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Research Article

Prototype of Automatic Watering and Fertilizing System for Oil Palm Seeds Based on Internet of Things

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A B S T R A C T

Watering and fertilizing are very important to maintain the quality of the oil palm seeds. If the oil palm seeds are not watered regularly the soil will dry out while the oil palm seeds generally need to maintain adequate soil moisture and require a loose textured soil medium. So far, farmers have not optimally fulfilled the needs for water and fertilizer for oil palm seeds because they still use manual and traditional methods. Technological developments have made it possible to create irrigation and fertilization techniques automatically. In this study, a prototype of an automatic watering and fertilizing system was designed and realized for oil palm seedlings using the NodeMCU ESP8266 as the main controller in addition to RTC, humidity sensors, relays, water pumps, LCDs, and smartphones. RTC is used for fertilization scheduling, humidity sensors to sense soil moisture levels, relays as automatic switches that turn on and off pumps, water pumps to pump water and liquid fertilizer, LCD to display information, and smartphones to monitor conditions and processes of watering and fertilizing coconut seedlings palm. The process of watering the oil palm seedlings in one day is carried out three times in weather conditions with a temperature of 29°C. While fertilization will take place according to the time that has been set at the time contained in the NodeMCU ESP8266, the two pumps will automatically be active for 20 seconds. One pump is activated and when the soil condition read by the humidity sensor is more than 60%, then one pump turns off (wet soil condition). While fertilization will take place according to the time that has been set at the time contained in the NodeMCU ESP8266, the two pumps will automatically be active for 20 seconds. one pump is activated and when the soil condition read by the humidity sensor is more than 60%, then one pump turns off (wet soil condition). The test results show that the prototype tool can work well. When the soil moisture is read by the humidity sensor less than 30% (dry soil condition) then pump one is activated and when the soil moisture is more than 60% (wet soil condition) then pump one turns off. Furthermore, fertilization can take place according to a predetermined schedule where the second pump will automatically activate with a duration of 20 seconds for each fertilization period.

INTRODUCTION

Oil palm can thrive in tropical climates with an annual rainfall of 1,500–4,000 mm and ideal temperatures of 24–28°C. Podzolic, latosol, gray hydromorphic, alluvial, peat soils, coastal plains, and estuaries are some of the soil types that are suitable for oil palm cultivation [1]. In general, watering and fertilizing the oil palm seedlings still requires using simple tools such as dippers, hoses and buckets to water and fertilize the oil palm seeds manually. Farmers must water each oil palm seed in each polybeth or oil palm seed pot until the soil is moist. Sometimes there is not enough water for manual watering.

Farmers continue to carry spray tanks and surround the field to fertilize the seedlings, just as they do by applying fertilizer to the oil palm seedlings. This process certainly requires a lot of time and energy from workers or farmers to care for it. Therefore, we need tools that are easy to use, easy to understand, and reduce the time farmers have to spend watering and fertilizing oil palm seeds.

This system can automatically water and fertilize oil palm seedlings using sensors and supporting components so that the watering and fertilizing of the seeds is controlled and the soil remains moist. This tool can also determine the soil moisture level of the oil palm seedlings which can be seen via the client's mobile phone, and of course it makes it easier and saves time for workers in doing their work. Therefore, if farmers have other commitments and don't have time to water the oil palm seedlings, it is sufficient to monitor and supervise via smartphone instead of physically visiting the oil palm nursery.

An automatic water sprayer prototype based on the AVR ATmega8 microprocessor and humidity sensor was used in an oil palm nursery by Viktorianus Ryan Juniardy for previous research. This research obtained results in the form of automatic

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watering in oil palm nurseries by measuring soil moisture and monitoring via LCD. The microcontroller processes the instrument [2].

Diana Shofa continued her studies and developed an inexpensive IoT-based automated liquid fertilizer administration device for growing organic crops. In this study, the fertilizer watering schedule was changed to regulate fertilizer watering using an Android application. Farmers receive notifications through the Android application [3]. Rudy Gunawan continued his research using a monitoring system for soil moisture, temperature, pH, and watering tomato plants based on the Internet of Things. Each sensor value is tracked using the blynk app. The temperature and humidity sensor reading values will determine whether the lights and pumps are turned on or off [4]. An IoT-based automatic watering and fertilizing tool for oil palm seedlings was developed using problems from the previous background. This research creates a program that can control the system remotely to make watering and fertilizing more effective.

