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Review on Solar Powered Automatic Seed Sprayer

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ABSTRACT

Agricultural activities in developing regions continue to rely heavily on manual seed sowing methods, which are labor-intensive, time-consuming, and prone to uneven seed distribution. This paper presents the design and development of a solar powered automatic seed sprayer intended to enhance efficiency and reduce human effort in agricultural operations. The proposed system employs solar energy as a renewable power source, making it suitable for rural and off-grid environments. The system comprises a solar panel, rechargeable battery, controller unit, DC motor, and a mechanical seed spraying mechanism. Automation of the seed spraying process ensures uniform seed dispersion while minimizing seed wastage. Experimental evaluation demonstrates that the system operates reliably under varying sunlight conditions and significantly reduces labor dependency. The proposed solution is cost-effective, environmentally sustainable, and well-suited for modern smart agriculture applications.

Keywords—Solar Energy, Automatic Seed Sprayer, Smart Agriculture, Renewable Energy, Agricultural Automation

1. INTRODUCTION

Agriculture plays a critical role in the economic development and food security of many countries. Despite advancements in agricultural technology, traditional farming practices such as manual seed sowing are still widely adopted, particularly in rural areas. These methods require substantial human effort, consume considerable time, and often result in non-uniform seed placement, which adversely affects crop yield. The growing emphasis on sustainable development necessitates the adoption of renewable energy sources and automation in agricultural practices. Solar energy, being clean, abundant, and renewable, offers a viable alternative to conventional energy sources. This paper proposes a solar powered automatic seed sprayer that integrates renewable energy with automation to improve seed sowing efficiency. The system is designed to reduce labor requirements, ensure consistent seed distribution, and support sustainable agricultural practices.

2. LITERATURE REVIEW

Numerous studies have been conducted on the development of seed sowing and spraying mechanisms to improve agricultural efficiency. Manual and semi-automatic seed sowing devices reduce physical effort but lack precision and consistency. Fuel-powered machines enhance productivity but increase operational costs and contribute to environmental degradation. Recent research has focused on solar-powered agricultural equipment, including irrigation systems, spraying machines, and automated seed sowing devices. These systems reduce dependence on non-renewable energy sources and are suitable for rural applications. However, many existing solutions are complex, expensive, or require skilled operation. The proposed system aims to address these limitations by offering a simple, affordable, and efficient solar powered automatic seed sprayer.

3. PROPOSED SYSTEM ARCHITECTURE AND HARDWARE DESIGN

The block diagram of the proposed solar powered automatic seed sprayer is shown in Fig. 3.1 The system is functionally divided into four major sections: power supply unit, control unit, actuation unit, and communication interface. The control unit is based on an ESP32 microcontroller, which acts as the central processing and decision-making unit of the system. The ESP32 receives power from the regulated supply and generates control signals for the motor driver, servo motor, and relay module. Wireless communication capability enables the microcontroller to receive user commands from a mobile controller through Wi-Fi or Bluetooth connectivity.
The actuation unit includes an L298N motor driver module, DC motors, a servo motor, a relay module, and a blower fan. The motor driver interfaces the ESP32 with the DC motors and supplies sufficient current to drive them safely. The DC motors are used for mechanical movement related to seed spraying. The complete circuit diagram of the proposed Solar Powered Automatic Seed Sprayer is illustrated in Fig. 3.2 The system is

designed around a renewable energy source and a microcontroller-based control unit to achieve automated seed spraying with minimal human intervention.

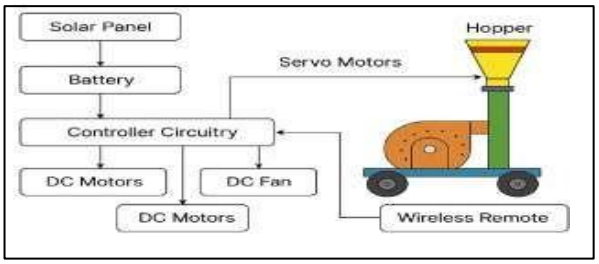

Fig. 3.1 Functional block diagram of the proposed seed sprayer system

The power subsystem consists of a solar panel, solar charge controller, lithium battery, and a DC–DC buck converter. The solar panel generates electrical energy from sunlight, which is regulated by the solar charge controller to safely charge the lithium battery. This ensures overcharge and discharge protection and improves battery lifespan. The stored energy in the bat tery serves as the primary power source for the entire system, enabling operation during low sunlight conditions. DC–DC buck converter is used to step down the battery voltage to a regulated level suitable for powering the control electronics, including the microcontroller and peripheral devices.

