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Agricultural Pesticide Spraying Robot

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Abstract: This project focuses on the development of an semi-automated pesticide spraying robot designed to assist farmers efficiently managing their crops while minimizing human labor and exposure to harmful chemicals. The system is powered by a NodeMCU microcontroller, which serves as the central processing unit, facilitating both autonomous and remote control via the Blynk IoT platform. The robot is equipped with L298N motor drivers that regulate the movement of its wheels, allowing smooth navigation across agricultural fields. A relay module is integrated to control the pesticide spraying system, which consists of a DC motor-driven water pump that ensures precise and uniform pesticide distribution over crops. The inclusion of a soil moisture sensor and a temperature and humidity sensor allows continuous monitoring of environmental conditions, providing farmers with real-time insights into field conditions. These sensor readings are transmitted to the Blynk server, enabling remote monitoring and control through a mobile application, ensuring timely interventions for crop health management. By reducing manual labor and optimizing pesticide usage, the system enhances agricultural productivity while minimizing excessive chemical application, which can be harmful to both crops and the environment. In our project, we have developed a fully functional prototype that integrates all the aforementioned components into a compact, mobile robotic platform. The NodeMCU microcontroller has been programmed to operate semi-autonomously based on sensor inputs, while also allowing manual override through the Blynk app for user-defined control. The L298N motor driver enables differential steering, granting the robot agility in navigating through various field terrains. The DC pump, actuated via the relay module, sprays pesticide only when required, based on preset moisture levels and environmental conditions, thereby conserving resources and reducing chemical runoff. All sensor data—including soil moisture, ambient temperature, and humidity—are visualized in real- time on the Blynk dashboard, enabling informed decision-making from remote locations.

Keywords: *Semi-Automated Pesticide Spraying; Nodemcu; IOT Agriculture; Soil Moisture Sensing; Temperature and Humidity Sensing; Blynk Control; Pesticide Management.*

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I. INTRODUCTION

Agriculture remains a cornerstone of the global economy, yet it continues to face challenges such as labour shortages, inefficient resource usage, and health hazards associated with manual pesticide application. Traditional methods of pesticide spraying not only demand significant human effort but also pose risks of over-application, leading to environmental damage and increased costs. With the advancement of automation and Internet of Things (IoT) technologies, there is a growing opportunity to modernize farming practices through intelligent systems that can enhance efficiency, safety, and productivity. This project addresses these challenges by introducing a semi-automated pesticide spraying robot designed to support farmers in managing their crops more effectively. By integrating smart sensors, remote control functionality, and autonomous decision-making capabilities, the system minimizes human intervention while ensuring precise and timely pesticide application. Leveraging the NodeMCU microcontroller and the Blynk IoT platform, the robot offers real-time environmental monitoring, mobile-based control, and optimized spraying operations based on field conditions. This solution not only aims to improve agricultural output but also to promote sustainable farming by reducing chemical usage and environmental impact and also this proposed system provides cost-effective, reduces human efforts, and safety.

II. METHODOLOGY

In this proposed project, we are developing an agricultural pesticide spraying robot using various components, including a NodeMCU, L298N motor driver, relay module, DC motor, water pump, soil moisture sensor, temperature and humidity sensor, and robot wheels. The

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project begins by initializing the NodeMCU, which controls the entire system via Wi-Fi connectivity. The L298N motor driver is used to control the robot's wheels, enabling autonomous navigation through the agricultural field. The relay module controls the water pump that activates the pesticide spraying mechanism when required. The soil moisture sensor continuously measures the moisture level of the soil. If the soil moisture falls below a certain threshold, the system triggers the spraying mechanism via the relay module, allowing the water pump to dispense pesticide. Additionally, the temperature and humidity sensor collects environmental data. The DC motor plays a crucial role in operating the water pump, ensuring a steady and controlled flow of pesticide during the spraying process. When activated by the relay module, the DC motor drives the pump to distribute pesticide efficiently, ensuring uniform application across the crops. The speed and operation of the motor can be adjusted to regulate the amount of pesticide sprayed, preventing overuse and minimizing wastage. The robot's movement is guided by the motor driver, allowing the system to move to various areas of the field while performing the pesticide spraying. The sensors provide real-time feedback, enabling the robot to make intelligent decisions on when and where to apply pesticide based on the moisture levels and environmental conditions. also designed for remote control and monitoring through a mobile or web interface, providing flexibility and ease of management. The system is calibrated to ensure that the pesticide is applied accurately and the robot operates smoothly across the field. Overall, the agricultural pesticide spraying robot automates the pesticide application process, improving efficiency, reducing labor, and ensuring the crops receive the right care based on real-time data from sensors. With the integration of the DC motor, the system ensures precise and controlled pesticide spraying, enhancing automation, efficiency, precision, and cost-effectiveness in modern farming.

