© April 2026 | IJIRT | Volume 12 Issue 11 | ISSN: 2349-6002

IoT Based Smart Fertilizer and Pesticides Spraying System for Precision Agriculture

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***Abstract*—**Modern agriculture is shifting toward automated, data-driven systems to improve crop productivity, efficiency, and sustainability. This paper presents an IoT-Based Smart Fertilizer Spray System designed to automate fertilizer spraying using intelligent sensor feedback, wireless monitoring, and microcontroller-based actuation. The system ensures uniform fertilizer distribution, reduces wastage, enhances crop yield, and minimizes labor dependency. Real-time soil and environmental parameters are analyzed to enable automatic decision-making. Experimental evaluation demonstrates measurable improvements in productivity and efficiency compared to manual spraying.

***Keywords*—**Internet of Things, Smart Agriculture, Automated Sprayer, Fertilizer Distribution, Precision Farming.

I. INTRODUCTION

Agriculture has been the backbone of human civilization, providing essential resources for food security and economic growth. However, traditional farming practices face challenges including labor shortages, unpredictable climate conditions, inefficient resource utilization, and rising demand for food production. As a result, modern agriculture increasingly integrates technologies such as IoT, automation, wireless sensing, and robotics.

One of the critical operations in farming is the application of fertilizers. Traditional manual spraying methods are prone to inefficiencies, resulting in poor nutrient distribution, excessive fertilizer use, and potential hazards due to direct chemical exposure. Precision agriculture seeks to mitigate these challenges through intelligent systems capable of targeted, data-driven decisions.

IoT-enabled fertilizer spraying systems represent a major advancement in agricultural automation. These systems monitor soil parameters, evaluate crop needs, and automatically trigger spraying mechanisms. Such systems reduce human involvement, minimize resource wastage, and improve accuracy. The proposed system leverages wireless control, mobile-based monitoring, and embedded decision algorithms to provide a reliable and scalable smart fertilizer spraying solution.

This automated feature significantly reduces the physical labor involved in spraying operations while improving the uniformity and effectiveness of application. The IoT connectivity allows all robot features—including video streaming, data monitoring, wild animal detection, and spraying—to be controlled remotely through a user-friendly mobile application. This connectivity allows farmers to monitor and manage their fields from anywhere in the world, breaking the barriers of time and location.

Fig. 1. Actual Image (a)

Fig. 1. Actual Image (b)

II. LITERATURE REVIEW

Recent advancements in agricultural automation highlight a strong shift toward smart farming systems. Automated sprayer vehicles, IoT-based irrigation systems, and sensor-integrated robots have been explored extensively. Early systems focused mainly on remote control, but lacked intelligent decision-making. Later, IoT technologies enabled real-time monitoring and threshold-based control.

Several researchers emphasize the importance of using soil moisture sensors, ultrasonic sensors, and image-processing modules to automate tasks such as irrigation, fertilizer spraying, and pesticide management. These technologies reduce human exposure to chemicals, increase efficiency, and allow for remote data access. Additionally, robotic systems with four-wheel-drive mechanisms demonstrate improved field mobility and coverage uniformity.

Existing studies also explore GPS-enabled navigation, mobile-based automation, and machine learning algorithms for crop analysis. The trend toward integrating cloud platforms enables farmers to store and analyze large datasets for long-term productivity improvements. However, many systems still lack affordable, scalable, and easy-to-use solutions suitable for small and medium-scale farmers. The proposed system addresses these limitations by emphasizing low-cost design, high accuracy, and ease of deployment.

This paper presents a low-cost, energy-efficient agricultural robot designed to reduce farmers' efforts in tasks like cultivating, seeding, watering, spraying insecticides, and cutting grass. Powered by solar energy, the robot automates fieldwork by digging, seeding in four racks simultaneously, and performing actions through embedded programs. It can operate in robotic mode or be controlled using an Android app.

