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Development of A Solar Operated Smart Multi-Functional Agribot

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***Abstract* - The Multipurpose Agricultural Robot is a compact and multifunctional farming machine designed to automate key agricultural operations such as grass cutting, seed sowing, and spraying of water, manure, weedicide, or pesticide. The robot is built on a rigid mild steel chassis and uses a 4-wheel drive system powered by 12V DC wiper motors to ensure stable locomotion on agricultural terrains.**

In addition to its operating functions, the robot is equipped with a 20-watt solar panel that charges the onboard battery, enabling partial energy independence and reducing dependence on external electrical sources. Grass cutting is performed using a high-speed RS-775 motor, while seed sowing is achieved through a mechanically driven metering shaft with drilled holes to dispense seeds uniformly. The entire system is controlled wirelessly using an Android smartphone via Bluetooth and an Arduino UNO microcontroller. This project aims to reduce manual labor, operational cost, and environmental impact while improving agricultural efficiency.

***Keywords* - Agricultural robot, Solar-powered automation, Arduino UNO, Bluetooth-based control, Seed sowing mechanism, Grass cutting system, Spraying unit.**

I. INTRODUCTION

Agriculture remains a vital pillar of economic development in many countries, particularly in developing regions where farming supports a large share of the population. Despite its importance, essential agricultural operations such as grass cutting, seed sowing, ploughing and spraying are still largely performed manually on small and medium-sized farms, making them labor-intensive, time-consuming and potentially hazardous due to prolonged exposure to agrochemicals.

Existing agricultural machinery is often costly, complex, or designed for large-scale applications, limiting its adoption by small farmers. To address these challenges, this work presents a Bluetooth-controlled multipurpose agricultural robot designed as a compact, cost-effective and multifunctional solution capable of performing multiple field operations on a single platform. The proposed system aims to reduce manual labor, operational cost and health risks while improving productivity, safety and sustainability in modern agriculture through affordable automation.

II. LITERATURE REVIEW

A. Automatic Seed Sowing Machine.

Year: 2019
Authors: P. Premalatha, Sharath Singh.
Source: Asian Journal of Electrical Sciences (AJES).

This paper focuses on the design of a solar-powered seed-sowing robot that uses Arduino Uno and L298N motor drivers. The system automates uniform seed dropping, row shifting and obstacle detection using ultrasonic sensors. It also sends alerts when the seed drum becomes empty. The fully automatic mechanism reduces human intervention and ensures accurate seed placement with minimal waste. Solar-powered DC motors make the system energy-efficient and sustainable. The robot also identifies row boundaries and shifts automatically, improving operational convenience.

B. Sensor-Based Agrobot For Sowing Seeds.

Year: 2019
Authors: S. Praseena, S. Sanjena, S.M. Thejaswini, Dr. M. Senthamil Selvi
Source: IRJET, Vol. 6, Issue 3

This paper presents an automatic seed-sowing robot that uses multiple sensors to enhance performance and accuracy. The robot uses IR, ultrasonic, temperature and soil-moisture sensors to navigate fields and monitor conditions. Its main objective is to ensure seeds are placed at uniform intervals.

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The robot is equipped with Arduino Uno, Wi-Fi modules, and DC motors for movement. It can detect moisture levels and automatically pump water when required. Obstacle detection enables safe movement across uneven terrain.The system helps farmers reduce labour, avoid seed wastage and improve sowing accuracy. This low-cost robotic solution supports precision agriculture and is especially useful for small farmland operations.

C. IOT Based Agribot For Agricultural Farming.

Year: 2019
Authors: Vasudha Hegde, Sumathi M, Varsha Nagarajaiah, Yeshaswini M.C, Prof. Chandan Raj B.R
Source: IJCSE, Special Issue 15

The paper presents a multipurpose IoT-based Agribot capable of performing ploughing, seeding, grass cutting and irrigation. The robot uses a Renesas microcontroller, DC motors, ultrasonic sensors and a Bluetooth module, enabling the user to select tasks through a mobile application. Its semi-automatic operation makes it more flexible compared to fully autonomous robots.