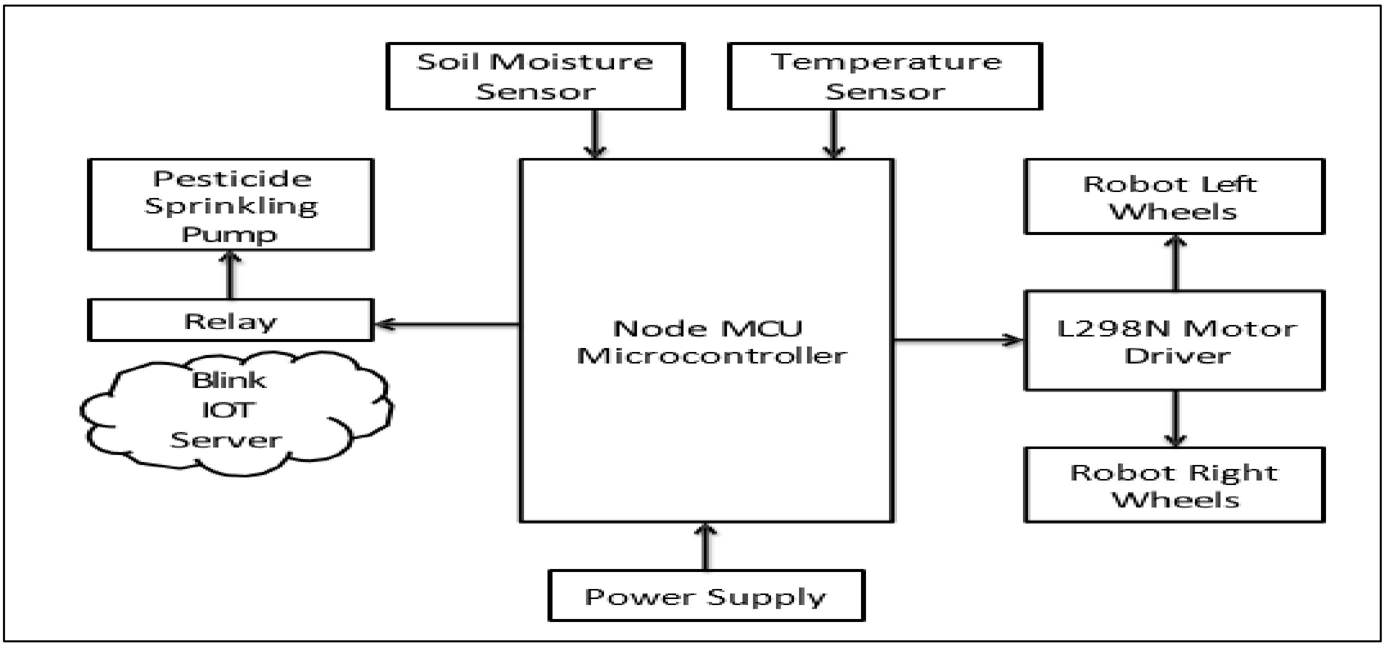

Fig 1 Block Diagram of Agricultural Pesticide Spraying Robot

➢ *Nodemcu Microcontroller:*

The NodeMCU is a Wi-Fi- enabled microcontroller that serves as the central control unit of the pesticide spraying robot. It receives data from sensors, processes the information, and sends commands to various components such as the motor driver, relay module, and water pump. It enables both autonomous operation and remote monitoring through IoT connectivity using the Blynk platform.

➢ *L298n Motor Driver:*

The L298N motor driver is responsible for controlling the movement of the robot by managing the speed and direction of the DC motors connected to the wheels. It allows precise navigation through the agricultural field, ensuring that the robot moves efficiently while covering the designated area for pesticide spraying. The dual H-Bridge configuration of the motor driver ensures smooth control of two DC motors independently.

