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Controlling System in Smart Agriculture for Automatic Monitoring of Plant Nutrition

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ABSTRACT

Technological developments have had a major impact on the lifestyle of Indonesian people through sophisticated communication tools such as smartphones and gadgets. However, the use of this technology is still not optimal. In the Indonesian context, computer and information technology, especially Intelligent Systems, has changed the way people work, interact and live. One significant implementation of Smart Systems is Smart Agriculture, which uses information and communication technology to increase agricultural productivity. The application of Greenhouse technology and hydroponic methods in agriculture supports more efficient and productive plant growth. The use of TDS sensors to measure nutrient concentrations in water in the hydroponic method helps ensure optimal conditions. In this research, the automation of providing nutrition to lettuce plants has been carried out well according to predetermined conditions. The solution to solve the problem that occurs is to use an automatic nutrition system. This system can control the amount and frequency of nutrients provided accurately and efficiently, without depending on the skill and caution of the hydroponic farmer. In addition, this system also ensures that nutrients are provided consistently and safely for farmers and the environment. This technology utilizes sensors and automation systems to monitor nutritional conditions in the planting media in real-time and farmers can ensure that their plants receive the nutrients they need and have maximum yields. This system also helps farmers speed up the plant growth process and saves time and energy.

INTRODUCTION

Technological developments that have led to the emergence of various sophisticated communication tools such as smartphones and gadgets have caused changes in the lifestyle of Indonesian people. However, society has not yet taken full advantage of technological advances (Pramartaningthyas, Ma'shumah, and Faud 2022). The development of the times determines the development of technology that takes advantage of the situation to advance the country, especially Indonesia. Increasing technology and information in the field of computers are able to develop efficiency and effectiveness in carrying out various scientific and technological work and have changed human life today. Almost every industry is supported by artificial intelligence, and the 4th generation industrial revolution always brings human life side by side with intelligent systems (Smart Systems) (Susanto, Dwisvimiar, and Agustina 2023).

The use of a greenhouse in hydroponic planting is as a place of protection and prevention from pests, diseases and insects that can attack plant growth. Greenhouses are often used for hydroponic plants because the use of greenhouses is safe to prevent pests, the use of greenhouses is very profitable for hydroponic plants (Fuada et al. 2023).

Hydroponic treatment mainly involves providing nutrition because nutrients are food for plants. Not only nutrition, there are many things that must be considered when caring for hydroponic plants in a greenhouse, such as greenhouse room temperature, water pH or water quality, irrigation for hydroponic plants which must flow 24 hours non-stop, pests or insects and providing nutrition to plants that must be monitored every day(Darmawan, Kumara, and Khrisne 2022).

Providing nutrition to each type of plant is different and the tool used is a TDS (Total Dissolved Solid) sensor to measure the amount of PPM (Parts Per Million) solution and the nutrients used AB Mix is a mixture consisting of various nutrients and minerals. which plants need in organic form (ANDRIANTO and SURYANINGSIH 2023). These nutrients function to replace complex compounds needed by plants in the food production process, and the method used to deliver these nutrients is through Deep Flow Technique (DFT) (Pamungkas, Rahardjo, and Raka Agung 2021). DFT is a system in hydroponic cultivation that uses standing water in the installation system. This installation has a flat shape so that it can keep the nutrient water stagnant at a height of around 4-6 cm, or the size can be equivalent to a quarter of the diameter of the pipe used (Bonde, Ludong, and Najoan 2021). Researchers have conducted research at Friends of Hydroponics by asking several questions that support my research on nutrition, especially on hydroponic plants with a value of 900-1000 PPM with nutrition being given more or less, giving nutrition to plants every morning with a ratio of 1L of water to 5ml of nutrients, The storage tank for nutrition contains 55L of water and for the nutrition given 275ml of

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nutrient A 275ml of nutrient B for a total of 550ml AB Mix.

The nutrition given must be precise, neither more nor less, if it is too much or not enough, the plants will easily rot, dry out and can cause crop failure, the nutrition given every day is often miscalculated and does not match the plant's needs which affects plant growth and hydroponic plant cultivators. having to provide nutrition to several different types of plants which will require a lot of time and effort (Wati and Sholihah 2021).

