

Innovative Crop-Spraying System beyond Hand Pump and Drones

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Abstract - Modern methods of pesticide application in agriculture, such as hand pumps and drone systems, have significant limitations. Hand pumps are labor-intensive, time-consuming, and expose farmers to harmful chemicals, making them unsuitable for large farms. On the other hand, drones, while technologically advanced, are expensive and ineffective in orchard environments due to structural and operational constraints.

To overcome these challenges, we have developed a low-cost, automated pesticide spraying system specifically designed for small and marginal farmers, particularly those engaged in orchard farming. This system features a sprinkler-based spraying mechanism combined with an automatic height adjustment function, ensuring efficient and uniform coverage of plants at varying heights. Additionally, the integration of soil moisture sensors enables the system to assess soil conditions and estimate the required nutrients, allowing for precise and timely application.

This innovative solution offers the benefits of automation, mobility, and precision. It reduces labor requirements, minimizes farmers' exposure to harmful chemicals, and lowers overall operational costs.

Keywords: Crop spraying, Precision agriculture, Autonomous spraying, IoT-based spraying, Smart farming.

I. INTRODUCTION

Agriculture is Backbone Of our country because it provides food for everyone It is one of the most important sectors because it provides food and income for many people, with the growing population farmers need smart methods to improve crop production. Crop spraying is an important task that helps plants grow by applying water, fertilizers, and nutrients. farmers used Traditional hand pumps which were simple and cheap but required lot of physical effort and chemicals are come directly contact with Farmers as well as the chemical wastage and health risk occurred Drone spraying systems were introduced to cover large areas faster and more accurately, but they are costly, need trained operators, have

limited battery life, and cannot spray some crops properly due to height and obstacles. The main Drawback of the Drone is it is not suitable for fruit trees there is no mapping Because of these challenge, innovative automatic spraying systems were developed using sprinklers, NPK sensors, web browsers, DC motors, nutrient pumps, motor controllers, and logic units. These systems work automatically, reduce human effort, and increase accuracy. They can also check the crop condition and spray only the required amount, saving chemicals and protecting the soil. With sensors and automatic movement, the system sprays uniformly, improves crop growth, and helps farmers increase productivity safely and efficiently.

II. RELEVANCE

Developing these innovative Crop spraying systems is very important for modern farming. They help farmers use fertilizers and nutrients carefully, which reduces waste and protects the environment. They also improve safety by reducing direct contact with chemicals. These systems can increase crop growth and Efficiency Using components like sprinklers, NPK sensors, DC motors, nutrient pumps, motor controllers, and logic units makes the system automatic and precise. Web browsers can be used to monitor and control the system easily. By using these technologies, farming becomes faster, safer, and more efficient. This system is useful for managing nutrients and spraying across large fields, providing a modern solution for better crop production Problem.

III. LITERATURE REVIEW

Recent research has focused on developing smart and ecofriendly spraying systems to improve agricultural efficiency. Sharma *et al.* created a solar-powered robot for spraying and weed cutting, while Koirala *et al.* combined drones and ground robots to detect unhealthy crops and spray only where needed.[1]

[2] Agarwal and Perez *et al.* used AI and image processing to target weeds precisely, reducing chemical usage by up to 70%. [3] [4] Joshi and Kumar developed sensor-based sprayers that adjust spray amounts based on crop density, helping to prevent chemical waste and environmental

harm. [5] Electrostatic spraying has also gained importance in modern farming. Studies by Sánchez-Hermosilla *et al.*, Law, and Lin *et al.* showed that charging spray droplets electrically improves pesticide adhesion, giving better leaf coverage and reducing chemical usage. [6] [7] Iranshahi *et al.* explored electro hydrodynamics (EHD) to produce fine and uniform droplets for accurate and efficient spraying. [16] Similarly, Ou *et al.* developed an air-assisted electrostatic sprayer for vineyards, combining airflow and charging for deep leaf penetration and minimal waste. [17] Automation and robotics have further enhanced spraying precision. Nguyen *et al.*, designed a line-following autonomous sprayer, while Pokharel *et al.* built a robot capable of spraying under crop canopies. [9] [13] Azghadi and Rahimi Azghadi's works focused on robotic spot sprayers and AI-based weed control robots like Auto Weed, which identified weeds with 97% accuracy while using 54% less herbicide. [10] Mingling Ou's research optimized multi-row electrostatic sprayers for faster and more efficient operations. [19] Overall, these innovations — combining solar power, AI, electrostatics, and robotics — are transforming crop spraying into a sustainable, cost-effective, and precision-based process that saves time, reduces chemical waste, and supports environmentally friendly farming practices.