➢ *Relay Module:*

The relay module acts as an electrically controlled switch that regulates the operation of the water pump. When the NodeMCU detects the need for pesticide spraying based on sensor readings, it triggers the relay module, which in turn activates the water pump. The relay ensures a reliable and efficient switching mechanism for automatic spraying.

➢ *Soil Moisture Sensor:*

The soil moisture sensor continuously monitors the moisture level in the soil, providing real-time data to the microcontroller. If the moisture level is too low, the system can trigger the water pump to spray pesticide accordingly. This helps in optimizing pesticide usage and ensuring that crops receive treatment based on actual field conditions.

➢ *Temperature And Humidity Sensor:*

The temperature and humidity sensor collects environmental data. This helps in avoiding excessive

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pesticide evaporation in high temperatures and ensures the most effective spraying time. The data collected is also transmitted to a mobile application for remote monitoring.

➢ *DC Motor:*

The DC motors are responsible for driving both the robot wheels and the water pump. The motors that control the wheels work in coordination with the L298N motor driver to allow movement in multiple directions, including forward, backward, left, and right. Another DC motor is used in the water pump mechanism to ensure a continuous and controlled flow of pesticide.

➢ *Water Pump:*

The water pump plays a crucial role in the pesticide spraying mechanism by ensuring a consistent and controlled distribution of the pesticide over crops. It is activated by the relay module and operates based on real-time sensor readings to optimize pesticide application. The pump is designed to deliver uniform spraying, preventing overuse and reducing chemical wastage.

➢ *Robot Wheels:*

The robot is equipped with durable wheels that enable smooth movement across different types of agricultural terrains. These wheels are powered by the DC motors and controlled by the motor driver, ensuring stable movement while navigating through the field. Proper traction and balance are maintained to prevent slippage and to ensure precise pesticide application.

➢ *Power Supply:*

The entire system is powered by a battery or an external power source, providing a stable voltage supply to all components, including the NodeMCU, sensors, motor driver, relay module, and water pump.

