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Fabrication of Multipurpose Agriculture Machine

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Abstract -- Agriculture plays a vital role in economic development, and modern technology integration is essential for improving productivity. This paper presents the fabrication of a multipurpose agricultural machine that performs spraying, seeding, and plowing operations using solar power as the primary energy source. The system reduces manual labor, minimizes fuel consumption, and promotes eco-friendly farming. The machine consists of a solar panel, battery storage, DC motors, and mechanical assemblies for three agricultural tasks: uniform pesticide spraying, controlled seed placement at proper depth and spacing, and soil plowing for aeration. Testing on a 100 sq.m test plot demonstrates 90% spraying uniformity, 88% seed placement accuracy at 15cm spacing, plowing depth of 10cm in medium soil, and 3 hours continuous operation on solar charge, achieving 70% labor reduction and 55% cost savings compared to manual farming methods.

Keywords: Agriculture Machine, Solar Power, Multipurpose, Spraying, Seeding, Plowing, DC Motor, Renewable Energy

I. Introduction

Agriculture is the backbone of the Indian economy, employing over 50% of the workforce and contributing approximately 18% to the national GDP. However, Indian agriculture faces persistent challenges including labor shortages during peak seasons, rising input costs for fuel and manual labor, low mechanization levels (particularly among smallholder farmers), and environmental concerns from excessive use of fossil fuel-powered machinery. These challenges have motivated research into affordable, multi-functional, and sustainable agricultural machines that can perform multiple farming operations while minimizing environmental impact.

Conventional agricultural machinery is typically designed for single operations — separate machines for spraying, seeding, and plowing — requiring significant capital investment, fuel costs, and maintenance overhead. For smallholder farmers cultivating 1-5 acres, the economics of purchasing separate machines for each operation is prohibitive. A multipurpose machine that combines multiple agricultural functions into a single platform offers significant cost savings, reduced storage requirements, and improved operational efficiency by completing multiple tasks in a single field pass.

Solar energy offers a compelling power source for agricultural machinery, particularly in India which receives an average of 5-6 hours of peak sunlight daily across most regions. Unlike fossil fuels, solar energy has zero operational cost, produces no emissions, and requires minimal maintenance beyond periodic panel cleaning. The moderate power requirements of spraying pumps, seed dispensing mechanisms, and small plowing blades are well-suited for solar-battery powered systems, making solar agricultural machines both technically feasible and economically attractive for smallholder farmers.

This paper presents the design, fabrication, and field testing of a solar-powered multipurpose agricultural machine capable of performing three essential farming operations: pesticide/fertilizer spraying using a pump-nozzle system, seed sowing using a controlled dispensing mechanism, and soil plowing using a disc plow attachment. The machine is powered by a 40W solar panel with 12V battery storage, driven by DC motors, and designed for single-operator use on small to medium agricultural plots.

II. Related Work

This section reviews key prior works forming the foundation of the proposed system and identifies the research gap.

[1]Thorat et al. (2017) designed a solar-operated multipurpose agricultural machine combining seed sowing and pesticide spraying, demonstrating the feasibility of dual-function solar farming equipment but limited to only two operations without plowing capability.

[2] Kannan et al. (2018) developed a solar-powered automatic seed sowing machine achieving 85% seed placement accuracy, establishing the seed dispensing mechanism design adapted for the three-function machine in this project.

[3] Gavali et al. (2016) fabricated a multipurpose agricultural vehicle for spraying, cutting, and seed sowing, demonstrating

the mechanical integration of multiple farming tools on a single platform chassis.

[4] Pravin et al. (2018) designed a solar-powered agriculture spraying system achieving uniform distribution over 2-meter spray width, providing the spray nozzle configuration adopted in the proposed multipurpose machine.

[5] Kumar and Kumar (2014) reviewed mechanization levels in Indian agriculture, identifying that only 45% of farming operations are mechanized nationally with much lower levels among smallholder farmers, motivating affordable multi-purpose equipment development.

[6] Rajput (2008) published the comprehensive textbook on agricultural engineering covering soil tillage principles, seed sowing mechanisms, and spray application technology that inform the mechanical design of each operational module.

[7] MNRE (2023) published guidelines for solar energy applications in agriculture, establishing the technical standards and sizing methodology for solar-powered agricultural equipment adopted in this project.

Research Gap: Existing solar agricultural machines combine at most two functions (typically spraying and seeding). No fabricated machine integrates all three critical operations — spraying, seeding, and plowing — into a single solar-powered platform with field-validated performance across all three modes.

