic Diagram of Hydroponic NFT Installation

B. Hardware Design Hydroponics System Controller

In this study, the hydroponic control system consists of two parts. The first part is a system for monitoring and regulating nutrient pH levels. The potential of Hydrogen, abbreviated as pH, is used to express the level of acidity or alkalinity in a liquid. The hydrogen ion activity coefficient cannot be measured experimentally, so its value is based on theoretical calculations. The pH scale is not an absolute scale. It is relative to a set of standard solutions whose pH is determined according to international agreements. Pure water is neutral, with its pH at 25 ° C set as 7. Solutions with a pH of less than seven are said to be acidic, and solutions with a pH of more than seven are said to be alkaline. The nutrient pH monitoring and adjustment system use a pH sensor to measure the pH level in the nutrient tank. The pH level of a nutrient is read by a pH sensor, where the output from this sensor is used to control the solenoid channel pH Up, pH Down, and Mixer Relay. Both pH and solenoid sensors are integrated modules in one system controlled using a microcontroller. The microcontroller is a functional computer system on a chip. It contains a processor core, memory (a small amount of RAM, program memory, or both), and input-output equipment. In other words, a microcontroller is a digital electronic device that has input and output as well as control with a program that can be written and erased in a special way [21]. This research, using a microcontroller that has been integrated with the Arduino Uno module. The design of the hydroponic nutrient pH regulator is shown in the form of a schematic diagram in Fig. 2.

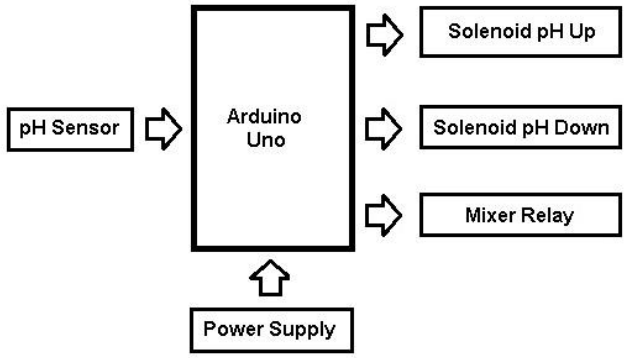

Fig. 2. Schematic Diagram The Hydroponic Nutrient PH Regulator.

The second part is the control of hydroponic nutrient distribution. In this section, a more efficient nutrient distribution control scenario in hydroponic systems is developed. The nutrient distribution system does not require a water pump working continuously for 24 hours. The system works by draining the nutrient liquid from the reservoir to a storage tank located higher with the plants using a water pump. The water pump will activate if the water in the nutrient storage tank is low. The ultrasonic sensor is used to detect the water level in the storage tank. The water pump will stop if the water in the nutrient storage tank is almost complete. Arduino Uno is used as a controller. A schematic diagram of hydroponic nutrient distribution control is shown in Fig. 3.

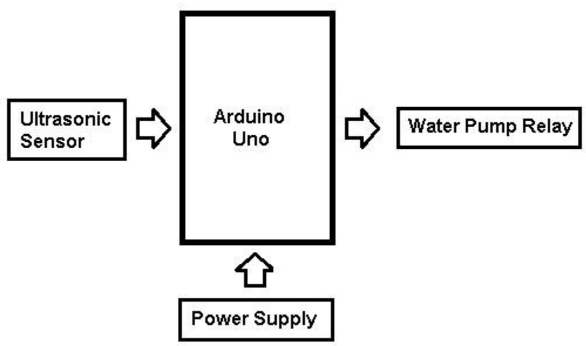

Fig. 3. Schematic Diagram of Hydroponic Nutrient Distribution Control.

C. Software Design

The software is designed using the Arduino IDE software. The design of the software consists of two parts. The first step, the design of hydroponic nutrition automatic control software. Hydroponic nutrition control starts from the pH sensor reading. An automated hydroponic nutrient control system will maintain the pH in the range of 6-7. If the pH level of the liquid in the storage tank is below 6, then the data read by the sensor is processed by Arduino then Arduino activates a signal to the solenoid valve pH up. Next, Arduino will activate the mixer relay signal. If the pH level of the liquid in the storage tank is above 7, then the data read by the sensor is processed by Arduino then Arduino activates a signal to the solenoid valve pH down. Next, Arduino will activate the mixer relay signal. The flowchart of the hydroponic nutrient pH regulator is shown in Fig. 4.

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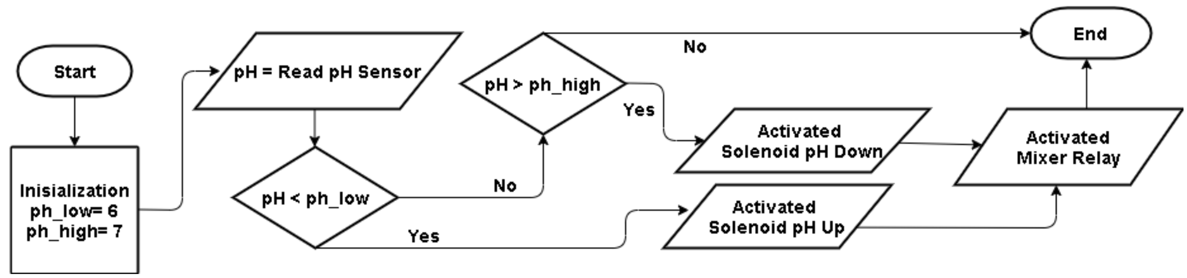

Fig. 4. The Flowchart of The Hydroponic Nutrient PH Regulator.