III. SYSTEM OPERATION

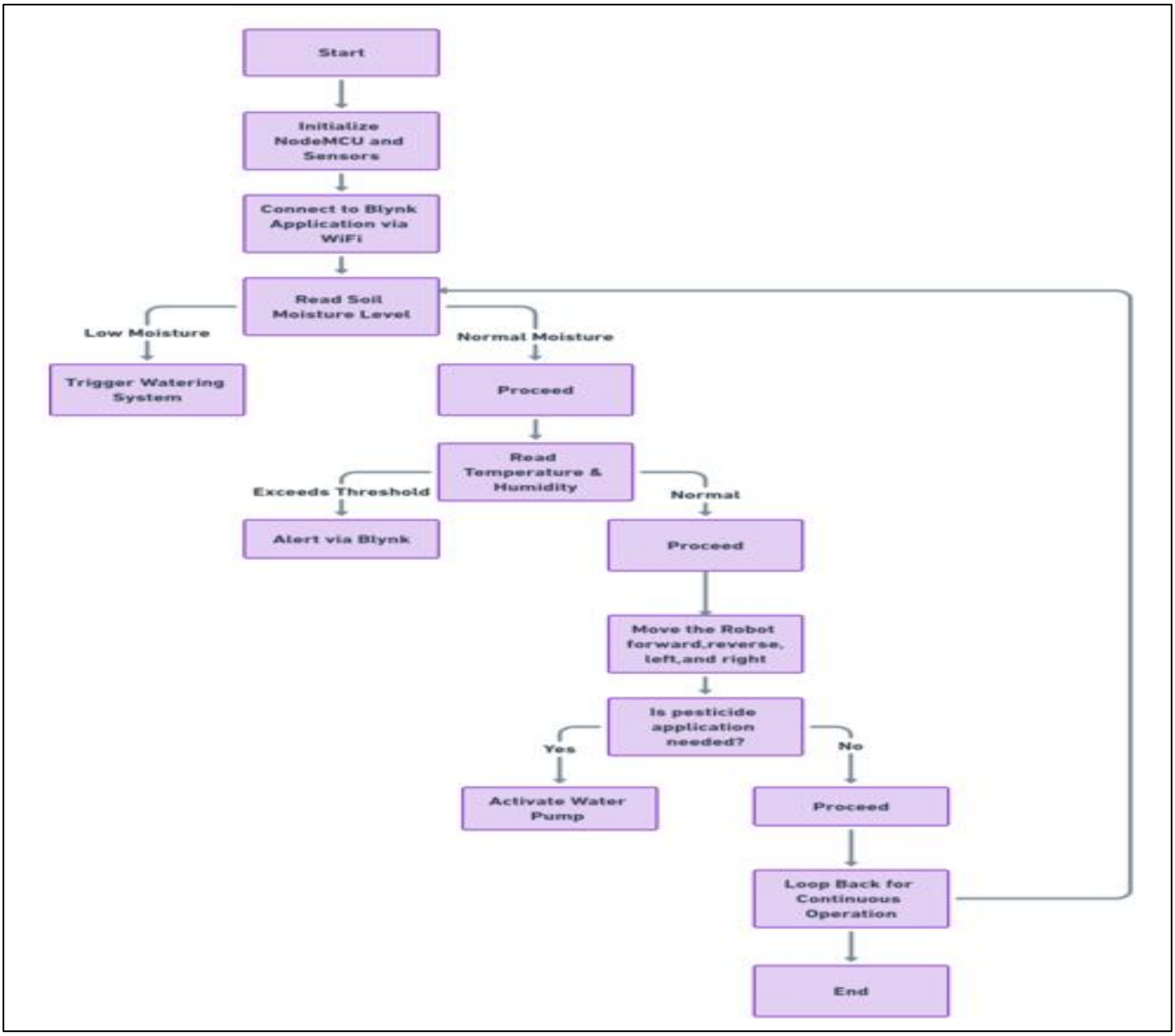

Fig 2 Flow Chart

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The overall working of the agricultural pesticide spraying can be divided into the following stages:

- *Robot Initialization:*

The robot system starts with initialization, where the NodeMCU (ESP8266 Wi-Fi module) is powered on and establishes connections. The NodeMCU is responsible for controlling and processing the robot's operations. Once powered up, the system prepares for operation and connects to the Wi-Fi network, allowing it to interact with the Blynk app for remote monitoring and control.

- *Soil Moisture Sensing:*

The soil moisture sensor is used to detect the moisture level of the soil. This is an important step because it helps the robot determine whether the soil needs watering or whether it is suitable for pesticide spraying. The sensor provides real-time data to the NodeMCU. If the soil is wet then it will show land is wet otherwise it will show the land is dry.

- *Temperature and Humidity Sensing:*

The temperature and humidity sensor monitors environmental conditions like temperature and humidity in the field. The data collected by the sensor is sent to the NodeMCU, which can adjust the spraying behavior based on the temperature and humidity levels to optimize pesticide application.

- *Movement Control with L298N Motor Driver:*

The L298N motor driver controls the movement of the robot's wheels, allowing it to navigate the field autonomously. The NodeMCU sends commands to the L298N motor driver to control the direction and speed of the robot's wheels. The robot can move forward, backward, turn left, or turn right. It uses the L298N motor driver to move and navigate around obstacles in the field. Water Pump Activation: If the soil moisture sensor detects that the soil is too dry, the robot will activate the water pump using a relay module. The relay serves as a switch, allowing the NodeMCU to control the pump.

- *Pesticide Spraying:*

After checking the moisture level and environmental conditions, the robot proceeds to the pesticide spraying task. The NodeMCU sends a signal to the relay module, activating the pesticide water pump. The pump sprays pesticide onto the targeted areas in the field. The robot uses the L298N motor driver to move and navigate around obstacles in the field.

- *Remote Control and Monitoring via Blynk Application:*

The Blynk application is used to provide remote monitoring and control of the robot. The NodeMCU is connected to the Blynk app via Wi- Fi, allowing users to view real-time data from the sensor. Users can also manually control the robot's movement, start/stop the water pump, and trigger pesticide spraying via the Blynk app.

- *Data Logging:*

The NodeMCU can log data from the sensors, to the cloud via the Blynk application. This data can be used to generate reports or feedback, allowing the user to analyze the robot's performance over time and make any necessary adjustments to optimize operations. Once the robot is activated, it can operate autonomously, and starts spraying the pesticide.

To summarize, the agricultural pesticide spraying robot uses the Blynk app for remote control and monitoring. The robot can autonomously navigate the field, irrigate the soil when necessary, and spray pesticide efficiently based on real-time data. This system is highly effective, reduces human labour, and ensures precise pesticide application, optimizing the agricultural process.