LITERATURE REVIEW

AB Mix nutrients are nutrients that are generally used in hydroponic systems. This nutrition is also called special nutrition because it meets the nutritional needs of hydroponic plants which are different from plants that grow in soil media. AB Mix nutrition consists of two parts, namely Nutrient A and Nutrient B, each of which has its own role in providing the nutrients needed by plants (Fadhilah and Hardjianto 2022). Nutrient A in AB Mix has a high nitrogen content, which is very important for the growth of plant leaves and stems. In addition, the phosphorus content in nutrient A plays an important role in root formation and the formation of flowers and fruit. Meanwhile, the potassium content in nutrient A helps plants to withstand environmental stress, improves fruit quality, and increases plant resistance to disease. Nutrient B in AB Mix contains micro elements that are really needed by plants. The boron content in nutrient B helps in the formation of plant cell walls, while the copper and iron content helps in the processes of photosynthesis and respiration. In addition, the manganese content in nutrient B is useful for the formation of chlorophyll and photosynthesis, while iron plays an important role in root formation and chlorophyll formation (Hariono and Fajriyah 2021). In hydroponic systems, AB Mix is generally used in certain doses, which vary depending on the type of plant and growth stage. It is important to pay attention to the nutrient dosage used, because doses that are too high or low can negatively affect plant growth. Therefore, it is important to understand the nutritional needs of plants and follow the appropriate instructions for use to get optimal results from using AB Mix nutrients in a hydroponic system.

Hydroponics is a technique for growing plants using water without soil, referring to techniques for managing water and nutrients according to plant needs so that they are absorbed by plant roots for optimal growth (Marisa, Carudin, and Ramdani 2021). Several plants have been proven to be able to grow in hydroponic systems supplied with water, so hydroponics is a promising technology for water treatment and food production. Plants that are usually grown in hydroponic media are mustard greens, lettuce, bok choy, kale, red spinach, mint leaves, siomak, padoga, caisim and many more. The care for each plant is different (Rustan 2021).

Smart System is a design pattern consisting of interrelated components to achieve a goal with a way of working that makes things easier for humans, with a smart way of working that will give birth to innovation. Smart system technology utilizes sensor and computer technology to monitor and control various processes automatically. This will help reduce human error and ensure that the system works well and efficiently (Nadhiroh et al. n.d.). Smart system technology is always experiencing continuous development and change, where smart systems need to be used in every field of life so that it is of course very profitable in daily activities. Smart systems are very necessary in any field of work, especially in agriculture (Wardhana and Pramusinto 2023). With the help of smart systems, agriculture in Indonesia will become very sophisticated and Indonesian agriculture will become smart agriculture or Smart Agriculture(Priono and Sujono Putro 2024).

Smart agriculture is an idea in agriculture that uses information and communication technology to increase production results, efficiency and effectiveness in the agricultural industry. The very important presence of agriculture in Indonesia is emphasized by the country's geography which is located right along the equator, creating tropical climatic conditions that support it. The existence of vast agricultural land around us is also proof that agriculture plays a major role in this country's economy (Ade Maulana et al. 2023). According to data from the Ministry of Agriculture of the Republic of Indonesia in 2013, the total area of agricultural land in Indonesia was 56.5 million hectares. Farmers usually use land as a medium to develop their agricultural products. Seeing the many failures in production from conventional agricultural land, currently there is another way to utilize agricultural land as an effort to develop production results with a smart agriculture system, namely hydroponic growing media in terms of care and growth by using a greenhouse (Praptodiyono et al. 2023).

METHOD

The DFT (Deep Flow Technique) hydroponic system in Figure 1 is a farming technique that uses water as a medium continuously supplied with nutrient solution. Plant container media usually uses paralon and is very suitable for using or planting types of vegetables that grow very quickly, for example: mustard greens, lettuce and pakchoy (Pertiwi et al. 2021). This type of farming technique is very popular with modern farmers, perhaps because the DFT hydroponic system has many advantages compared to other techniques. The installation material can use PVC paralon pipe. The relatively affordable price of paralon can be used for a long time, which is very appropriate when choosing a DFT system.

