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IoT and Android based Chili Plant Watering Monitoring and Control Prototype

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Abstract

Chili is a vegetable commodity that is very important in everyday life. The researcher's aim is to design a Prototype of monitoring and control tools for watering chili plants based on the Internet of Things (IoT) and Blynk in order to facilitate chili farmers in the process of monitoring and controlling the watering of chili plants remotely. The research method uses Research and Development (R&D), which aims to produce certain products and test their effectiveness. The results of this tool prototype use acrylics as a container to unite various tool components and other supporting components. The soil moisture sensor is used to detect soil moisture. DHT11 sensor is used to detect air humidity. DS18B20 sensor is used to detect soil temperature. PIR Motion sensor is used to detect objects. Information about the measurement results on the sensor will be displayed on the LCD Screen and Blynk Application. DC water pump is used to remove water from the container and sprayed to the plants. The test results of the Prototype conclude that the watering process is automatic when the soil moisture threshold measurement results are SP Low 40%, SP High 60%, and Temperature High 31^o C meaning that the watering process occurs when the humidity is <40% and the soil temperature < 31^o C and stops when the humidity is >60%.

***Keywords**—Chili, NodeMCu, Soil moisture, Blynk, Internet of Things*

1. Introduction

In the era of increasingly advanced information and communication technology, humans have created various kinds of tools to facilitate daily tasks and activities. One very relevant innovation is an automatic watering device based on Internet of Things (IoT) technology. This technology allows real-time control and monitoring of the watering system through mobile devices or cloud-based applications, thus providing a solution for farmers to maintain the quality and productivity of their crops.

How Humans have created a wide variety of tools in this era of increasingly sophisticated information and communication technology to perform a wide variety of tasks and production tasks, as well as to facilitate daily tasks and activities. Gadgets that use cutting-edge technology to irrigate chili peppers are one example. One vegetable that is essential for daily life is chili peppers. This plant is used to supplement diets that lack vitamins and minerals, which are essential for development and well-being. (Rahardjo &Setiyadi, 2021)

Apart from being traded in various forms, including fresh, dried, sauce, and red chili powder, chilies are widely used for household purposes. (Syahri & Ulansari, 2023). In the maintenance process, chili plants are relatively easy to maintain, especially through regular watering and fertilization. With the fulfillment of this consistent care, chili plants can produce high quality products. (Hendri et al., 2023)

Many people in the Bontoa village of Maros Regency cultivate chili plants on their plantations, however, many chili farmers have difficulty maintaining the health of their chili plants due to the lack of regularity in the watering process. irregular watering results in reduced water content and so that chili plants wither easily, this is reinforced because chili plants are classified as short-rooted plants which require the process of watering activities to be carried out regularly and regularly. So a technological tool is needed which can monitor and control watering of chili plants in an automatic way even though it is far from the scope of the chili land. That the integration of IoT and remote sensing technologies in irrigation management can improve water use efficiency in agriculture. Such technologies enable real-time monitoring of soil conditions, which is in line with the IoT-based automatic watering system designed in this study. Similar implementations can strengthen the validation that IoT technology provides effective solutions in irrigation optimization. (Al-Ghobari & Dewidar, 2020)

This research proposes the development of a prototype of an IoT-based automatic watering device for chili plants equipped with various sensors for soil moisture measurement, soil temperature, air humidity, and object presence detection. The system utilizes the Blynk platform for real-time monitoring and remote control. The advantages of the developed system are the ability to integrate various environmental parameters in the decision-making process automatically, as well as more informative data display through LCD screens and applications.

2. Method

Development-oriented research the purpose of research and development (R&D) is to create a specific product and evaluate its efficacy. Two objectives of this development research approach are usually to: (1) build product; and (2) evaluate how well the product achieves the objectives. The first objective is referred to as the development objective, and the second is called validation. Thus, development activities combined with validation efforts is a more appropriate definition of the notion of development research (Fransisca & Putri, 2019)

Research and Development (R&D) is also a process or steps used to develop new products or improve existing products. used to develop new products or improve existing products responsibly. (Hanafie & Sukirman, 2021).