IV. SOFTWARE DESIGN

- *Libraries:*

The system uses libraries such as ESP8266WiFi, Wire, Adafruit Sensor, and DHT to facilitate communication between the NodeMCU and various components like the soil moisture sensor, temperature and humidity sensor, relay module, L298N motor driver, DC motor, and water pump.

- *Initialization:*

At initialization, the system sets up the libraries and components. This includes configuring the Wi-Fi module for remote monitoring, initializing sensor communication, setting up the L298N motor driver for motor control, and configuring the relay module for activating the water pump. The system also reads stored parameters from memory to load predefined spraying conditions.

- *Main Loop:*

The main loop of the program continuously monitors sensor readings, controls the movement of the robot, and activates the water pump based on soil moisture levels and environmental conditions. The loop consists of several functions that are called repeatedly, including reading sensor data, processing the data, controlling motor movement, and triggering the spraying mechanism.

- *Reading Sensor Data:*

The system continuously reads data from the soil moisture sensor and the DHT sensor (temperature and humidity). If the soil moisture level is below the threshold, the system determines that pesticide spraying is necessary. Temperature and humidity readings help adjust spraying intensity or delay spraying if environmental conditions are not favorable.

- *Controlling Robot Movement:*

The system controls the robot's movement using the L298N motor driver, which drives the DC motors attached to the robot wheels. Based on predefined path- following algorithms or manual control via a web interface, the robot navigates through the field while ensuring even pesticide distribution.

- *Activating the Water Pump:*

When the system detects low soil moisture or receives a remote spraying command, it activates the relay module, which powers the water pump. The pump sprays pesticide

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through the attached nozzles while the robot moves across the field. The spraying duration and intensity are adjusted based on real-time sensor data.

➢ *Logging Data:*

The system logs sensor readings, spraying activity, and movement patterns for future reference. This data is stored in memory and can be accessed remotely via a web interface. Logged data helps optimize pesticide usage and improve field coverage efficiency.

➢ *Data Management:*

The system includes a data management function that allows administrators to remotely view and analyze sensor readings, adjust spraying parameters, and manually control the robot. This function can be accessed through a web interface connected via Wi-Fi. The system also allows administrators to export collected data in CSV format for further analysis and decision- making.

