

## Automatic Petition Spraying System That Refers to The Parameters of Wind Speed and Time

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### ABSTRACT

*This research aims to design and implement an automatic pesticide spraying system based on wind speed and time using the NodeMCU ESP8266 microcontroller. The system is built to operate only when environmental parameters meet ideal conditions, specifically when the wind speed is between 4–6 km/h and the time is within the operational window of 06:00–08:00 WIB. The system integrates several components, including an anemometer, wind direction sensor, voltage sensor, LCD I2C, relay module, and a DC water pump. Additionally, a push button is used as a manual override feature to cancel spraying. Data is displayed via LCD and sent in real-time to a web server for remote monitoring. The testing process, conducted on a red onion farming field, showed that the system successfully executed spraying only under the defined safe conditions. The push button feature worked reliably as a manual override, and the system responded accurately to changes in wind speed and time. This innovation offers a more efficient and safer alternative for pesticide application, minimizing human exposure to chemicals and reducing pesticide waste. The system is suitable for further development in precision agriculture, with potential enhancements such as GSM integration, solar power, and mobile app connectivity.*

**Keywords:** *Automatic Pesticide Spraying, Wind Speed, NodeMCU ESP8266, Internet of Things (IoT), Smart Agriculture System.*

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### INTRODUCTION

Shallots (*Allium ascalonicum L*) is one of the horticultural commodities with high economic value that is widely cultivated in Indonesia (Stuttgart, 2022). In its cultivation practice, pest control is still mostly done manually through spraying pesticides using a sprayer sling. This method consumes time and effort, poses a risk to farmers' health due to direct exposure to chemicals, and reduces the effectiveness of spraying if it is done when wind speeds are not ideal. This condition raises the need for technological innovation that can help the spraying process automatically, efficiently, and safely for users and the surrounding environment.

As technology develops, the application of the Internet of Things (IoT) in the agricultural sector is becoming increasingly relevant. This technology allows real-time monitoring and control of the system based on environmental parameters such as temperature, humidity, and wind speed. Several previous studies have developed microcontroller-based automatic spraying systems. For example (Istiqomah et al., 2022) designing a spraying system based on soil moisture sensors and RTCs; (Murdiyantoro et al., 2021) developing Arduino-based wind speed and direction measuring instruments; While (Afandi et al., 2024) implement IoT and solar power in remote spraying systems. However, to date, there has been little research that specifically combines wind speed and time parameters as the main controls in automated pesticide spraying systems.

Based on this background, this study aims to design and build an automatic pesticide spraying system based on NodeMCU ESP8266 that is only active at a certain time range (06:00–08:00 WIB) and when the wind speed is at a safe threshold (4–6 km/h). The system is also equipped with a manual cancellation feature using a push button and sending data in real-time to the server for remote monitoring. It is hoped that this system can be an appropriate technological solution that can increase the efficiency and effectiveness of spraying, reduce excessive use of pesticides, and increase work safety for farmers.

Automatic pesticide spraying systems are a form of technological innovation in agriculture that integrates various sensors, actuators, and microcontrollers in one system. The various components used in the development of this system have been extensively discussed in the previous literature.

Some studies show that the effectiveness of spraying is greatly influenced by the speed and direction of the wind. For this reason, a device is needed that can automatically monitor and regulate the system based on environmental conditions. As for the main components that are commonly used in automatic spraying systems, here is a description of each of their roles:

#### **NodeMCU ESP8266**

It is a WiFi-based microcontroller that is the center of the system's control. This board allows for the capture of time data via NTP, processing of spraying logic, and the delivery of sensor data to the server in real-time (Nuzuluddin et al., 2022).

#### **Wind Speed Sensor (Anemometer)**

Used to measure wind speed in the environment around the system. This sensor is the main parameter in determining whether spraying can be done or not (Langga et al., 2024).

#### **Wind Direction Sensor**

This sensor functions to detect the direction of the wind to avoid spraying in unwanted directions, such as settlements. Directional data is used as supporting information (Hafidin Bangun Widyanto, 2024).

#### **25V DC Voltage Sensor**

Functions to monitor power conditions, especially 12V batteries as a backup power source. Helps ensure the system does not shut down suddenly due to voltage drop (Ramadhany & Hardjono, 2020)

#### **Push Button (Tombol Pembatal)**

Used as a manual controller that allows the user to cancel spraying even if the sensor conditions are met. This button reinforces the safety and flexibility aspects of the system (Octodinata & Purnomo, 2024)

#### **5V Relay Module**

It acts as an electronic switch that connects the NodeMCU with the DC pump. The relay is active when the spraying conditions are met and the power is flowing from the power supply to the pump (Transfer et al., n.d.).

#### **LCD 16x2 I2C**

It is used to display data such as wind speed, wind direction, battery voltage, time, and system status (on/off). This LCD is pin efficient because it uses only two communication lines: SDA and SCL (Susanta, 2025)

#### **12V DC Water Pump**

Serves to spray pesticide liquid when the system is active. The pump runs for a certain period (e.g. 2 minutes) whenever the spraying conditions are met (Yulianto & Pujiyanto, 2025)

#### **Nozzle**

The nozzle determines the spray pattern and pressure of the liquid. The selection of nozzle type affects the range and efficiency of pesticide distribution (Annafiyah et al., 2021).