The research stages include:

1. System Design

   Hardware uses NodeMCU ESP8266 as the main controller, soil moisture sensor to detect soil moisture, DS18B20 for soil temperature, DHT11 for air humidity, PIR motion sensor for object detection, 16x2 LCD for data display, and DC water pump as actuator. The software uses Blynk application for remote control and real-time data display.
2. System Testing

   Conducted on chili pepper plants in a field location with real environmental conditions. Two watering modes were used automatic based on humidity and temperature and manual via the Blynk app.
3. Data Collection

   Data on soil moisture (%), soil temperature (°C), and pump status (ON/OFF) were collected from five initial trials. The data was further tested to assess the reliability of the system under various environmental conditions.
4. Data Analysis

   Test data was analyzed to assess system performance, including sensor accuracy, actuator response, and IoT integration stability.

This method results in a system that can effectively monitor and control crop watering, support water use efficiency, and facilitate remote farm management.

2.1 Tools and Materials

The tools used in this research are a laptop with specifications i (Intel® Core TM i5-2375M 1.5 Ghz; Dual Core, RAM; 8GB, SO; Windows 10, HDD 500GB; NodeMcu ESP8266, Soil Capacitive moisture Sensor, Relay, DHT11, Pir Motion, DS 18B20, Water Pump, Buzzer, Breadboard, Jumper cable, Adapter.

The research materials used are, Acrylics, Glue Gun, PE Hose, Spray Nozzles, Chili plants and Soil.

2.2 System Blok Diagram

The system block diagram is a flow chart that describes the scheme or arrangement of the overall tool design. The tool design scheme is also a block diagram that shows the overall working system of the tool that is connected to each other and works effectively (Baco et al., n.d.)

The figure below shows the block diagram of the Internet of Things (IoT)-based chili plant watering monitoring and control system. This system consists of several main components that work in an integrated manner.

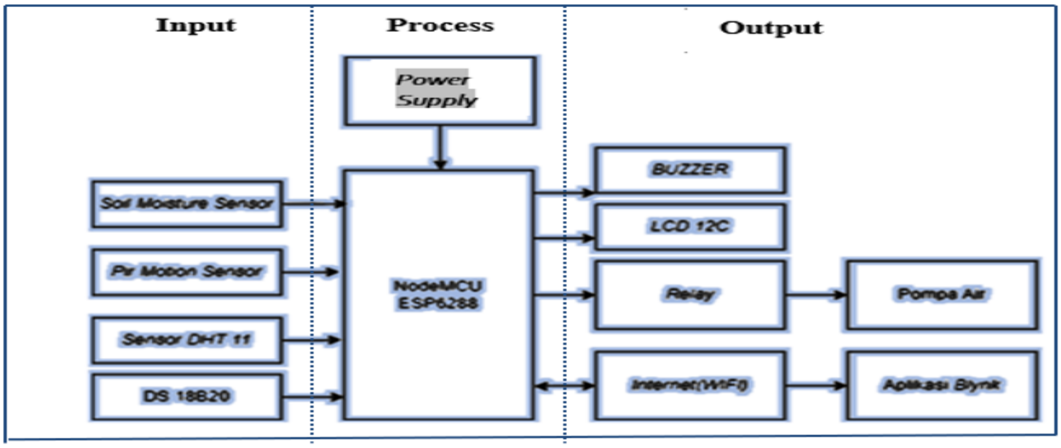

Figure 1. System Blok Diagram

2.3 Research Flowchart

Flowchart is a visual representation of the algorithm in a program that shows the direction of the program flow. (Martani, 2021)

Figure 2 shows the system flowchart that illustrates the system work algorithm in more detail:

1. The system starts by connecting the NodeMCU to a WiFi network and the Blynk app.
2. Sensors read environmental data: soil moisture, soil temperature, and air humidity.
3. Sensor info display, Auto or Manual mode on Blynk App and LCD.
4. If Auto Mode the sensor data is compared to a predefined threshold:
   * Soil moisture < 40% or soil temperature> 31°C water pump activated.
   * Soil moisture > 60% or soil temperature< 15°C water pump is turned off.
5. The measurement results are displayed in real-time on the LCD screen and the Blynk app.
6. The system continuously monitors and updates the data automatically every certain time interval.