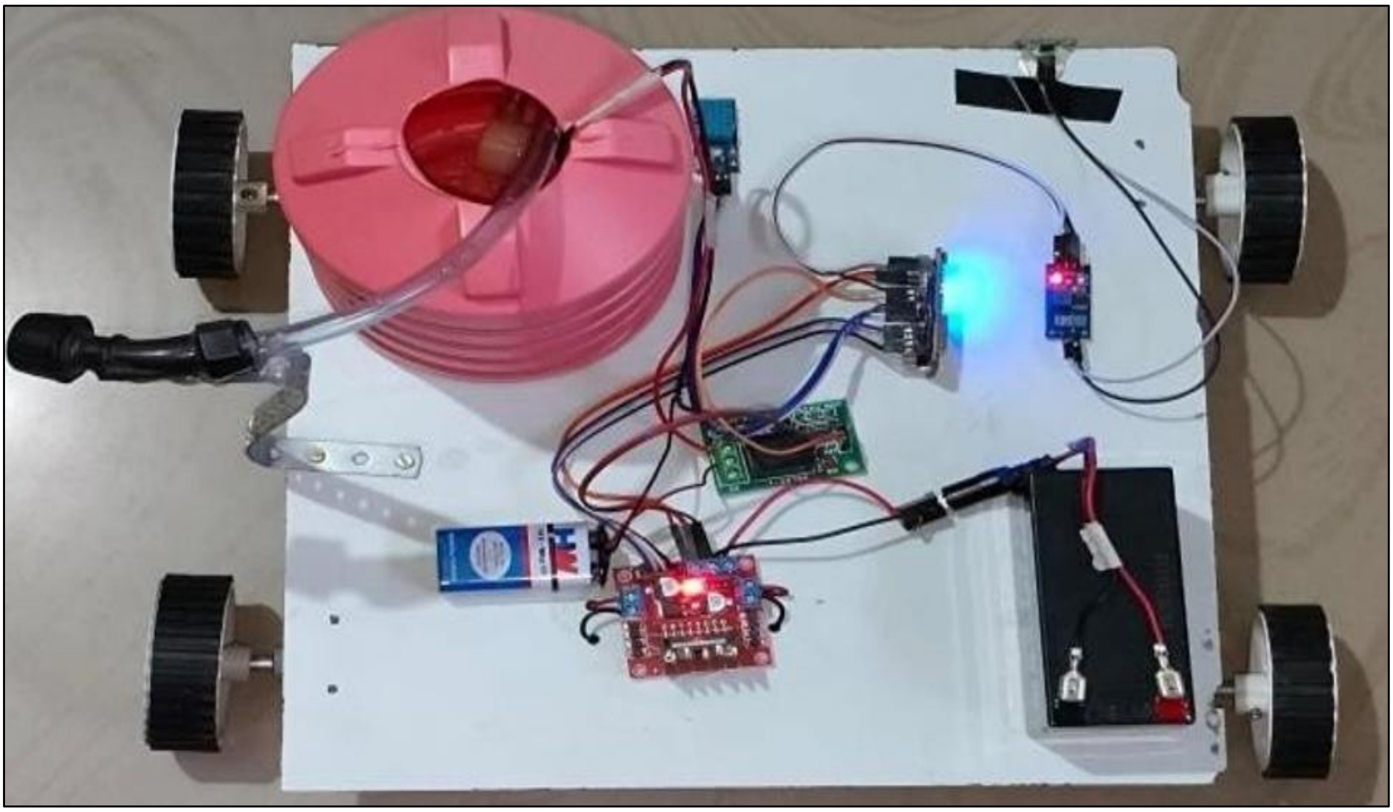

Fig 3 Hardware Implementation

V. RESULT AND DISCUSSION

The prototype of the semi-automated pesticide spraying robot, as shown in the image, was successfully developed and tested under controlled conditions. The system integrates all the planned components, including the NodeMCU microcontroller, L298N motor driver, DC water pump, relay module, soil moisture sensor, temperature and humidity sensor, and the Blynk IoT platform. Mobility and Navigation**:** The robot demonstrated stable movement across flat surfaces, with the L298N motor driver enabling effective differential steering. The four-wheel configuration provided balanced support and smooth motion.

➢ *Pesticide Spraying Mechanism:*

The DC motor-driven pump functioned accurately when triggered by the relay module. It delivered a consistent and targeted spray of liquid (used as a pesticide substitute during testing).Spraying was executed only under predefined moisture level conditions, confirming the functionality of the sensor-based control logic.

➢ *Sensor Performance:*

The soil moisture sensor and DHT11 temperature and humidity sensor provided accurate and timely readings. Data was successfully transmitted to the Blynk dashboard, and environmental parameters were visualized in real-time on a mobile application.

➢ *Remote and Semi-Autonomous Control:*

The Blynk app effectively allowed manual override, enabling user- defined navigation and spraying. The robot also operated semi-autonomously by responding to sensor data, showcasing its dual control capabilities.

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Table 1 Tabulation

Condition	Recommendation for Spraying Pesticide	Temperature Range	Humidity Level	Notes
Dry Soil	Yes (if no drought stress)	15–28°C	50–80%	Spray early morning or late afternoon to reduce drift and evaporation.
Wet Soil	Caution	15–28°C	50–80%	Risk of runoff; avoid if waterlogged or heavy rain is expected.
High Temperature	No	>30°C	<40%	Rapid evaporation and drift; reduced pesticide effectiveness.
Low Temperature	Caution	<10°C	>80%	Slower pest metabolism; poor pesticide absorption.
High Humidity	Generally Good	15–28°C	60–90%	Reduces evaporation; improves absorption for systemic pesticides.
Low Humidity	No	15–35°C	<40%	Increases evaporation and spray drift.

VI. CONCLUSION

The research demonstrates the effectiveness of using a semi- automated pesticide spraying robot to support modern farming practices. This robot, built with a NodeMCU microcontroller, soil moisture and temperature sensors, and a water pump, helps farmers apply pesticides only when necessary. It combines both automatic operation based on sensor data and manual control using the Blynk mobile app. Through testing, the robot showed it could move smoothly across flat surfaces, spray pesticides accurately, and send real-time data about the soil and environment to the user’s phone. This allows farmers to monitor and control the system from anywhere, helping them make better decisions for crop health.

By reducing the need for manual labour and avoiding overuse of pesticides, the system improves efficiency and protects both farmers and the environment. The research also shows that such a robot can be built at a low cost and can be upgraded in the future with features like GPS navigation and solar charging.

Overall, the project proves that combining simple electronics with IoT technology can create a powerful tool for smart and sustainable agriculture.

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