IV. GAP IDENTIFICATION

According to the above research, it is understood that modern agricultural spraying methods such as hand pumps and drones have certain drawbacks. The hand pump system is Manual Sprayers required significant physical effort and slow down the spraying process while drones are mainly used on a large scale for crops like sugarcane and soybean. However, this system cannot be used for spraying fruit trees, as the drone's operating system is not suitable for orchard conditions. At present, tractors are used for spraying in fruit farming, but this system is not effective or suitable in all seasons.

V. PROBLEM STATEMENT

Agriculture is important in our country, providing food and livelihood for millions of people. With the growing population and rising demand for food, farmers need modern and efficient ways to improve crop production crop spraying, which supports plant growth by applying water, fertilizers, and nutrients.

Traditionally, farmers have used on hand pumps and manual sprayers. All these methods are low-cost and simple, they require significant human effort, and Conventional hand pumps are inefficient for large farms due to their high labor requirement. Often lead to uneven spraying, and can result in overuse of chemicals. Manual spraying poses health risks due to direct contact with fertilizers and pesticides.

Drone spraying systems can cover large areas faster and spray more accurately than manual methods. However, drones are 1. Web Browser (UI) Fig. No. 1 expensive, have limited battery life, carry only small quantities of chemicals, and require trained operators. They are also not suitable for short and tall fruit trees.

These challenges highlight the need for an innovative, low-cost, and efficient crop spraying system specifically designed for fruit trees. Modern systems use incorporate technologies like sprinklers, NPK (nutrient) sensors, DC motors, nutrient pumps, motor controllers, and logic units to automate spraying. Web-based monitoring and control allow farmers to manage the system easily and precisely. Such systems ensure even spraying, reduce human effort, save time, and improve crop growth and efficiency.

VI. OBJECTIVE

The main objective of this project is to develop a crop spraying mechanism that works beyond the limitations of hand pumps and drones used in the agricultural field. In agriculture, hand pumps and drones are commonly used for spraying pesticides, insecticides, and fertilizers on crops. However, both methods have certain drawbacks that affect efficiency, safety, and cost-effectiveness. To overcome these limitations, this project aims to design and develop an innovative spraying system capable of improving the overall spraying process.

Traditional hand pumps require excessive manual effort from farmers, often resulting in physical strain and fatigue. In addition, hand pump spraying leads to uneven distribution of fertilizers or pesticides, causing wastage of chemicals and poor crop coverage. The process is also time-consuming, especially for large agricultural areas.

Drone-based spraying systems, on the other hand, are expensive and thus unsuitable for small and medium-scale farmers. They also face challenges such as limited battery life and difficulty in targeting specific areas accurately.

Therefore, the proposed system focuses on reducing these limitations by developing a cost-effective, efficient, and user-friendly crop spraying mechanism. The system ensures uniform distribution of fertilizers and pesticides over crops, minimizes chemical wastage, and enhances farmers' safety by reducing direct exposure to harmful chemicals. Additionally, it aims to automate or semi-automate the spraying process to improve accuracy, save time, and promote sustainable farming practices.

VII. PROPOSED BLOCK DIAGRAM

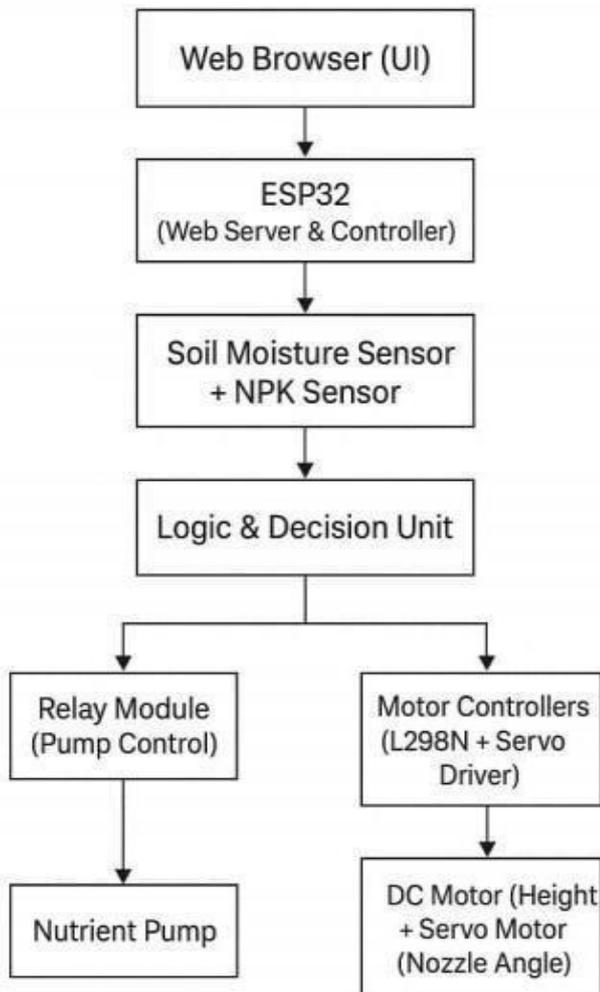


Figure 1

1. Web Browser (UI)

This is the user interface (UI) where the farmer or operator can monitor and control the system through a web application.