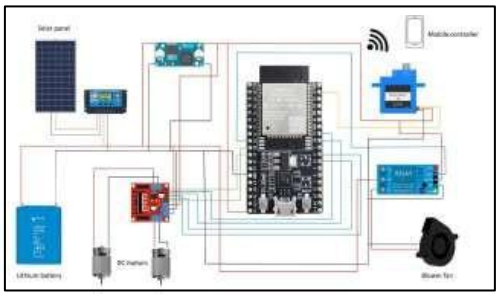

fig 3.2 Schematic circuit of the proposed solar powered automatic seed sprayer

The following hardware components are used in the design and implementation of the proposed solar powered automatic seed sprayer system.

3.1 Power Supply Components

Solar Panel – Used as the primary renewable energy source to generate electrical power from sunlight. Solar Charge Controller – Regulates the charging process and protects the battery from overcharging and deep discharge. Lithium-Ion Battery – Stores electrical energy to ensure continuous system operation during low or no sunlight conditions. DC–DC Buck Converter – Steps down and regulates the battery voltage to a suitable level for electronic components.

3.2 Control and Processing Components

ESP32 Microcontroller – Acts as the central control unit, responsible for processing control logic, wireless communication, and actuator control.

3.3 Actuation Components

L298N Motor Driver Module – Interfaces the microcontroller with DC motors and provides sufficient current for safe motor operation. DC Motors – Used for mechanical movement and seed spraying operation. Servo Motor (SG90) – Controls the seed outlet mechanism, enabling precise regulation of seed flow. Relay Module – Provides electrical isolation and allows safe switching of high-power devices. Blower Fan – Assists in uniform seed dispersion by generating airflow during spraying.

3.4 Mechanical Components

Seed Container (Hopper) – Stores seeds before dispensing. Seed Spraying Mechanism – Facilitates controlled and uniform seed distribution.

3.5 Communication and Miscellaneous Components

Mobile Controller (Smartphone) – Used for wireless control of the system through Wi-Fi or Bluetooth communication. Connecting Wires and PCB / Breadboard – Used for electrical interconnections.
Mechanical Frame / Chassis – Supports and holds all system components.

4. METHODOLOGY AND EXPERIMENTAL SETUP

4.1 Methodology

The methodology adopted for the development of the proposed solar powered automatic seed sprayer follows a systematic approach that includes system design, hardware integration, software implementation, and experimental validation. Initially, the system architecture was designed based on functional requirements such as renewable power utilization, automation, and ease of operation. A solar energy–based power supply was selected to ensure eco-friendly and off-grid operation. The power generated by the solar panel is regulated using a solar charge controller and stored in a lithium battery. A DC–DC buck converter is employed to provide a stable and regulated voltage to the control and actuation units. The ESP32 microcontroller is used as the central control unit. It is programmed to receive control commands wirelessly from a mobile controller and generate appropriate control signals for the actuators. The L298N motor driver is used to intern ace the ESP32 with DC motors, enabling controlled motor operation. A servo motor is employed to regulate the seed outlet mechanism, ensuring precise control of seed flow. A relay module is used to control the blower fan, which assists in uniform seed dispersion. The overall methodology emphasizes low power consumption, reliable control, and efficient seed spraying to support sustainable agricultural practices.

4.2 Experimental Setup

The experimental setup of the proposed system consists of a fully assembled prototype integrating the power supply unit, control unit, actuation components, and mechanical structure. The solar panel is mounted to receive maximum sunlight and connected to the charge controller and battery. The ESP32 controller, motor driver, relay module, and buck converter are housed securely within the system frame to protect them from environmental factors. seed container is mounted above the spraying mechanism, and the servo motor is connected to the seed gate for controlled dispensing. DC motors and the blower fan are positioned to facilitate effective seed spraying. Wireless communication between the ESP32 and the mobile controller is established to enable remote operation of the system. Experimental testing is carried out under varying sunlight conditions to evaluate system performance, power efficiency, and reliability. The system is tested for parameters such as uniformity of seed distribution, response time to control comman ds, and continuous operation using battery backup. The experimental results confirm the feasibility and effectiveness of the proposed system for automated seed spraying applications. Fig. 4.1 is showing the circuit used for the solar energy charging control system.