The system addresses issues such as labour shortage, inconsistent farm operations and high equipment cost. The mobile app interface allows farmers to switch between functions easily, while the robot's sensors assist with navigation and obstacle detection. This improves operational efficiency and reduces the need for skilled labour.

D. Title-Solar Powered Automatic Grass Cutter & Pesticide Spreading Robot.

Year: 2022
Authors: Prashant M. Chavan, Dhiraj V. Khurde, Sushant N. Adepwar, Shubham S. Kute and Dipannita R.Kundu
Source: International Research Journal of Engineering and Technology (IRJET).

In this research work, the authors developed a remote-controlled multifunctional agricultural robot capable of grass cutting and weedicide spraying. The system used an RF transceiver for wireless operation, allowing safe and easy control from a distance. An ultrasonic sensor was added to detect obstacles and ensure smooth navigation.

The robot was designed to be compact, lightweight and easy to transport, making it suitable for small farms. A high-speed motor powered the cutting mechanism for effective grass management. The spraying unit enabled uniform weedicide application while reducing farmer exposure to chemicals. The robot operated efficiently on uneven terrain due to its stable mechanical design. A solar panel was integrated to continuously charge the battery and reduce dependence on external power. This renewable-energy approach lowered operating costs and increased system reliability. Overall, the model provided a simple, eco-friendly solution for modernizing basic agricultural tasks.

E. Multipurpose Agricultural Robot With Ploughing, Seeding & Spraying Mechanism.

Year: 2022
Authors: Samardeep Singh Chopra et al.
Source: Global Scientific Journal (GSJ)

This work introduces a multipurpose agricultural robot designed to perform ploughing, seeding, and spraying operations. The robot operates using a 12V battery and DC motors and is built as a prototype to improve field efficiency with minimal human involvement. It is suitable for agriculture, forestry and gardening.

The robot's multi-functionality reduces labour requirements and allows farmers to complete several operations using a single machine. It supports soil preparation, seed placement and fertilizer or pesticide application in a single workflow.The system highlights the importance of automation in agriculture for improving productivity. The robot is affordable, scalable and adaptable, making it suitable for real-world farming applications after further refinement.

F. IOT Based Solar Grass Cutting Robot.

Year: 2023
Authors: Ch. Bhanu Sri, Sk. Khaja Mohiddin, S. Naresh Kumar, V. Mohan Kalyan, A. Veer Raju, K. Nagendra Prasad, U. Sai Mohan
Source: IJFMR, Vol. 5, Issue 2

This research introduces an IoT-enabled solar grass-cutting robot designed for autonomous lawn maintenance. It integrates GPS, ultrasonic sensors, cameras and cloud connectivity to navigate terrain, detect obstacles and operate remotely through smartphones. The use of solar panels reduces the need for external charging and ensures long-term, eco-friendly operation.The robot uses sharp rotating blades for precise and low-noise grass cutting, making it suitable for residential and commercial use. Real-time data-including grass density, battery level and location-is sent to a cloud server for monitoring and performance improvement. Its autonomous nature eliminates the need for constant human supervision while maintaining high accuracy

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G. Summary of Literature Review

In this research work, the authors developed a remote-controlled multifunctional agricultural robot capable of grass cutting and weedicide spraying. The system used an RF transceiver for wireless operation, allowing safe and easy control from a distance. An ultrasonic sensor was added to detect obstacles and ensure smooth navigation. The robot was designed to be compact, lightweight and easy to transport, making it suitable for small farms. A high-speed motor powered the cutting mechanism for effective grass management. The spraying unit enabled uniform weedicide application while reducing farmer exposure to chemicals. The robot operated efficiently on uneven terrain due to its stable mechanical design. A solar panel was integrated to continuously charge the battery and reduce dependence on external power. This renewable-energy approach lowered operating costs and increased system reliability. Overall, the model provided a simple, eco-friendly solution for modernizing basic agricultural tasks.