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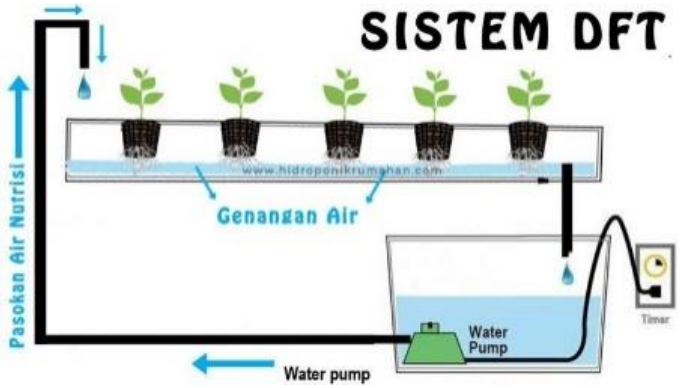


Figure 1. Deep Flow Technique

The use of paralon pipes also turns out to have advantages that are very profitable for farmers. This paralon pipe allows water to still be available when frequent power outages occur (Kamali et al. 2023). Maybe in areas that frequently experience power outages, the DFT hydroponic technique is highly recommended. If there is standing water in the PVC paralon pipe, the plants will still be able to survive and still get nutrients from the standing water. In contrast to the NFT hydroponic system which is very dependent on electricity, if a power outage occurs, the plants will wilt and even die if the power outage occurs for a very long time, even though the NFT hydroponic system is an industrial scale operation and has a lot of plants. Just imagine how much loss you will experience if there are frequent power outages and without preparing for it.

The farming system using the DFT technique is not always perfect, this technique also has several shortcomings. One of the advantages of this technique is that it saves electricity usage because the water cycle does not need to be done continuously. We can turn off the pump at certain times but not for too long. The supply of nutrients from plants can still be maintained, thereby maintaining the survival of plants until harvest (Kurniawan, Ristiono, and Sulistiadi 2021).

Researchers have visited Friends of Hydroponics in Rajabasa as a first step in observing, we conducted research at Friends of Hydroponics. The data and information we get at Friends of Hydroponics such as how to plant, how to care for plants, harvest results, and problems that exist at Friends of Hydroponics. Planting or sowing seeds is done every afternoon and covered and should not be exposed to sunlight for 2 days. There are many types of plants planted such as lettuce, mustard greens, bok choy, kale, spinach, padoga, mint leaves, caisim and many more. The planting medium used is NFT (Nutrient Film Technology) and during the treatment period it is divided into three parts, namely N1, N2 and N3 (Caniago 2023). After the sowing period, the seeds that have been sown are moved to N1 for 14 days with the same amount of nutrient solution of 800-900 PPM for all types of plants, after 14 days they are transferred to N2 for 4 days to adjust the roots to the amount of nutrient solution that varies for each type of plant. , then after adjusting the roots for 4 days it is transferred to N3 for the growing period until harvest, the average harvest period is 35 days except for lettuce plants, which is calculated from the sowing period. The harvest period at Friends of Hydroponics is carried out every day if there are orders, usually orders from supermarkets or restaurants. The harvest every day is around 200 packs weighing 200 grams and with an average price of Rp. 10,000, the largest orders are for pak choy and lettuce and in the dry season or rainy season it does not affect the harvest (stable).

When providing a nutrient solution for each plant, it should not be less or more, the nutrient used is AB Mix with a ratio of 1:5 (1L water 5ml nutrients) if 1000L water then 5L nutrients, if the nutrient calculation is not correct it will affect plant growth and the harvest could fail. Nutrition is provided as water is added to the reservoir (In hydroponic friends, nutrition is provided every morning).

Table 1. PPM Value of Hydroponic Plants

Plant Name	PPM Value
Lettuce	900 - 1000
Pakcoy	1100 - 1200
Mustard	1100 - 1200
Water Spinach	1100 - 1200
Spinach	1100 - 1200
Pandoga	1100 - 1200
Mint Leaves	1100 - 1200
Caisim	1100 - 1200

Table 1 above is a list of hydroponic plants along with the recommended PPM (Parts Per Million) values for providing nutrition to these plants. PPM is a unit for measuring the concentration of nutrients in nutrient solutions used

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to maintain hydroponic plants. The PPM values recommended in the table may vary depending on the type of plant and plant growth stage.

