



Smart Agriculture Robot for Seed Sowing and Spraying: A Review

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DOI: 10.5281/zenodo.19558679

ABSTRACT

Agriculture is undergoing rapid transformation through automation and intelligent robotic systems aimed at improving productivity, minimizing labor dependency, and enhancing resource efficiency. Among modern smart farming solutions, agricultural robots capable of seed sowing and spraying operations have attracted significant research attention due to their ability to perform repetitive and labor-intensive tasks with precision. This review paper explores recent advancements in smart agriculture robots designed for autonomous or semi-autonomous seed sowing and spraying. The study analyzes system architectures, control mechanisms, sensing technologies, navigation techniques, and spraying methodologies.

Recent findings indicate that integration of Internet of Things (IoT), machine vision, GPS-based navigation, and intelligent control systems significantly improves farming accuracy while reducing chemical usage and operational costs. The paper highlights key challenges including terrain variability, power management, and scalability, and presents future directions for developing low-cost multifunctional robotic platforms suitable for precision agriculture.

Keywords:- Smart agriculture, agricultural robot, seed sowing, pesticide spraying, IoT farming, precision agriculture, autonomous robot.

I. INTRODUCTION

Agriculture remains one of the most labor-intensive industries worldwide. Increasing population, labor shortages, and the need for sustainable food production have accelerated the adoption of smart farming technologies. Robotics has emerged as a promising solution for automating repetitive agricultural activities such as sowing, spraying, harvesting, and weed management.

Seed sowing and pesticide spraying are two critical farming operations directly affecting crop yield and plant health. Traditional methods often involve inconsistent seed placement, excessive chemical usage, and high labor costs. Smart agriculture robots aim to overcome these limitations by enabling precision placement and controlled spraying through automated systems.

Recent studies emphasize that multifunctional agricultural robots combining sowing and spraying capabilities can significantly improve field efficiency and reduce environmental impact by minimizing overuse of chemicals.

II. METHODOLOGY OF REVIEW

This review is based on recent research literature and technical reports focusing on:

- Autonomous seed sowing systems
- Intelligent spraying robots
- IoT-based agricultural automation
- Precision farming robotic platforms
- Sensor and navigation technologies in agriculture

Selected studies include experimental prototypes, design-based research, and review papers published between 2021–2025.

III. ARCHITECTURE OF SMART AGRICULTURE ROBOTS

Typical smart agriculture robots consist of the following modules:

A. Mechanical Structure

Most robots use four-wheel or tracked mobile platforms designed for uneven agricultural terrain. Lightweight structures improve mobility and energy efficiency while ensuring stability during seed dispensing and spraying operations.

Recent designs integrate multifunctional modules allowing ploughing, sowing, and spraying in a single platform, reducing operational time and labor requirements

B. Control Unit



Microcontrollers such as Arduino or embedded processing boards serve as central control units. These coordinate motor motion, seed dispensing mechanisms, pump control, and sensor data processing. IoT-enabled systems allow remote monitoring and control through wireless communication, enabling smart farming decisions based on real-time conditions.

C. Sensor Integration

Sensors play a vital role in ensuring accurate field operation:

- Ultrasonic sensors for obstacle detection
- Soil sensors for condition monitoring
- GPS/RTK modules for navigation
- Camera-based vision for crop recognition

Machine vision combined with robotic spraying enables targeted application, reducing chemical waste and environmental contamination.

IV. SEED SOWING MECHANISMS

Seed sowing is one of the primary applications of agricultural robotics.

A. Automated Seed Dispensing

Robotic seed sowing systems typically use:

- Rotor-based seed release
- Servo-controlled seed valves
- Encoder-based distance tracking

These mechanisms ensure uniform spacing between seeds, improving germination rates and crop uniformity.

A design analysis study showed that automated seed dispensing significantly reduces manual errors and increases precision compared to traditional sowing methods.

B. Navigation for Precision Sowing

Autonomous navigation enables robots to move in straight rows and maintain consistent planting geometry. GPS-assisted systems or encoder-based path tracking are commonly used for row alignment.

Open-source robotic platforms have recently demonstrated low-cost designs that allow modular add-ons for sowing and spraying operations.

V. SPRAYING SYSTEMS IN AGRICULTURAL ROBOTS

Spraying chemicals efficiently while reducing environmental impact is a major focus of modern agricultural robotics.

A. Conventional vs Smart Spraying

Traditional broadcast spraying often leads to excessive herbicide usage and environmental damage. Smart robotic spraying uses vision systems and controlled nozzles for selective spraying.

Field studies show that robotic spot spraying can reduce herbicide usage by approximately 35–65% while maintaining nearly the same weed control effectiveness as conventional approaches.

B. AI and Vision-Based Spraying

Recent robotic systems integrate cameras and machine learning algorithms to:

- Detect crop health conditions
- Identify weed locations
- Apply pesticides selectively

Ground-based robotic spraying offers improved precision compared to aerial drones due to stable image acquisition and reduced air disturbance.

VI. IOT AND SMART CONNECTIVITY

IoT-enabled smart agriculture robots allow:

- Remote operation through mobile devices
- Real-time monitoring
- Data collection for precision farming

Review studies indicate that combining robotics with IoT improves resource management and enables predictive farming strategies.

VII. ADVANTAGES OF SMART AGRICULTURE ROBOTS

Major benefits identified in literature include:

1. Reduced labor dependency



2. Improved seed placement accuracy
3. Lower pesticide exposure risk for farmers
4. Reduced chemical consumption
5. Enhanced productivity and yield
6. Continuous field operation with minimal supervision
Solar-powered or energy-optimized systems further improve sustainability.

VIII. CHALLENGES AND LIMITATIONS

Despite technological progress, several challenges remain:

- High initial setup cost
- Navigation difficulties in uneven terrain
- Power and battery limitations
- Sensor reliability under dust and mud conditions
- Scalability for large farms

Community and research discussions also highlight reliability and cost barriers in real-world deployment.

IX. FUTURE RESEARCH DIRECTIONS

Future research should focus on:

- Fully autonomous multi-task robots
- AI-driven crop recognition systems
- Swarm robotics for large-scale farming
- Solar-powered continuous operation
- Low-cost designs accessible to small farmers
- Hybrid systems combining sowing, spraying, and weeding

Integration of precision spraying and autonomous sowing with intelligent decision-making is expected to define next-generation agricultural robots.

X. CONCLUSION

Smart agriculture robots designed for seed sowing and spraying represent a significant advancement toward sustainable and precision farming. Recent studies demonstrate that integrating robotics, IoT, and intelligent sensing can reduce labor dependency while improving efficiency and environmental safety. Although challenges related to cost, robustness, and scalability remain, ongoing research indicates strong potential for widespread adoption in future agricultural practices. Continued development of multifunctional, cost-effective, and autonomous systems will play a crucial role in achieving smart and sustainable agriculture.

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