III. OBJECTIVE

The objectives of this project are:

A. To design and fabricate a multifunctional agricultural robot.

B. To perform grass cutting, seed sowing and spraying operations using a single machine.

C. To design a mechanical seed sowing mechanism for uniform seed distribution.

D. To implement a multi-liquid spraying system for water, manure, pesticide and weedicide.

E. To enable remote control through Bluetooth and Arduino UNO.

F. To integrate a solar charging system using a 20-watt solar panel to charge the battery.

IV. METHODOLOGY

The project begins with problem identification, where the need and objectives of the system are clearly defined. This is followed by planning and design, in which the overall structure, working principle and design layout of the system are prepared. Based on the design, appropriate materials and components are selected and purchased. The required parts and frame are then fabricated according to the specifications. After fabrication, mechanical assembly is carried out to form the basic structure of the system. Electronics integration is performed by installing sensors, motors, controllers, and power supply units. Programming and control are then implemented to ensure proper operation and coordination of all components. Once this is completed, final assembly is done by combining all mechanical and electronic parts. The system is then subjected to testing and evaluation to verify its performance and functionality. Finally, necessary modifications are made based on test results to improve efficiency and reliability.

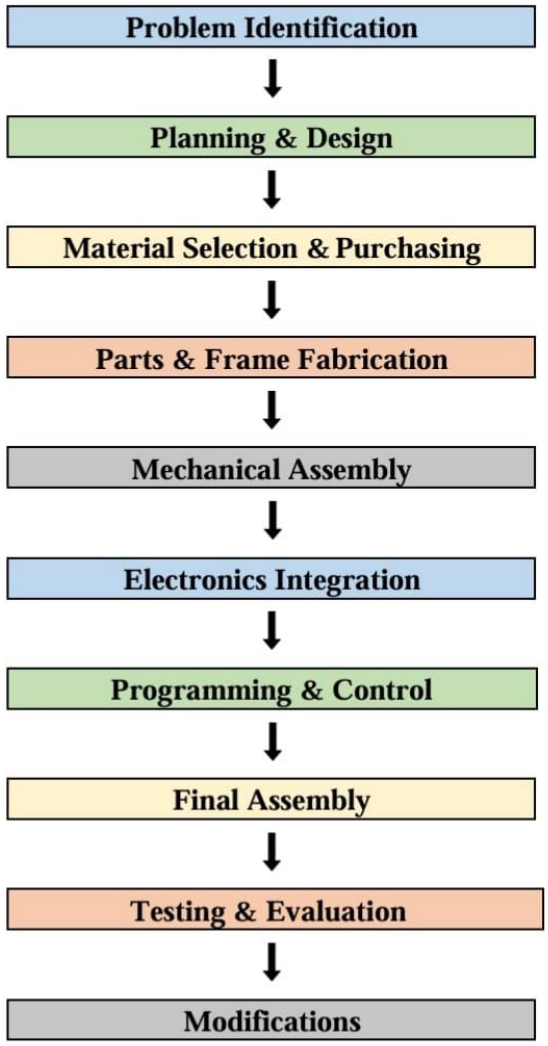

FIG.1: WORKING FLOWCHART.

V. DESIGN

This section describes the detailed CAD-based design and mechanical configuration of the solar-operated smart multifunctional Agribot. It focuses on the structural framework, individual functional mechanisms, and their systematic integration into a single compact unit. Each subsystem—including the chassis, seed sowing mechanism, grass cutting unit, ploughing tool and spraying system—is designed with proper dimensional accuracy, material considerations and functional constraints. The complete CAD assembly demonstrates the spatial arrangement, alignment, and interoperability of all components, providing a comprehensive virtual model for analysis, fabrication and performance evaluation.

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A. Chassis.