METHOD

This research begins with a literature study related to the use of technology in agriculture and its development opportunities. Furthermore, the authors designed the planned tool and realized it in the form of a prototype. After the prototype is tangible, testing is carried out to obtain data and perform data analysis to obtain conclusions about system performance.

Block Diagram of System

The block diagram is the basis of the entire system to be designed, where each part of the block diagram has its own function. Therefore by making a block diagram it can make it easier to know the working principle of the tool as a whole. The block diagram of designed system was shown in Figure 1.

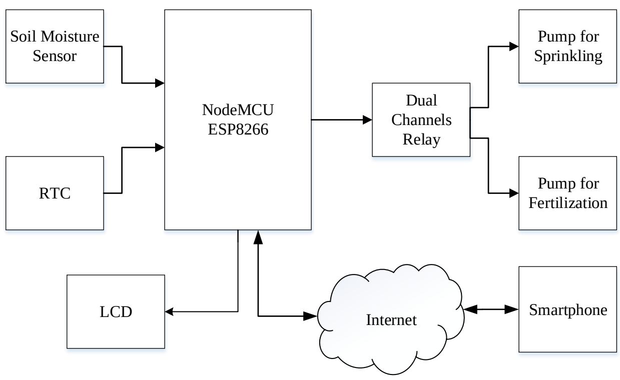

Figure 1. Block diagram of system

Automatic watering and fertilizing system for oil palm seedlings was designed using the NodeMCU ESP8266 as the main controller in addition to real time clock (RTC), soil moisture sensor, relays, water pumps, LCD, and smartphone. RTC is used for fertilization scheduling, soil moisture sensor to sense soil moisture levels, relays as automatic switches that turn on and off pumps, water pumps to pump water and liquid fertilizer, LCD to display information, and smartphones to monitor conditions and processes of watering and fertilizing coconut seedlings palm.

Components of System

Internet of Things

The internet of things (IoT) is an internet-based structure that can connect real and virtual objects that communicate with sensors and are connected to the internet network [5]. Size, area and timing must all be considered when developing the internet of things, as time is a fundamental barrier to its deployment. Government, industry, transportation, offices, agriculture, and the private sector all use the internet of things [6].

NodeMCU ESP8266 is an electronic board with WiFi connectivity controlled by a microcontroller [7]. Because it has many I/O pins, applications to control and monitor IoT projects can be developed using it. The Arduino compiler can be used to program the NodeMCU ESP8266 using the Arduino IDE [8]. NodeMCU's physical form is equipped with a USB (mini USB) connector to facilitate programming [9]. Figure 2 shows a physical form of the NodeMCU ESP8266.

Figure 2. NodeMCU ESP8266

Currently, NodeMCU is widely used by various electronic devices, including for monitoring of PDAM water [10], monitoring system for hazardous gas and fire detection in building [11], controling pond water quality in koi fish farm [12], application for real-time accident detection [13], and many others applications.

Soil Moisture Sensor

Soil moisture sensor is a humidity sensor that can detect moisture in the soil. This sensor measures the amount of water in the soil and its surroundings. Monitoring of plant moisture content is made easy with this sensor. By combining it with a microcontroller, the soil moisture sensor is able to determine the humidity value which indicates the amount of water in the soil [14]. Ground resistance decreases as the amount of liquid in the soil increases, making it easier for electricity to flow through it. Likewise, ideally, a high resistance indicates that the electric current is small, indicating that the soil is dry. According to [15], the application of this sensor requires a 3.3V to 5V power supply and an output voltage of 0-4.2V. Currently, soil moisture sensor is widely used by various electronic devices, including for monitoring soil temperature and humidity [16], hydroponic system [17], and many others applications. Figure 3 presents a soil moisture sensor.

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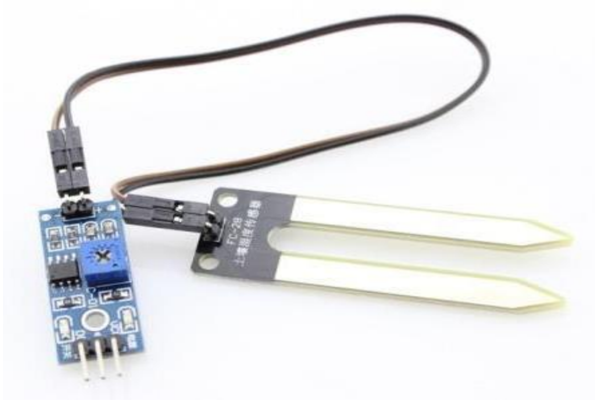

Figure 3. Soil moisture sensor

Real Time Clock

Real time clock (RTC) is a device that can receive and store day, date, month and year data in real time. This study used the DS3231 RTC type. RTC can automatically store all time, day, date, month and year data up to the difference between the 30th and 31st of each month [18]. Figure 4 shows the physical form of a DS3231 RTC module.