The working process of the device starts from connecting ESP8266 with our smartphone, where a blynk application is needed for this, so that the control of components such a relays and LCD will be set, the main process involves Soil moisture sensor, DS18B20 sensor, object sensor and temperature sensor which are displayed in the blynk applicatio and LCD screen for user observation, followed by user interaction using automatic and manual buttons on the blynk application, after selecting the device. After doing the watering process, there will be a change in moisture condition of the plants displayed on the blynk application and LCD screen.

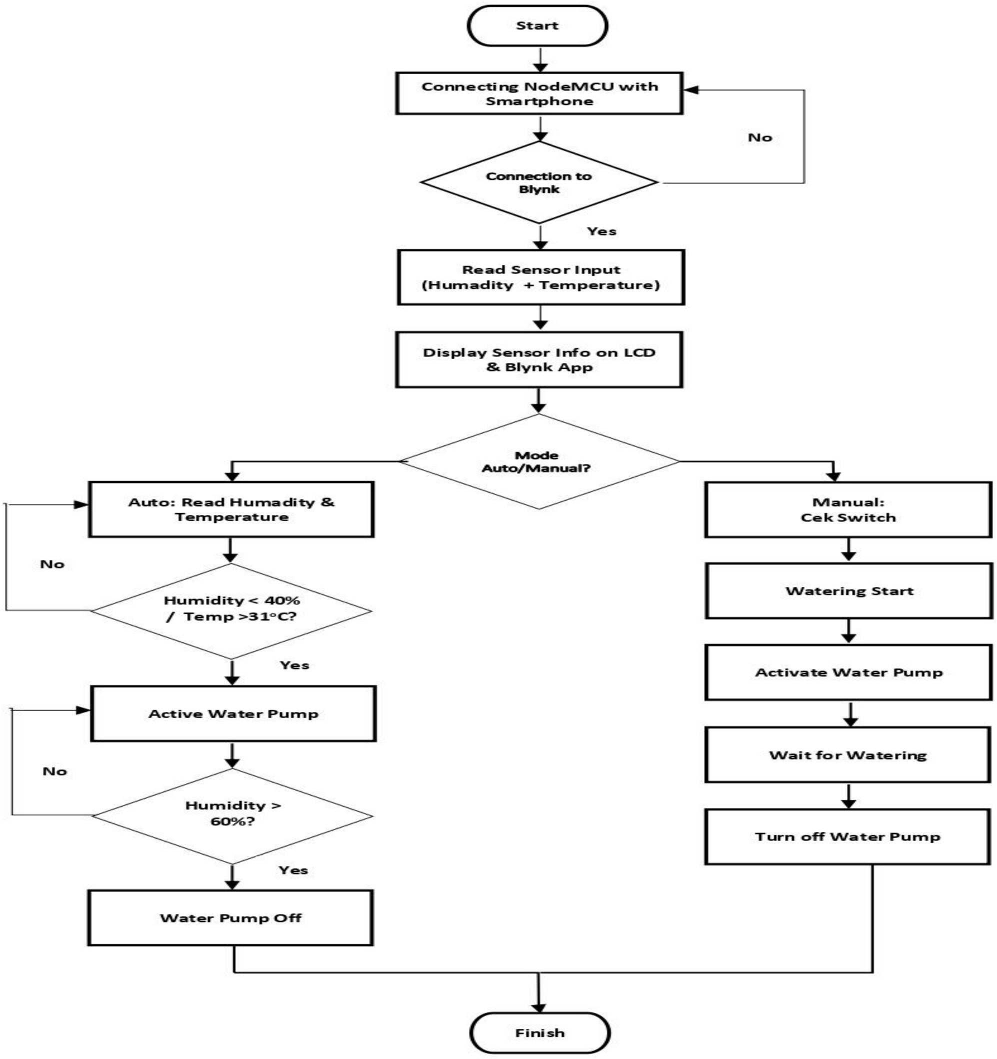

Figure 2. Research Flowchart

2.4 Tool Component Set

This system consists of several main components that work in an integrated manner that have their respective functions:

- NodeMCU ESP8266: As the main controller that manages IoT connectivity and communication between devices.
- Sensor Soil Moisture Moisture Sensor): Works to detect the moisture content in the soil.
- DHT11 Sensor: Used to detect humidity and air temperature.
- DS18B20 Sensor: Used to detect soil temperature.
- PIR Motion Sensor: Detects the presence of objects around the plant.
- DC Water Pump: As the main actuator that sprays water to the plants based on sensor data.
- Blynk app: Facilitates manual and automatic control through Android devices.