The second part is designing the distribution of hydroponic nutrients. The distribution of hydroponic nutrients starts from the initialization of the low and high variable readings of the ultrasonic sensor in the storage tank. If the liquid level in the storage tank has reached a low level, Arduino will process the incoming data and send a signal to activate the water pump relay to turn on. If the liquid level in the storage tank has reached a high level, Arduino will process the incoming data and send a signal to deactivate the water pump relay so that the pump will stop. The flowchart of nutrient distribution in the hydroponic system is shown in Fig. 5.

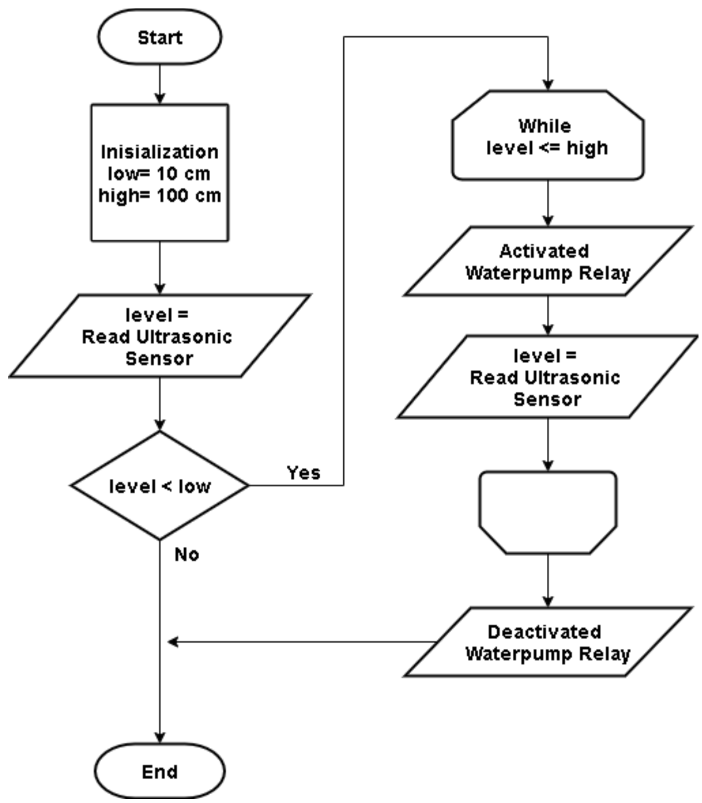

Fig. 5. The Flowchart of Nutrient Distribution In The Hydroponic System.

III. RESULT AND DISCUSSION

The efficiency of electricity consumption in the NFT hydroponic system automation emphasizes using an AC electric pump as the main component in the NFT hydroponic system. The water pump used is a water pump (AC 220 volt / 50Hz / 2900 Rpm / 125 watts). Nutrient storage tank with a volume of 250 liters. The measurement and analysis results obtained in this study are described in the following sub-chapters.

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A. Analysis of Pump Water Discharge Measurement

Measurement of the water flow produced by the pump is done by turning on the water pump for 1 minute, then measuring the volume of water that has been sucked from the reservoir to the nutrient storage tank. The results of measuring the volume produced by the pump are shown in Table I.

TABLE I
MEASUREMENT OF THE WATER PUMP VOLUME

Test	Time (minutes)	Volume (liter)
1	1	18,2
2	1	18,2
3	1	18,2
4	1	18,2
5	1	18,2

B. Analysis of Water Pump Power Consumption

The unit of electric power used in everyday life is KWh (KiloWatt Hour). The State Electricity Company uses this unit in calculating the cost of using its customers. To determine the electrical power consumption of electronic devices, it is necessary to know the length of time the electronic device is used. The conversion of total Watt usage of electronic devices into kWh values is: each Watt used for 1 (one) hour must be divided by 1,000 (kilo). If a 125-watt water pump works for 24 hours, you will get 3 KWh per day. Based on table 1, it takes 0.0379 KWh to fill the 250-liter nutrient storage tank. If the distribution of nutrients is 25 liters per hour, then every 10 hours, the pump will work, and a day requires 2.4 x 0.0379 KWh or 0.9 KWh. So, it can be used by using a storage tank of 0.9 / 3 x 100% = 30%. That way, it can save power by 70%.

IV. CONCLUSION

Based on tests carried out using a 220-volt AC / 50 Hz / 125-watt water pump, and a 250-liter nutrient storage tank. An AC water pump has a flow rate of 18.2 liters per minute and can fill a 250-liter storage tank for 13.7 minutes. Hydroponic system automation using nutrient storage tanks can save electricity consumption by 70%.

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