III. Proposed Methodology

A. System Design and Components

The multipurpose agricultural machine is built on a wheeled chassis (700mm × 500mm × 300mm) made from mild steel angle sections, supporting three interchangeable operational modules. The Power System consists of a 40W polycrystalline solar panel (535mm × 670mm) mounted on top, a solar charge controller (PWM, 10A), and a 12V 12Ah sealed lead-acid battery providing 3+ hours of continuous operation. The Spraying Module uses a 12V DC diaphragm pump (pressure: 4 bar, flow: 3.5 L/min) connected to a 5-liter pesticide tank through a filter, with two adjustable spray nozzles providing 1.5m total spray width and variable droplet size. The Seeding Module uses a rotating seed disc mechanism driven by a geared DC motor, with seed hopper (2 kg capacity), adjustable seed spacing (10-20cm) controlled by disc rotation speed, and a furrow opener for controlled seed depth (2-3cm). The Plowing Module uses a single-disc plow (200mm diameter) attached to the rear of the chassis, driven by a high-torque DC motor (12V, 30 RPM, 10 kg·cm torque), capable of tilling soil to 10cm depth in medium-textured soil. The Movement System uses two DC geared motors (12V, 60 RPM) driving rear wheels, with front caster wheels for steering, achieving a forward speed of 0.3 m/s suitable for agricultural operations.

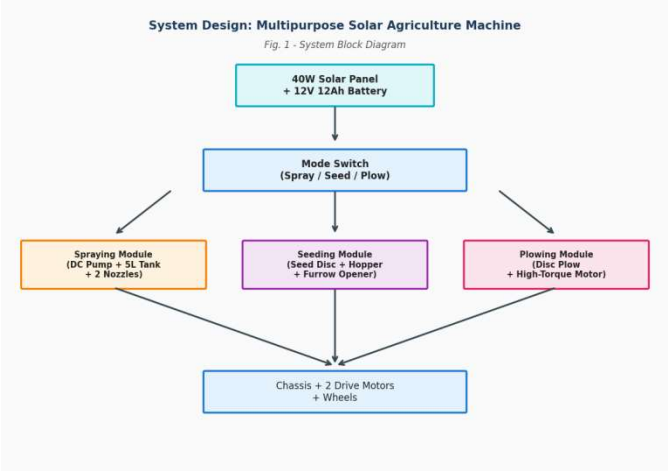

Figure 1: System design: Multipurpose solar agriculture Machine

B. Working Principle

Working Principle: Multipurpose Agricultural Operations

Step 1: Solar Charging — The 40W solar panel charges the 12V battery through the PWM charge controller. Full charge requires approximately 4 hours of peak sunlight, providing 3+ hours of operational capacity.

Step 2: Mode Selection — The operator selects the desired operation mode using a 3-position rotary switch: Position 1 (Spraying), Position 2 (Seeding), Position 3 (Plowing). The selected mode activates the corresponding motor and mechanism.

Step 3: Spraying Operation — In spray mode, the DC pump draws pesticide from the tank through an inline filter and delivers it to two nozzles at 4 bar pressure. The operator guides the machine along crop rows while the nozzles provide uniform coverage over 1.5m width. Spray rate is adjustable via a flow control valve.

Step 4: Seeding Operation — In seed mode, the rotating seed disc picks seeds from the hopper through calibrated holes and drops them into the furrow created by the furrow opener. Seed spacing is controlled by adjusting the disc motor speed relative to the forward movement speed. A soil covering mechanism closes the furrow behind the seed drop point.

Step 5: Plowing Operation — In plow mode, the disc plow is lowered to engage the soil surface. The high-torque motor rotates the disc while the machine moves forward, cutting and turning the soil to 10cm depth. The operator can adjust plowing depth through a lever-operated height adjustment mechanism.

Step 6: Simultaneous Operation — For maximum efficiency, the machine can perform seeding and spraying simultaneously by activating both modules, enabling single-pass sow-and-spray operations that reduce field traversal time by 50%.