#### **Jumper Cable**

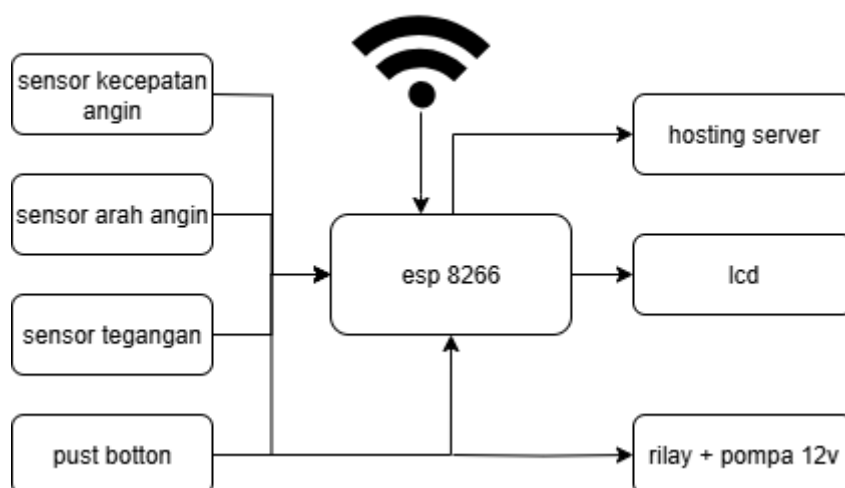
Used to connect various components on breadboard without soldering, making the prototypical assembly and testing process easier (Tantowi & Yusuf, 2020)

#### **12V Power Supply and 12V Battery**

Serves as the primary resource and backup for the system. The combination of the two guarantees the stability of the work of electronic devices in this automation system (Salam et al., 2024)

## **METHOD**

The system design was carried out using an experimental approach involving programming of ESP8266 NodeMCU microcontrollers, environmental sensors, and Internet of Things-based water pump actuators. The main components used in the system include the NodeMCU ESP8266, wind speed sensor (anemometer), wind direction sensor, 25V DC voltage sensor, push button, 16x2 I2C LCD, relay module, 12V DC pump, and 12V power supply. The software is developed using the Arduino IDE with the C++ programming language, and the system is connected to a server for time synchronization as well as data delivery



**Figure 1. Block Diagram Planning**

The initial step of the system is the initialization of the WiFi connection and the time capture of the NTP server. This time data is used to determine the operational range of the system, which is 06:00–08:00 WIB. Wind speed sensors are used to detect whether the wind speed is within the safe threshold, which is between 4–6 km/h. If the wind time and speed conditions are met, then the microcontroller will activate the relay module to turn on the atomizer pump for 2 minutes. If the wind is too strong or the cancel button is pressed, then the system cancels the spraying process.

To facilitate direct monitoring, the system is equipped with an I2C LCD that displays information on wind speed, wind direction, battery voltage, pump status, and system status (on or off). Data is also periodically sent to the server using an HTTP POST connection, and can be accessed through the browser in JSON format.

#### **System Flowchart**

The system has a flowchart as shown in Figure 2. The main flow of the system is: the system starts with initializing and connecting to the WiFi network, then performs a time synchronization from the NTP server. After that, the system reads data from the wind speed sensor, wind direction, and voltage. If the time is in the range of 06:00–08:00 WIB, and the wind speed is within the safe limit (4–6 km/h), and the cancel button is not pressed, then the pump will be activated for two minutes. After the time is up or if conditions are not qualified, the pump is turned off. Next, wind speed, wind direction, voltage, and system status data are sent to the server and displayed on the LCD screen in turn. This entire process continues to run repeatedly as long as the system is active.