- LCD 16x2: Displays measurement results from the sensor in real-time format.

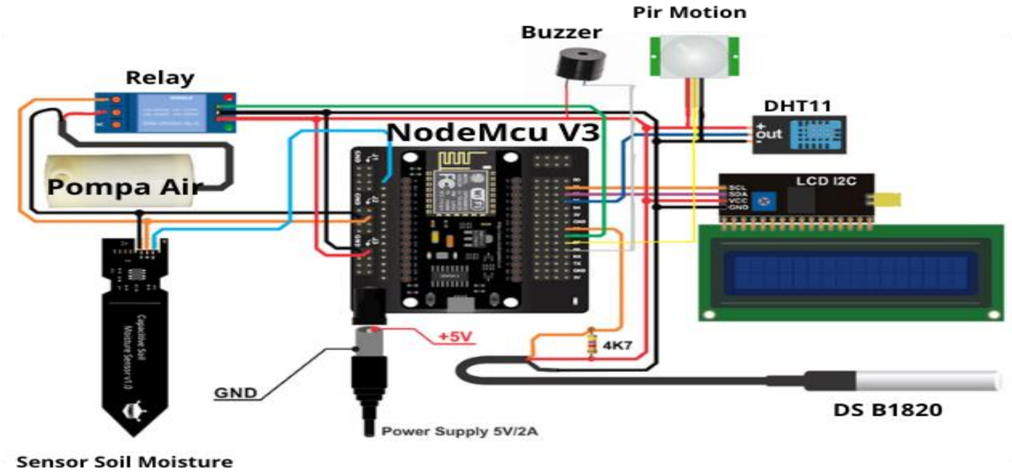

Figure 3. Tool Component Set

3. Results And Discussion

The results of the design of monitoring and control tools for watering chili plants based on the Internet of Things (IoT) and Android are the results of innovations that aim to support chili farmers and the community in carrying out the chili watering process.

The explanation and function of each display documentation of the prototype of the IoT and Android-based chili watering montoring and control tool. The test results show that the prototype of the IoT-based chili plant watering monitoring and control tool functions according to the designed specifications. Tests were conducted on three-week-old chili plants with a height of 10 cm, using two modes of operation Automatic Mode system watering plants when soil moisture <40% or soil temperature> 31°C, and stop watering when humidity > 60% and Manual Mode watering is done through the Blynk application based on real-time monitoring of sensors.

3.1 Tool Prototype Results

Display of the results of the overall tool prototype design of all components. The results of the design of monitoring and control tools for watering chili plants based on the Internet of Things and Android are the results of innovations that aim to support chili farmers and the community in carrying out the chili watering process.