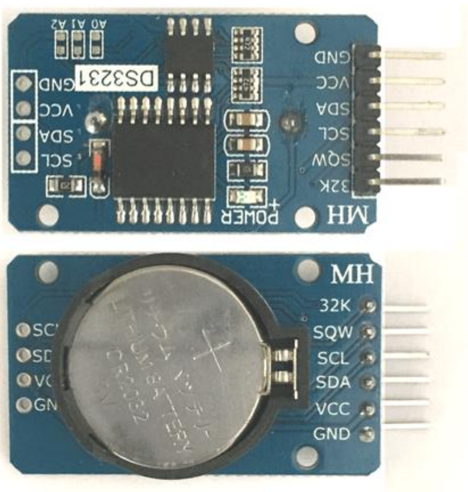

Figure 4. Real time clock

Relay

An electromagnetic coil and a mechanical component form a relay, which is a component that can only recognize HIGH and LOW values. The pump is controlled by a relay [19]. Relay is a switch that can be activated by an electric current. Relays are used as a means of controlling electronic components when excess current flows and high voltage components occur. HIGH and LOW conditions are used with a special time relay to set the relay on the water pump. Time delay is when allocating a certain amount of time for a task [20]. Here, the action in question is turning on the water pump when the relay is set to HIGH and turning it off when the relay is set to LOW. The physical form of a two-channel relay can be seen in Figure 5.

Figure 5. Dual channels relay

Liquid Crystal Display

An electronic device that can display numbers or text is known as a liquid crystal display (LCD). There are two main types of LCD panels capable of displaying text: alphanumeric text, which is often used in cell phones and copiers, and numeric text, which is used in watches, calculators, and other devices [21]. The physical form of an LCD can be seen in Figure 6.

Figure 6. Liqiud Crystal Display

DC Water Pump

An direct current electric water pump is an electromechanical device that continuously pushes water from an area of low pressure to an area of high pressure or from an area of low pressure to an area of high pressure using electricity. Processes that require high hydraulic pressure can also benefit from the use of pumps. This research utilizes a DC water pump which is usually found in aquariums. This ensures that the water pressure is not too high to water the plants and that it is easy to adjust so that it doesn't overflow during the process. Figure 7 shows a physical form of a DC water pump. Currently, this DC water pump is widely used in various electronic devices, including for fish pond water acidity control systems [22], supplying water in mini ebb and flow hydroponic system [17], and many others applications.

Figure 7. DC water pump

Blynk Application

Currently, human life is increasingly facilitated by the emergence of smartphones, mobile computing, and cloud computing. By simply dragging and dropping widgets, one can create a graphical user interface for the built-in tools in Blynk, the digital dashboard. Blynk is very simple and easy to set up and takes less than five minutes. Blynk doesn't rely on any particular shield or microcontroller. Instead, Blynk will get the tool online and ready for the internet of things, whether via Wi-Fi, Ethernet, or the ESP8266 chip on an Arduino or Raspberry Pi [23]. Figure 8 presents the appearance of the Blynk application on a smartphone.

Figure 8. Blynk application at a smartphone

Work Procedure for Watering and Fertilizing

Understanding the working order of the tools to be made is very necessary before making a program so that it can be sequenced as desired. In Figure 9 presented a flow chart of the system in question.