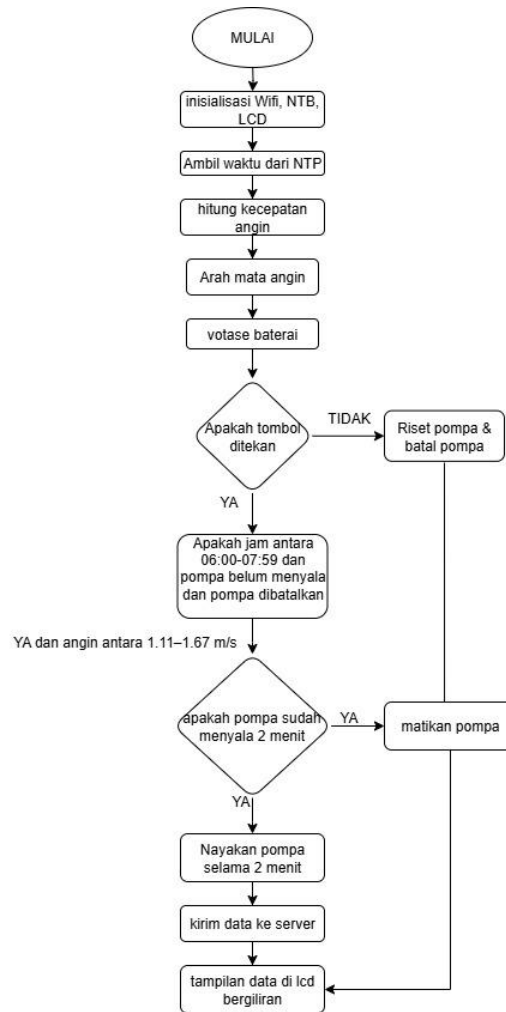


Figure 1. Flowchat System Design

### Testing Scenarios

The test is carried out directly on agricultural land by paying attention to the time and wind speed parameters. The spraying time is determined between 06:00–08:00, and the pump is only active if the wind speed is within a safe range. The cancel button is used to manually turn off the pump when conditions are not supportive, and the cancellation status will be automatically reset the next day. The test result data is recorded in the form of daily monitoring tables and graphs.

## RESULT AND DISCUSSION

### Spraying System Implementation

The developed automatic pesticide spraying system was successfully implemented using a ESP8266 NodeMCU microcontroller integrated with wind speed sensor, wind direction sensor, voltage sensor, LCD, push button, and 12V DC pump. The system software is designed using the Arduino IDE and supports real-time communication with the server for time capture as well as sensor data transmission.

This system will only activate the pump in the time range of 06:00–08:00 WIB, and if the wind speed is within the safe threshold (1.12–1.8 m/s). For user flexibility, the system is equipped with a push button as a manual spraying canceller.

### Test Results Per Component

In this section, the implementation and testing of the NodeMCU-based automatic pesticide spraying system ESP8266 was carried out. Testing is carried out on both the hardware and software sides to ensure that the system is working as designed and can respond to environmental parameters in real-time.

### Toolbox

The series of systems that have been created consists of NodeMCU ESP8266, wind speed sensor (anemometer), wind direction sensor, 25V DC voltage sensor, 16x2 I2C LCD, relay module, push button, and 12V DC pump. All components are assembled in a protective case with a jumper cable connection on

the breadboard. The system is designed to work independently in the open field with a power source from a 12V power supply and a battery as a backup.



**Figure 2 Final Assembly System**

Each component is tested individually:

1. **The wind speed sensor** is able to read the variations in wind speed from the test fan, and displays the data in real-time on the LCD.
2. **The wind direction sensor** can detect the direction of the wind, useful as additional information although it is not the main parameter of the control.
3. **The voltage sensor** reads the battery voltage level and sends it to the server.
4. **The push button** serves to cancel spraying if pressed before operating hours.
5. **The relay and pump** work responsively when all conditions are met and cut off the current if a null condition or strong winds are detected.

#### **System Integration Testing**

The test was carried out on a shallot field with a size of  $\pm 90$  m<sup>2</sup>. The installation of the tool is carried out by placing the sensor on a pole, the microcontroller in a closed box, and the pump is connected to the spray tank. The system automatically monitors environmental conditions and makes decisions according to programming logic.

- a. Installation of wind speed and cardinal direction sensors



**Figure 3 Installation of wind speed and cardinal direction sensors**

b. Pump system and whole automatic spray in the field



Figure 4 Pump system and whole automatic spray in the field

**Field Testing Data**

The following table presents the results of the system test over several days:

Date	Time	Wind Speed (m/s)	Button Status	Active Pump	Information
August 2025	3, 06:51	1.82	Unpressed	Yes	Ideal conditions
August 2025	4, 06:03	0.00	Pressed	Not	Active manual cancellation
August 2025	6, 06:10	2.64	Unpressed	Not	Wind speed exceeds threshold

From the test results, the system is able to work stably and in accordance with the specified parameters. Spraying only occurs if the time and wind speed are in ideal conditions, and the cancel button is not pressed. This indicates that the system's logic is running as planned.

The main advantages of the system are:

- Reduce farmers' direct exposure to pesticides.
- Saves pesticide materials by avoiding spraying at the wrong time.
- The system can be monitored remotely using a web-based server.

However, the system still has some limitations, such as dependence on WiFi networks and the absence of additional supporting sensors such as rain or temperature. For further development, the system can be added GSM module or solar panel to improve flexibility and energy efficiency.

**CONCLUSION**

This research aims to design and implement an automatic pesticide spraying system based on NodeMCU ESP8266 that can work based on wind speed and time parameters. Based on the test results, the system successfully sprays pesticides automatically only when the time is in the range of 06:00–08:00 WIB and the wind speed is within the ideal threshold (4–6 km/h). In addition, the push button feature has proven to work well as a manual spraying canceling tool.

The system developed has been proven to be able to improve farmers' work efficiency, reduce direct exposure to pesticides, and provide appropriate technological solutions for modern agriculture. Sensor data can be monitored in real-time through LCD displays or web-based servers, providing convenience in system monitoring.

However, this system still has limitations, such as dependence on WiFi connections and is not equipped with supporting sensors such as rain or temperature sensors. Therefore, it is recommended in future research to add GSM features, solar panels as an alternative energy source, as well as mobile

application-based interface integration so that the system can be accessed more flexibly by users.

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