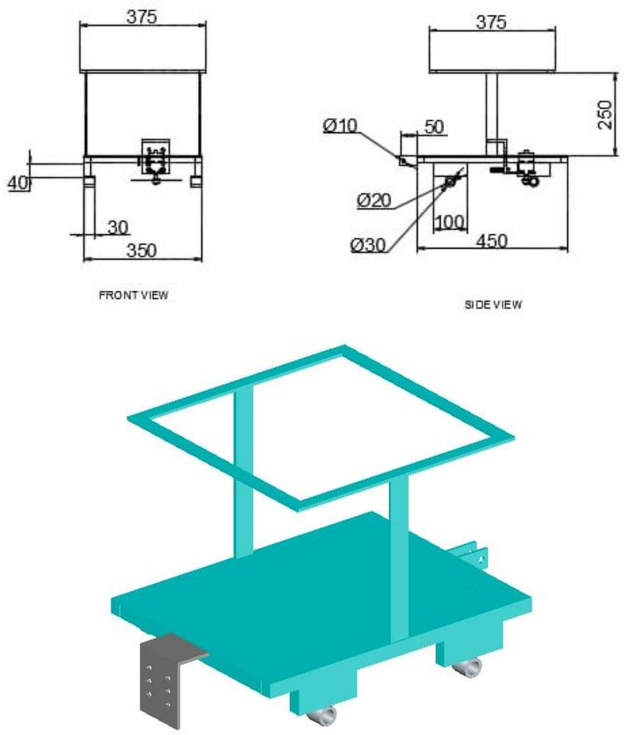

FIG.2: Chassis Cad Desing.

B. Seeder Mechanism.

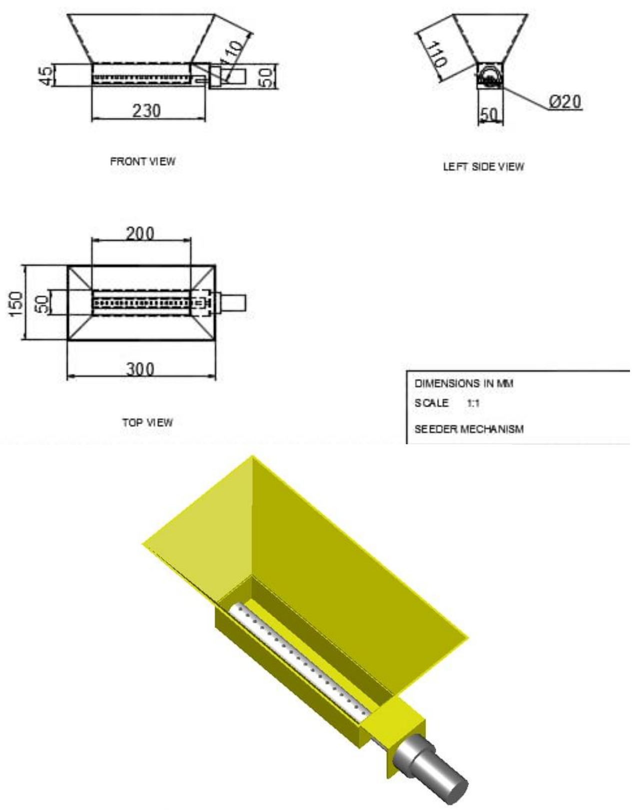

FIG.3: Seeder Mechanism Cad Desing.