It displays real-time data like soil moisture, NPK (nutrient) values, and spraying status. The user can also send commands such as start/stop spraying or adjust nozzle height.

2. ESP32 (Web Server & Controller)

The ESP32 is the main controller and communication device of the system. It connects to Wi-Fi and acts as a web server, receiving commands from the web browser. It collects sensor data, processes it, and controls other components like the pump and motors. It forms the “brain” of the system, ensuring automation and decision-making.

3. Soil Moisture Sensor + NPK Sensor

These sensors collect real-time data from the soil. Soil Moisture Sensor measures how much water is present in the soil. NPK Sensor measures the nutrient content — Nitrogen (N), Phosphorus (P), and Potassium (K) — which are vital for plant growth. The readings are sent to the ESP32 for analysis.

4. Logic & Decision Unit

This unit is a software-based decision-making section inside the ESP32. It compares sensor readings with predefined threshold values. Based on conditions (e.g., if soil is dry or nutrients are low), it decides whether to start the pump or adjust the spray angle/height. It ensures automation and precision spraying without human effort.

5. Relay Module (Pump Control)

The Relay Module acts as an electronic switch. It receives a control signal from the logic unit to turn the nutrient pump ON or OFF. This ensures that nutrients or pesticides are sprayed automatically when required.

6. Nutrient Pump

The Nutrient Pump sprays the fertilizer, pesticide, or nutrient solution onto the crops. It is controlled through the relay, ensuring automatic and efficient operation without manual effort.

7. Motor Controllers (L298N + Servo Driver)

The L298N motor driver controls DC motors, and the Servo Driver controls servo motors.

These help manage the movement and positioning of the spray system.

The motor controllers receive commands from the logic unit to adjust the system as needed.

DC Motor (Height) + Servo Motor (Nozzle Angle) The DC Motor adjusts the height of the spraying arm to target different crop levels.

The Servo Motor adjusts the angle of the spray nozzle for better coverage and precision.

Together, they ensure uniform spraying and efficient coverage of crops.

Table 1: Comparison

IX. CONCLUSION

Sr.no	Parameter	Old system	New Innovative system
1.	Method of operation	Manual pumping	Auto-mated electric spraying mechanism
2.	Labor Requirement	High very	Very low, one man can operate system.
3.	Accuracy	Low to medium	very high
4.	chemical consumption	high due to uniform spraying	very low applies only where require
5.	Health And safety	operator exposed to chemicals	operator stays away very safe
6.	maintains	low	medium
7.	environmental Impact	Higher wastage runoff	very low targeted spray and less chemical pollution
8.	skill Require	low	medium
9.	cost	low	High

This innovative crop spraying system, beyond hand pumps and drones, is more accurate than the old spraying methods and saves chemicals by spraying only the required amount at specific locations. It reduces labor effort, ensures safer operation, and is very useful and effective for crop protection, especially for fruit trees.

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Advantage

- Advantages of innovative crop spraying systems:
- Accurate and uniform spraying on crops.
- Reduced human contact with harmful chemicals.
- Saves time and labor costs.
- Works efficiently with low power consumption.
- Decreases pesticide wastage and pollution.
- Suitable for different types of farms and crop heights.
- Promotes sustainable and eco-friendly agriculture

VIII. FUTURE SCOPE

In the future, crop spraying systems will become more advanced with the use of artificial intelligence, machine learning, GPS, and smart sensors. These technologies will help the system automatically spray only where needed. This selective spraying will save pesticides, protect the environment, and increase crop health.

Solar-powered will also use which will save the electrical energy IoT-based control, farmers will be able to operate and monitor their machines through mobile applications. Moreover, by designing low-cost and easy-to-maintain systems, even small farmers will be able to adopt this technology.

Hence, innovative crop spraying systems beyond handpump and drones will play a major role in the future of farming. They will make agriculture more modern, smart, and sustainable, helping farmers increase their productivity while protecting their health and the environment.

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