Lettuce has a PPM value of around 900-1000, while other plants such as Pakcoy, Mustard Greens, Kale, Spinach, Pandoga, Mint Leaves, and Caisim require a PPM value of around 1100-1200. If the PPM value is too low, the plant will not get enough nutrition and may experience suboptimal growth. However, if the PPM value is too high, the plant can experience overfeeding and can damage the plant roots. It is important to check and control the nutrient concentration in the nutrient solution regularly. This can be done by measuring the PPM value of the nutrient solution using a PPM meter and adjusting the amount of nutrients given to the plants. Apart from that, the type of nutrition used must also be adjusted to the plant's needs and the plant's growth stage.

In conclusion, the table above provides a guide to the recommended PPM values for providing nutrition to several types of hydroponic plants. It is important to check and control the nutrient concentration in the nutrient solution regularly and adjust the nutrient dosage given to the plants.

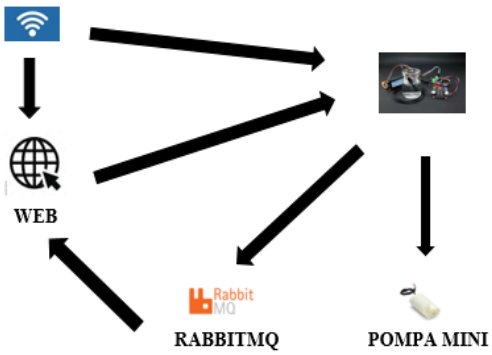


Figure 2. System Workflow

Based on Figure 2, the TDS sensor system workflow captures data processed on the NodeMCU and the data is sent to the RabbitMQ server and the data is retrieved by the web. The data that has been taken by the web will appear in real time, and the data taken by the relay functions as a signal to give orders and turn on and turn off the pump.

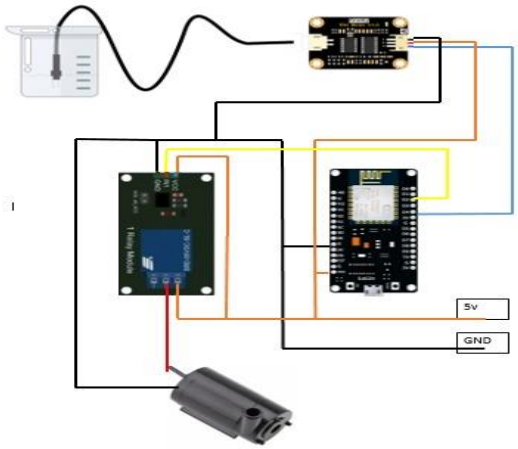


Figure 3. Sensor Device Series

Based on Figure 3, which is a picture of the hardware circuit which uses a Node MCU which is connected to a TDS sensor and a Node MCU which is also connected to a relay where the relay is connected to a 5 Volt adapter which is useful as a balancer for electrical voltage so that the flow does not flow directly from the Node MCU which causes the Node The MCU heats up quickly, causing damage to the MCU node, and the relay is also connected to a mini pump which functions if nutritional conditions are lacking and the pump will flow nutritional fluid.

RESULT

In this research, researchers have implemented a system for controlling nutrition in plants. This system will not only be used by farmers, but can be used in various aspects such as students who want to learn and develop this system. Currently researchers are developing a system for controlling nutrition in plants based on the Internet of Things (IoT) which is to help users and is operated automatically, in its development and use where tools with MAC Address

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identifiers can use the internet network as a communication medium (exchanging data). This system was created using the C programming language. In this system for controlling nutrition in plants, there are several components such as TDS (Total Dissolver Solids) sensors, relays, servers, websites. All of these components are connected to each other and communicate with each other. This research aims to make the system for controlling nutrition in plants computerized, thereby helping users in controlling nutrition in plants to make it more effective and efficient.



Figure 4. Overall Hardware

In Figure 4 is the overall hardware, connect the USB cable to the Node MCU and a 5 Volt adapter from the relay connection to the electrical terminal, and the relay is connected to a mini pump which functions to release nutrient fluid when nutrients are lacking then open the Arduino IDE, enter the source code and upload it.