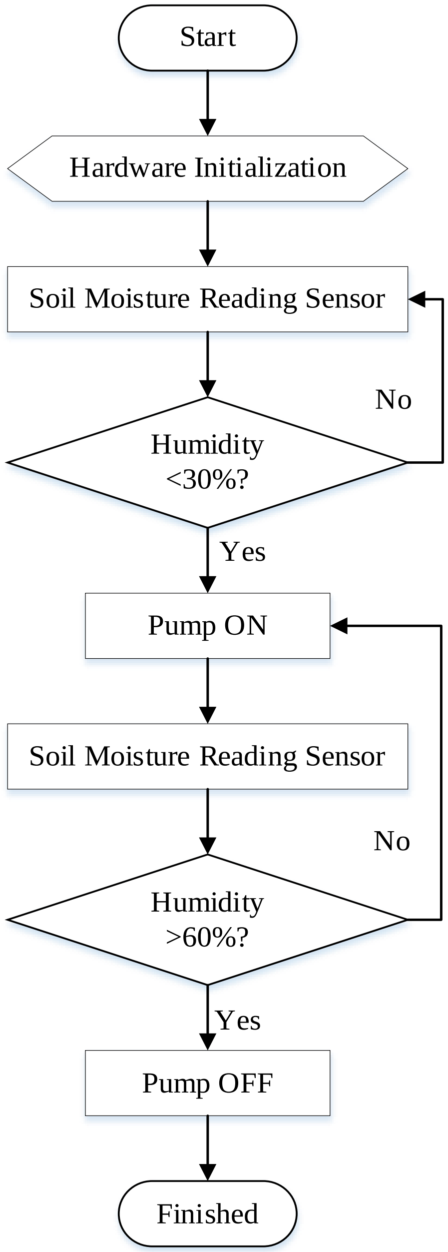

Figure 9. Flowchart of automatic watering work system

Figure 9 explains the automatic watering system based on soil moisture readings by the humidity sensor. If the tool gives information that the soil moisture is less than 30%, the water pump will start automatically. Then the soil moisture sensor will provide information on the LCD if the soil moisture has reached a predetermined number, which is more than 60%, and the water pump will automatically turn off, then the process is complete.

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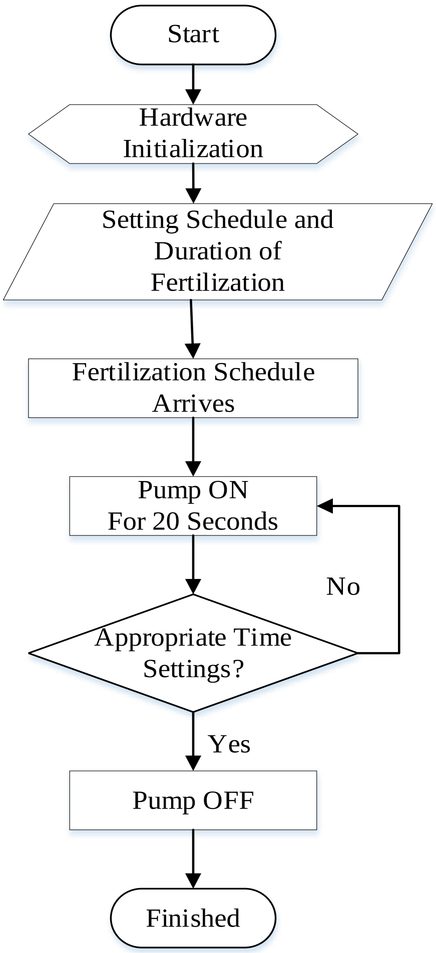

Figure 10. Flowchart of automatic rertilizing work system

Figure 10 explains the automatic watering system based on the schedule that has been set on the RTC. If the schedule that has been determined by the RTC arrives, the water pump containing liquid fertilizer will run for a predetermined time, which is for 20 seconds. When the fertilization time is over, the water pump will automatically turn off as well, and will display information on the LCD.

Electronic Design

The electronic design in this study has several electronic designs consisting of NodeMCU ESP8266, humidity sensor, DS 3231 RTC module, 16×12 LCD, 2 channel relay. The electronic design is shown in Figure 11.

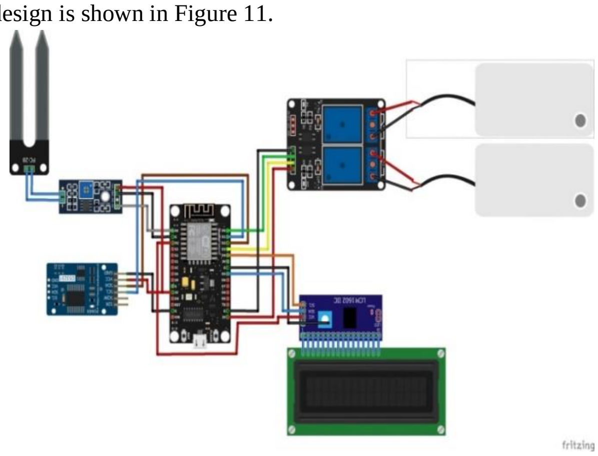

Figure 11. Electronic design

Mechanical Design

The mechanical design in this study is in the form of a bucket which will later be used for placing water and liquid fertilizer measuring 28cm long, 15cm high, and 30cm wide. And later use wood for placing oil palm seeds and pipe lines for watering which are 60cm long and 45cm high. In Figure 12 mechanical design of the system is presented.