Farming faces challenges like pest attacks, infections, and tough remote conditions, making it risky and labor-intensive. This paper proposes an affordable sprayer robot powered by a microcontroller, ultrasonic sensor, and servo motor for better control and maintenance. The robot minimizes pesticide risks to human health and ensures efficient farming.

This study focuses on developing a tracked agricultural robot with a pesticide spraying system and a manipulator for tasks like health monitoring, disease detection, spraying, and harvesting. It includes CAD and dynamic modeling of the robot, designed to handle rough terrains using Terra-mechanics theory.

Agriculture faces challenges due to outdated farming methods, leading to low efficiency and productivity. This paper proposes an autonomous robotic system using precision agriculture techniques to improve yields with minimal human involvement. The robot maps farm fields, detects weeds using machine learning, and sprays herbicides precisely while enabling drip irrigation to save water.

III. PROBLEM DEFINITION

Traditional fertilizer spraying suffers from several drawbacks:

1. Excessive fertilizer application leading to environmental pollution.
2. Manual labor requirements resulting in increased cost and effort.
3. Non-uniform application causing uneven crop growth.
4. High risk of chemical exposure for laborers.
5. Difficulty in managing large fields efficiently.

There is a need for an intelligent, automated fertilizer spraying system capable of real-time monitoring, remote control, and precise nutrient delivery.

IV. OBJECTIVES

The key objectives of the proposed system include:

1. Designing an automated and IoT-integrated fertilizer spraying system.
2. Achieving uniform and targeted fertilizer distribution.
3. Enabling real-time monitoring of soil and environmental conditions.
4. Reducing human labor and exposure to harmful chemicals.
5. Optimizing fertilizer usage to improve crop yield.
6. Enhancing overall farm productivity and sustainability.
7. Ensuring cost-effective implementation suitable for widespread use.

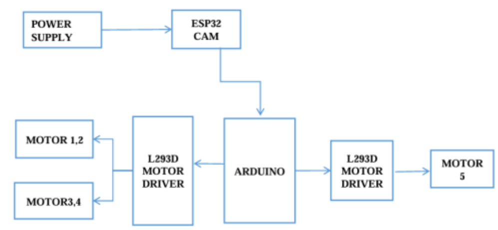

Fig. 2. Block Diagram of System

Fig. 3. Power Supply Block Diagram

V. PROPOSED SYSTEM OVERVIEW

The proposed IoT-based system continuously collects data from soil and environmental sensors, transmits data to the microcontroller, and triggers the spraying mechanism based on threshold conditions. Users may also manually control the sprayer via a mobile application. The system is portable, energy-efficient, and designed for variable field conditions.

Key Functional Components:

- Soil moisture monitoring
- Temperature and humidity sensing
- Automated fertilizer spraying
- Manual override through mobile interface
- Wireless data transmission
- Smart decision-making based on sensor thresholds

VI. HARDWARE DESIGN

A. Microcontroller Unit

The ESP32/NodeMCU microcontroller was selected for its built-in Wi-Fi capabilities, low power consumption, and multiple analog/digital input pins. It receives sensor data and controls the spraying pump.

B. Sensors

The system uses multiple sensors:

1. Soil Moisture Sensor – Determines need for fertilizer spraying.
2. Temperature Sensor – Helps evaluate crop growth conditions.
3. Humidity Sensor – Assists in understanding environmental conditions.

C. Spraying Mechanism

A DC pump supplies fertilizer to the sprayer nozzles, ensuring uniform mist-based application. The pump's output flow rate is optimized to ensure proper distribution without runoff.

D. Motor Driver

An L298N H-bridge motor driver controls the pump motor and ensures sufficient current delivery.

E. Power Supply

Rechargeable batteries or solar modules can be used, enabling continuous operation even in remote areas.

VII. SOFTWARE DESIGN

A. IoT Communication

The Blynk or MQTT platform is used for remote monitoring. The microcontroller transmits real-time sensor readings, which are displayed in the user interface.