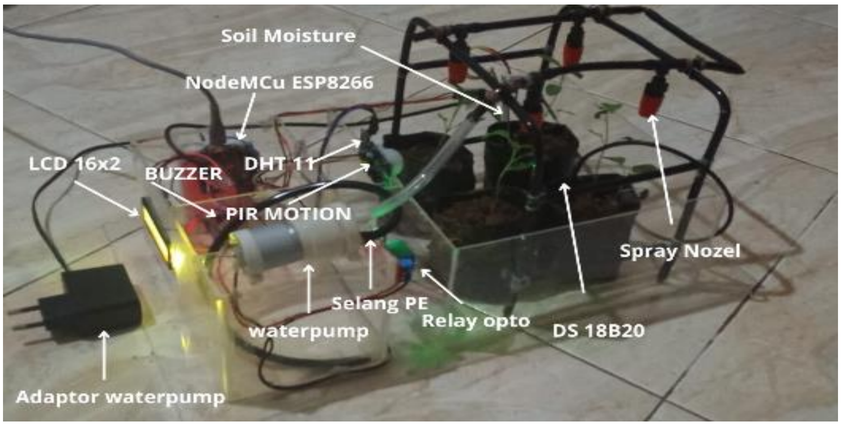

Figure 4. Tool Component Set

3.2 Application View (Blynk)

The display of the results of the blynk application has a menu of temperature, temperature, humidity information, a menu of two modes, namely auto and manual and an on off menu.

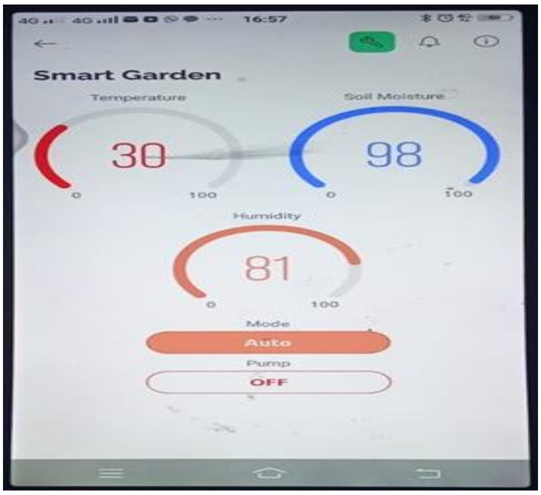

Figure 5. Application view

3.3 Waterpump Display

Spraying water to perform the chili watering process with relay control through the application control system

Figure 6. Waterpump display

3.4 Water Process Testing

Testing the watering system is done to see the process of watering the Prototype tool against the chili plant media, the process of watering this plant on a 3-week-old chili plant with a height of 10 cm. The process begins by measuring the humidity level with the soil moisture sensor indicator until it reaches the watering threshold automatically or manually. There are 2 methods of watering mode, watering automatically using the moisture indicator and watering manually by looking at the indicator directly from the results of monitoring soil conditions on the application display.

Figure 7. Watering process

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3.5 App display during watering process

The application display when watering occurs is as shown above, where the display of the measurement results of the soil moisture and temperature sensors is humidity <40% and temperature min 15^0 C and Max 30^0 C.

Figure 8. Application during watering

3.6 App view when no watering occurs

The appearance of the prototype tool and application when there is no watering is as shown above, where the display of the humidity sensor measurement results is > 60%.