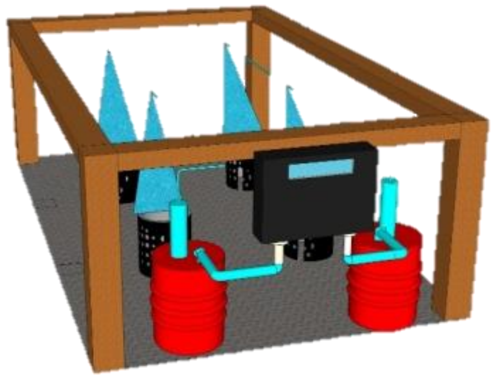

Figure 12. Mechanical design

RESULTS AND DISCUSSION

Mechanical Realization

The mechanical design process consists of several parts, including making a framework used for placing oil palm seeds and also for placing water tanks and liquid fertilizer tanks. In addition, this frame is also used as a place for hose lines, where the hose above functions for watering and the one below functions for fertilization. This design uses wood with a length of 60 cm, a width of 48 cm and a height of 45 cm. The pictures of the results of the mechanical design of this tool can be seen automatically as shown in Figure 13.

Figure 13. Mechanical realization

Realization of Electronic Circuits

The electronic design has been designed in the previous discussion and has been built, the electronic equipment that has been built consists of NodeMCU ESP8266, 2 channel relay, humidity sensor, real time clock, 12V 5A power supply, 16x2 LCD, and two mini water pumps. Electronic design drawings can be seen in Figure 14.

Figure 14. Realization of electronic circuits

Overall System Testing

Testing the entire tool is the final stage of testing the automatic IoT-based watering and fertilizing tool for oil palm seeds. This test combines all the components used and uses the program as a whole. The first stage in this test is to assemble all the components as shown in Figure 15. From this test the performance of the IoT-based automatic watering and fertilizing oil palm seedlings will be obtained. After designing the entire tool along with assembling all the components, combine them into one part and combine the entire tool program. In the testing process this tool is divided into two tests, namely the automatic watering test and the automatic fertilization test.

Figure 15. Overall testing of system

Auto Watering Test

This procedure explains that before the tool is started, it must first connect to the source. After the initial display appears, a humidity sensor is plugged into the ground to detect moisture in the soil. When the humidity sensor detects moisture in the soil but the soil is dry, it sends a signal to the NodeMCU ESP8266 to turn on the pump to water the oil palm seedlings. The set point that has been set in the program and will be displayed on the LCD will cause the pump to stop automatically whenever the humidity sensor detects that the soil is wet. The most common way to water plants is done automatically when the humidity sensor reads the moisture in the soil. In Figure 16 the process of watering the oil palm seedlings automatically is presented.

Figure 16. Initial view of LCD on the system

Figure 17. Humidity sensor installation

Figure 18. Moisture value of 32%

Figure 19. Moisture value of 30%

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It can be explained in Figure 17 that a humidity sensor is plugged into the ground to detect moisture in the soil. Figure 18 shows the condition of soil moisture, which is rated at 32%, which means the soil is dry. However, at this value, it is not possible to do automatic watering of the oil palm seeds because the minimum moisture in the soil is less than 30%. After a few minutes, the soil moisture value of the oil palm seeds has been raised to 30%, which will automatically water the seeds. Description of the humidity value on the LCD will be displayed in Figure 19.

Figure 20. Watering process

Figure 21. Pump OFF

In Figure 20, the process of watering the oil palm seedlings is done automatically because the humidity sensor gives a humidity value of 30%. After that, in Figure 21, the watering process has been completed because the humidity value has reached the maximum limit, which is 65%, so the watering process is complete.