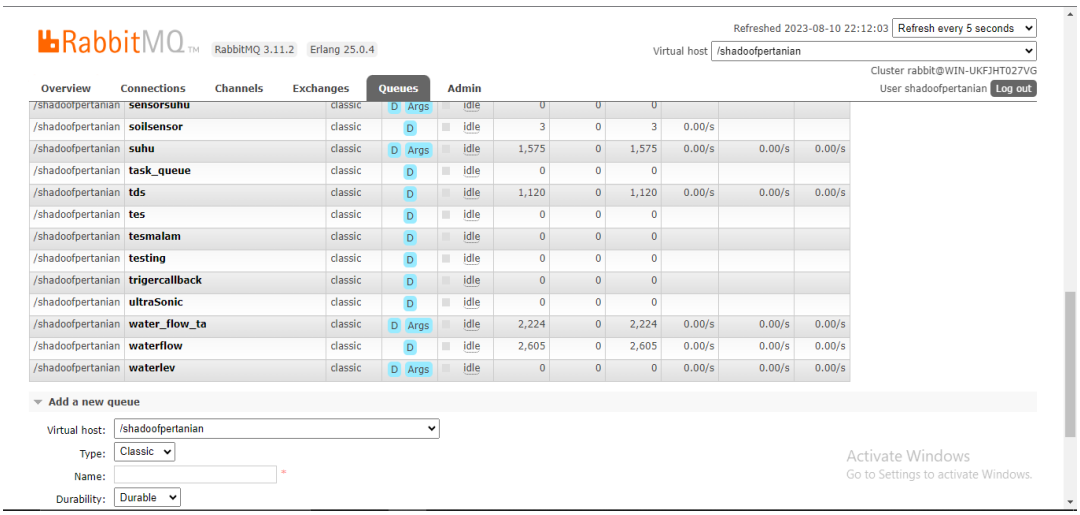


Figure 5. data from sensor devices

Based on Figure 5, create new queues to accommodate data from sensor devices that are sent according to the existing source code, where the Virtual host is an isolated environment in the broker which allows managing resources separately in one system, the virtual host used is /shadoff farming and type.

DISCUSSION

From the research that has been carried out, researchers have completed a system for controlling nutrition in plants using a TDS sensor, a system that can read plant nutrition and can provide sufficient nutrition needed by plants, by uploading a source code in the Arduino IDE that has been determined, if the nutritional condition is lacking. nutritional value of 900 ppm the pump will release liquid and the nutritional conditions are sufficient. With a value of 1000 ppm the pump will stop releasing nutritional liquid. Output is 5 VDC, relay contacts are used to ON and OFF the pump as an automatic nutrition control system. The TDS sensor output voltage has a linear scale factor between the voltage and the ppm value. So it can be calibrated directly in ppm values. The TDS sensor is one of the sensors that has quite good quality, judging by its response and fast data reading. The TDS sensor will detect the nutritional value in plants and display it on the computer and Android. This tool works automatically by responding to the ppm value

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detected by the TDS sensor, then processing the ppm value and providing a previously programmed output. Therefore, to get accurate ppm value readings, the minimum power voltage on the system must be stable so that we can adjust it appropriately to the actual nutrition.

Table 2. TDS Sensor Data Validation

PPM	Details	MAC
902	sufficient	2C:F4:32:14:4F:75
905	sufficient	2C:F4:32:14:4F:75
910	sufficient	2C:F4:32:14:4F:75
850	deficient	2C:F4:32:14:4F:75
851	deficient	2C:F4:32:14:4F:75
870	deficient	2C:F4:32:14:4F:75
889	deficient	2C:F4:32:14:4F:75
898	deficient	2C:F4:32:14:4F:75

Based on Table 2, it can be seen that if the ppm value changes past a value above 900 ppm, the pump will automatically turn on, but when the ppm value is less than 1000 ppm, the pump will not turn on or turn off. From the results of this test, it can be seen that the TDS sensor components, MCU nodes, relays and pumps work according to the program that has been created.

CONCLUSION

Based on the results of the research and discussion of this final assignment, the conclusion is that the controlling system in smart agriculture for monitoring plant nutrition automatically allows accurate and responsive monitoring of plant nutritional needs. This technology also increases agricultural efficiency by reducing manual labor and minimizing the risk of nutritional imbalances. The use of these automated systems has the potential to encourage sustainable agriculture and increase crop yields in a more controlled environment.

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