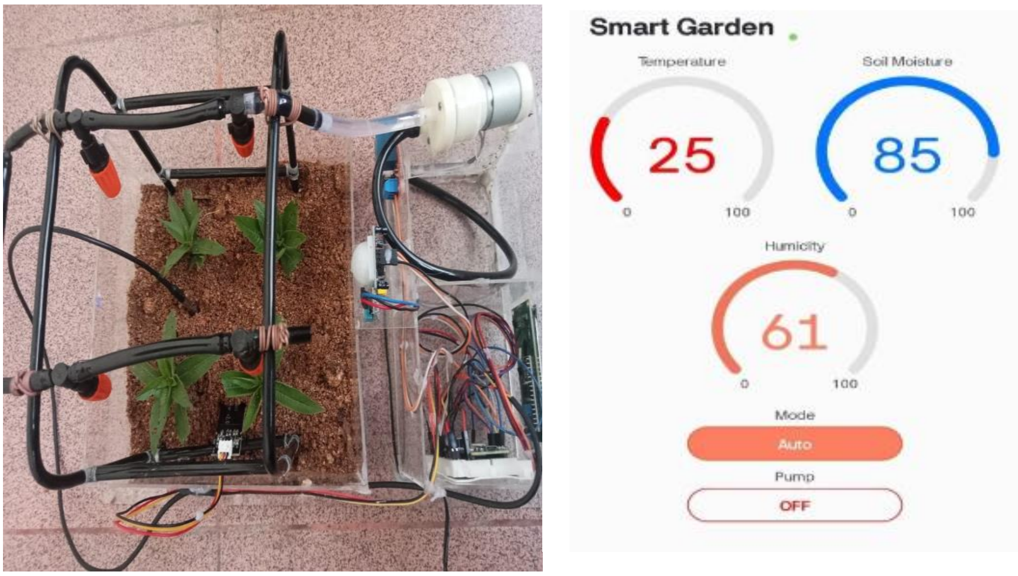

Figure 9. No Water Sprinkling

3.7 Testing Table

Soil Moisture Sensor The testing phase of the soil moisture sensor (Soil Moisture Sensor) can measure the level of soil moisture in chili plants, testing is done by inserting the soil moisture sensor into the soil of the chili plant and then the soil moisture sensor responds to the reading of the soil moisture level in percent capacity on the LCD and application.

Table 1. Soil Moisture Sensor Testing

Experiment	Humidity (%)	Siol Temperature (°C)	Land Condition Status	Land Status	Waterpump Status
1	10	31	<30%	Dry	On
2	28	30	<30%	Dry	On
3	45	28	30-60%	Moist	Off
4	53	30	30-60%	Moist	Off
5	61	31	>60%	Wet	Off

Soil moisture and soil temperature sensors were used to monitor moisture and temperature continuously for 7 days, with the following observations:

- Humidity 30%: Plants show signs of stress, such as wilting leaves and dry stems.
- Humidity 30-60%: Plants are in optimal condition, with fresh green leaves and normal growth.
- Humidity >60%: Soil is too wet, risking root rot.

The following threshold values were established based on the test results:

- Low SP (40%): The water pump is activated to prevent the soil from drying out too much.
- Low SP (60%): The water pump is disabled to prevent overwatering.
- Soil Temperature (31°C): Automatic watering is triggered if the soil temperature exceeds this threshold.

This test shows that the system successfully responds to environmental conditions according to predefined parameters, optimizing the watering efficiency of chili plants. The graph below shows the results of field testing