Automatic Fertilization Testing

Schedules, such as days and hours, must be set before the automatic fertilization process can begin. After setting the day and hour, then the schedule has arrived, relay 2 will automatically turn on to activate pump two and carry out the fertilization process on the oil palm seeds. The watering process will stop automatically for a predetermined time, which is 20 seconds of the fertilization process according to the settings that have been made in the program. In Figure 22 below is the process of automatically applying liquid fertilizer to oil palm seedlings.

Figure 22. Fertilization time setting

In Figure 23 illustrated the scheduling time for fertilizing oil palm seedlings, here the fertilization time is set on Sunday at 12.00 WIB. The fertilization schedule will be repeated the following week according to the time that has been set, and fertilization lasts for 20 seconds. In Figure 17 presented the automatic fertilization process.

Figure 23. Fertilizing process

System Test Result Analysis

Analysis of the results of system testing is an assessment questionnaire for the entire operation and feasibility of the system from automatic IoT-based watering and fertilizing of oil palm seeds that has been carried out which aims to determine the level of success of the system. Following are the results of the test data that has been carried out.

Watering Data

The data for automatic watering of oil palm seedlings is shown in Table 1.

Table 1. Results of Automatic Watering Test

No.	Day/Time	Humidity Land	Relays	Condition of Pump
1	Sunday, 07.00	31%	OFF	OFF
2	Sunday, 08.00	27%	ON	ON
3	Sunday, 09.00	54%	OFF	OFF
4	Sunday, 10.00	48%	OFF	OFF
5	Sunday, 11.00	42%	OFF	OFF
6	Sunday, 12.00	39%	OFF	OFF
7	Sunday, 13.00	29%	ON	ON
8	Sunday, 14.00	58%	OFF	OFF
9	Sunday, 15.00	45%	OFF	OFF
10	Sunday, 16.00	38%	OFF	OFF
11	Sunday, 17.00	30%	ON	ON

The conclusion that can be drawn from table 1 is that oil palm seedlings are automatically watered sufficiently. When the soil moisture sensor detects soil moisture less than 30%, the relay will turn on to water the oil palm seeds, and when the soil moisture reaches more than 60%, the pump will automatically shut down. This is how the relay operates according to the program that has been made. The data collection process is carried out once a day every one hour. And it can be concluded that the process of watering the oil palm seedlings in one day is carried out three times in weather conditions at 29°C.

Fertilizing Data

The automatic fertilization data for oil palm seedlings is shown in Table 2.

Table 2. Results of Fertilization Testing

No.	Date and time	Time	Relays	Condition of Pump
1	Sunday, 15-01-2023	12.00 WIB	ON	Light up
2	Sunday, 22-01-2023	12.00 WIB	ON	Light up
3	Sunday, 29-01-2023	12.00 WIB	ON	Light up
4	Sunday, 05-02-2023	12.00 WIB	ON	Light up
5	Sunday, 12-02-2023	12.00 WIB	ON	Light up

Giving liquid fertilizer will start if the program has been scheduled on a certain day and time in advance. This is because watering the oil palm seedlings with liquid fertilizer is usually done once a week, and the following week the application of liquid fertilizer will be carried out automatically without the need to reset the program. Conversely, if the fertilization schedule changes, such as days and hours, it is necessary to reset the program. The program setpoints indicated that the fertilization system was effective. Liquid fertilizer is given to the oil palm seeds by watering them so that the nutrients are maintained and they don't die.

CONCLUSIONS

In this study prototype of automatic watering and fertilizing system for oil palm seeds based on internet of things have been designed, realized, and measured the performance. Some of components of the system included in the design of an automatic fertilizing and watering of oil palm seedlings include the ESP8266 nodeMCU which functions as a prototype control center, soil moisture sensors that detect soil moisture levels, RTC which functions as a time indicator for the fertilization process, relays which function as disconnectors and connectors. electric current to the water pump, and other supporting components. The arrangement of each component is based on its location and position. Then programming is done on the Arduino IDE by inserting a pin, so that an IoT-based programmable watering and fertilizing oil palm seedling tool is made. The design of a programmed oil palm seed watering and maintenance tool involves a soil moisture sensor for estimating soil moisture in oil palm seedlings. This design can flush according to a predetermined set point. the water pump will start working when the soil moisture is less than 30%, and will stop working when the soil moisture is more than 60%. For the fertilization process, this plan can carry out preparations according to a predetermined schedule, namely every Sunday at 12.00, and the treatment cycle lasts for 20 seconds.

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