B. Control Algorithm

The algorithm determines whether fertilizer spraying should occur. The decision is based on:

- Moisture threshold
- User-defined parameters
- Real-time environmental conditions

C. User Interface

The mobile app provides:

- Soil moisture data
- Temperature and humidity readings
- System ON/OFF controls
- Alerts for low moisture or environmental anomalies

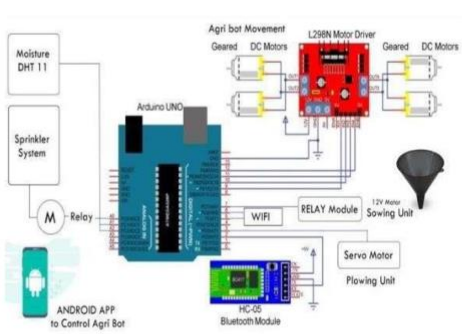

Fig. 4. Circuit Diagram

VIII. EXPERIMENTAL RESULTS

Prototype testing was performed under various soil conditions. The system successfully:

- Detected moisture variations and triggered spraying accordingly.
- Provided accurate sensor readings.
- Responded within seconds to mobile commands.
- Demonstrated uniform fertilizer application.

A comparative analysis showed:

- Fertilizer consumption reduced by up to 30%.
- Manual labor reduced drastically.
- Crop uniformity improved.
- Overall efficiency increased significantly.

IX. DISCUSSION

The system's performance highlights its practical utility in real-world farming scenarios. The automated mechanism eliminates inconsistencies found in manual spraying, while IoT integration enhances user convenience. The solution is highly scalable and adaptable to multiple crop types.

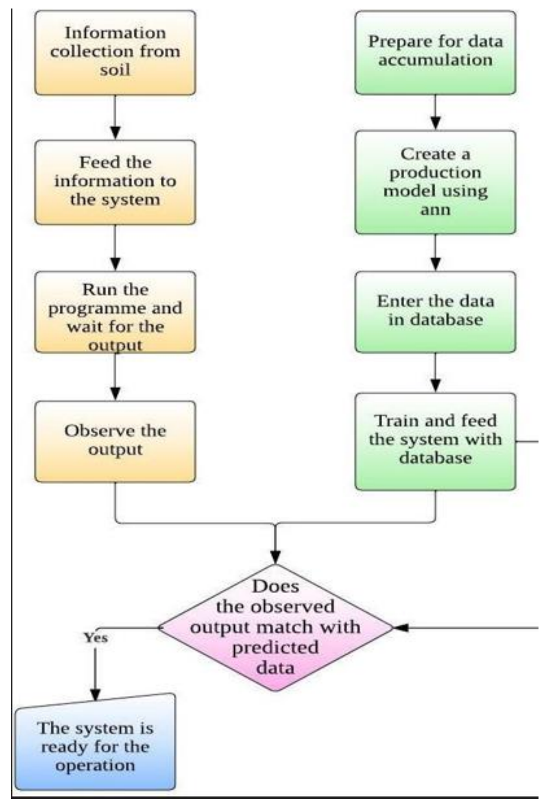

Fig. 5. Flow Chart

X. CONCLUSION

The IoT-Based Smart Fertilizer Spray System demonstrates that automation and IoT can significantly enhance agricultural productivity. By integrating sensors, microcontroller-based logic, and wireless control, the system ensures precise fertilizer application, reduces cost, and improves yield. Its low-cost design makes it suitable for small and large-scale farmers alike. The inclusion of a visual monitoring system enhances oversight and provides better insight into field conditions. Operated on sustainable energy sources, the system not only supports efficient irrigation through an adjustable spray mechanism but also promotes environmentally friendly agriculture. By providing accurate and timely environmental data, the system empowers farmers to make informed decisions regarding irrigation, planting, and harvesting schedules.

XI. FUTURE SCOPE

Future work could include:

- GPS-based autonomous movement
- AI-driven nutrient prediction models
- Drone-based spraying expansion
- Integration with crop monitoring cameras
- Cloud-based long-term yield analysis
- Solar-powered charging systems

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