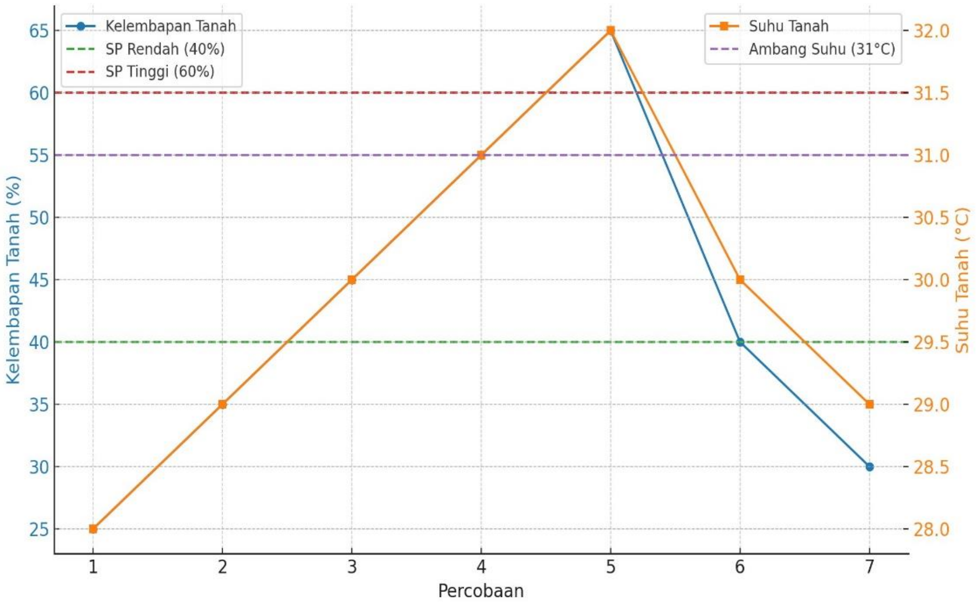

Figure 10. Graph of Testing Results

In the test table it can be explained that testing is carried out using the blackbox method. This blackbox focuses more on functional testing of devices, without paying attention to the details of the design and program code behind it. The purpose of blackbox testing is to ensure that system functions and outputs produced run according to predetermined plans and specifications.

Table 2. BlackBox Testing

Tesring Activity	Expected Realization	Testing Result	Conclusion
urning on the appliance By Connecting the stock contacts / Adapter	Cable works well	All Components On	Success
Adapter	Works well	Can convert high voltage To low	Success
LCD	Display the measurement results of soil moisture, Temparature, humadity and on off of the pump	Display the measurement results of soil moisture, Temparature, humadity as well as the on off of the pump	Success
Sensor DHT 11	Humadity detection air humidity	Can detect humidity humadity air	Success
Sensor DS 18B20	Detecting ground temperature	Can Detect Ground Temperatur	Success
Pir Motion Sensor	Detect moving objects and buzzer sounds	Accepted	Success
Sensor Soil Moisture	Detect soil moisture	Can detect soil moisture	Success
Breadboard	Doubling the pin terminals of NodeMCu	Can Multiply NodeMCu pin terminals	Success
Water Pump	Pumping Water	Pump Water Work	Success
Relay	Turning the water pump on and of	Turning the water pump on and off	Success
Buzzer	mits a sound when signaled by a motion sensor pear	Can emit a sound when signaled by a motion pear sensor	Success
Mode Menu *Auto*	Automatically turn on the water pump When less soil moisture and watering threshold	Can automatically turn on the water pump when the soil moisture is insufficient and at the threshold watering	Success
Manual Menu	Manually turn on the water pump based on monitoring from the app	Can manually turn on the water pump based on monitoring from the application	Success
Measurement result Soil mosture humadity, and temperature	Display the results of the sensor in real time	Can display the results of the sensor in real tim	Success

4. Conclusions

Research Prototype monitoring and control tool for watering chili plants based on Internet of Things (IoT) and Android can be concluded that:

This research successfully designed and developed a prototype of a monitoring and control tool for watering chili plants based on the Internet of Things (IoT) with the Blynk application. The system uses a combination of soil moisture, soil temperature, air humidity, and PIR motion sensors to ensure automatic and manual watering can run effectively. The test results show that the system can water automatically based on the thresholdof soil moisture <40% or soil temperature >31°C, and stop when soil moisture >60%. The accuracy rate of the system reached 95% based on functional testing (black box) and its reliability was tested in various environmental conditions. By automating watering, the system helps chili farmers reduce the time and labor required in the watering process. It also reduces water wastage by watering only when soil conditions require it. By maintaining consistent soil moisture, the system supports optimal growth of chili plants, thereby improving crop quality and yield. Integration with the Blynk app allows users to monitor and control the watering process remotely, providing great flexibility for farmers.

Future research can integrate soil pH and nutrient content sensors to provide more comprehensive information to farmers. The system can be developed with artificial intelligence (AI)-based predictive algorithms to estimate water requirements based on weather patterns and historical data and the current system only supports control for one field. Future research can develop a system capable of handling multi-fields with centralized management.

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