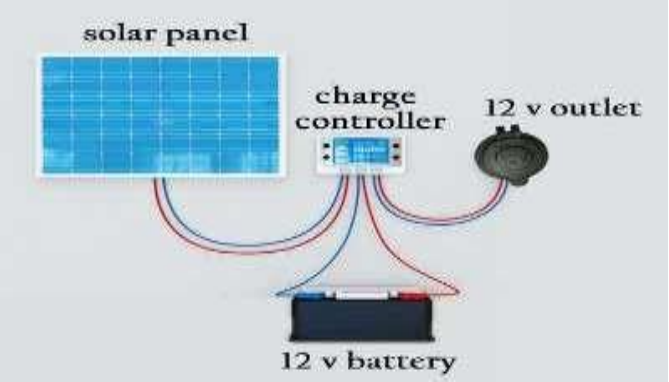

Fig. 4.1 Circuit of solar energy charging

The solar power supply and battery charging configuration used in the proposed system. The solar panel converts solar energy into electrical energy, which is regulated by the charge controller. The charge controller ensures safe charging of the 12 V battery by preventing overcharging and deep discharge.

Sr. no	Parameter	Value
1.	Solar panel voltage	12 V
2.	Battery voltage	12 V
3.	Controller supply voltage	5 V
4.	Motor operating voltage	12 V

5.	Blower operating voltage	12 V
6.	Charging method	Solar charge controller

The computer-aided design (CAD) model of the proposed solar powered automatic seed sprayer is illustrated in Fig. 4.2 The model represents the mechanical structure and spatial arrangement of the system components. A solar panel is mounted at the top of the frame to harvest renewable energy, while a rechargeable battery is placed on the base platform to provide energy storage for continuous operation. The seed hopper is designed in a conical shape to facilitate smooth and controlled seed flow under gravity. A servo-controlled mechanism regulates the opening of the hopper outlet to ensure uniform seed dispensing. The blower unit, mounted on the chassis, assists in seed dispersion and is designed in a compact gray housing to improve durability and aesthetic consistency. The CAD model validates the feasibility of the proposed mechanical design and ensures proper integration of mechanical and electronic components prior to physical fabrication.

Fig. 4.2 Three-dimensional CAD model of the proposed system

5. DESIGN ANALYSIS AND EXPECTED OUTCOMES

The proposed solar powered automatic seed sprayer is designed to improve efficiency and reduce manual effort in agricultural seed spraying operations. The integration of solar energy is expected to eliminate fuel dependency and reduce operational costs. The automated control of motors, servo mechanism, and blower unit is expected to provide uniform seed distribution with minimal human intervention.The system design ensures efficient power management through the use of a solar charge controller and battery backup, allowing continuous operation under varying sunlight conditions. Wireless control using the ESP32 microcontroller enhances usability and supports smart agriculture applications. Once fully implemented and tested, the system is expected to demonstrate reliable performance, improved seed spraying accuracy, and eco-friendly operation suitable for small and medium-scale farming.

6. CONCLUSION

This paper presented the design and proposed implementation of a solar powered automatic seed sprayer aimed at improving efficiency and reducing manual effort in agricultural seed spraying operations. The system integrates renewable solar energy with an automated control mechanism to provide an eco-friendly and cost-effective solution suitable for rural and off-grid environments. The proposed architecture incorporates a solar-based power supply, microcontroller-based control unit, motor-driven actuation system, and a controlled seed dispensing mechanism. The use of a conical seed hopper, servo-controlled outlet, and blower-assisted dispersion is intended to ensure uniform seed distribution. Wireless control using the ESP32 microcontroller enhances system flexibility and supports smart agriculture applications. Although the physical prototype and experimental validation are currently under development, the design analysis indicates that the proposed system has strong potential to improve operational efficiency, reduce labor dependency, and minimize energy costs. The presented design serves as a strong foundation for future implementation and testing. Once fully realized, the system is expected to contribute effectively toward sustainable and automated agricultural practices.

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