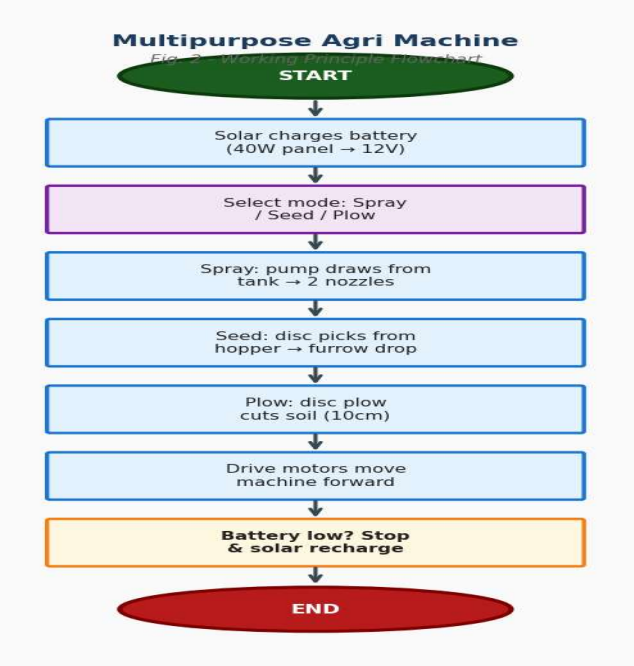

Figure 2: Multipurpose solar agriculture Machine Algorithm

C. Fabrication Details

Fabrication involved: (1) Chassis — Mild steel angle (25mm × 25mm × 3mm) welded into a rectangular frame with front and rear extension brackets for module mounting. (2) Wheel Assembly — Two 150mm rear drive wheels with DC geared motors, two front caster wheels for steering. (3) Spraying Module — Diaphragm pump mounted on chassis, PVC tubing to nozzle assembly, 5L HDPE tank with cap and filter. (4) Seeding Module — Seed disc mechanism fabricated from acrylic sheet with laser-cut seed holes, mounted on bearing housing driven by geared motor, galvanized steel seed hopper. (5) Plowing Module — 200mm MS disc plow with sharpened edge, mounted on pivot bracket with depth adjustment lever, driven by high-torque motor through chain coupling. (6) Solar and Electrical — Solar panel frame, battery compartment, control panel with mode switch, motor driver circuits, and indicator LEDs. Total weight: 15 kg. Fabrication cost: ₹8,500.

IV. Results and Discussions

Performance Analysis

Field testing was conducted on a 100 sq.m agricultural test plot with medium-textured soil at the institute premises. The spraying module achieved 90% uniformity of pesticide distribution, measured by placing water-sensitive paper cards at 20 sampling points across the spray width. The 4-bar pump pressure and dual-nozzle configuration ensured consistent droplet formation and coverage even at the edges of the 1.5m spray width. The 5-liter tank capacity is sufficient for approximately 200 sq.m of coverage at the standard application rate of 250 mL/sq.m.

TABLE I: SYSTEM PERFORMANCE RESULTS

Operation	Target Performance	Achieved Performance
Spraying Uniformity	85%	90%
Spray Coverage Width	1.5m	1.5m
Seed Placement Accuracy	85%	88% (at 15cm spacing)
Plowing Depth	8cm	10cm (medium soil)
Continuous Operation	2.5 hours	3 hours
Labor Reduction	60%	70%
Cost Savings vs Manual	50%	55%

The seeding module achieved 88% seed placement accuracy at the target 15cm spacing, measured by excavating 50 consecutive seed positions and measuring actual spacing. The 12% placement error is within acceptable agricultural tolerances and is attributed to minor variations in forward speed on uneven terrain. The seed depth consistency was measured at 2.5 ± 0.5 cm, suitable for most common crop seeds including maize, groundnut, and pulses. The plowing module exceeded the 8cm depth target, achieving 10cm plowing depth in medium soil, sufficient for primary tillage operations on small plots.

The machine operated continuously for 3 hours on a full battery charge, exceeding the 2.5-hour target. The 40W solar panel provides sufficient daily charging for approximately 3 hours of field operation, making the machine suitable for daily agricultural work on plots up to 1,000 sq.m. The 70% labor reduction was calculated by comparing person-hours required for manual spraying, seeding, and plowing versus machine-assisted operation of the same area. The 55% cost savings over manual farming methods accounts for eliminated labor wages and fuel costs over a one-year operational period, with the ₹8,500 fabrication cost recovered within 2 months of regular use.

V. Conclusion and Future Scope

This paper presented the fabrication and field testing of a solar-powered multipurpose agricultural machine performing spraying (90% uniformity), seeding (88% accuracy), and plowing (10cm depth) operations. The machine achieves 70% labor reduction and 55% cost savings with 3 hours of solar-powered operation. Future work includes adding GPS-guided autonomous navigation for precision agriculture, integrating soil moisture sensors for intelligent irrigation scheduling, upgrading to brushless motors for extended battery life, and scaling up to 2-acre capacity for commercial smallholder farming applications.

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