C. Grass Cutter Mechanism.

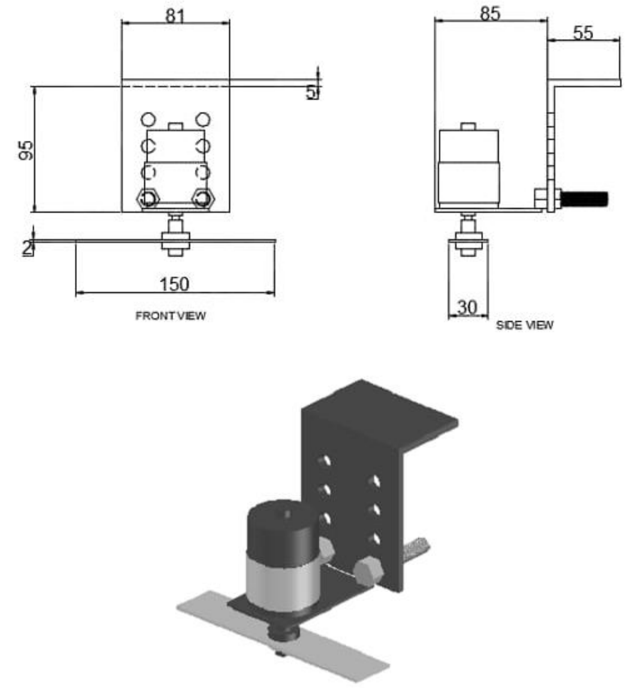

FIG.4: Grass Cutter Mechanism Cad Design.

D. Ploughing Tool.

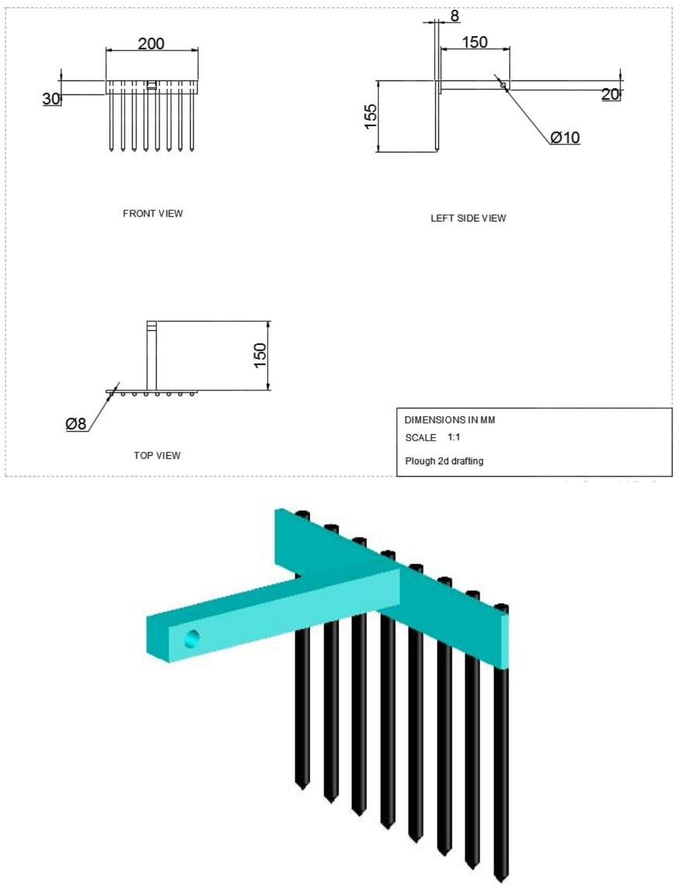

FIG.5: Ploughing Tool Cad Design.

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E. Spraying System.

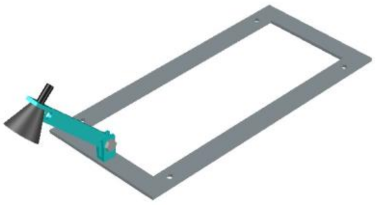

FIG.6: Spraying System Can Design.

F. Assembly.

The complete CAD assembly of the agribot project begins with creating the base chassis model using precise dimensions and material constraints. Each component, such as wheels, shafts, motors and brackets, is individually modeled in 3D using Solid Edge. The grass-cutting mechanism, ploughing tool, seed-sowing unit and spraying system are designed as separate subassemblies. These subassemblies are inserted into the main assembly environment and aligned using mates, axial constraints and planar constraints. Proper spacing and clearances are maintained to ensure smooth motion without interference. The solar panel, tank and pump are added and positioned accurately on the chassis. Pipes, nozzles and wiring paths are represented using sweep features and reference sketches. Exploded views are created to visualize how the entire agribot is structured internally. Isometric views, front views and side views are generated for documentation. The final CAD assembly provides a complete digital representation of the agribot before fabrication.

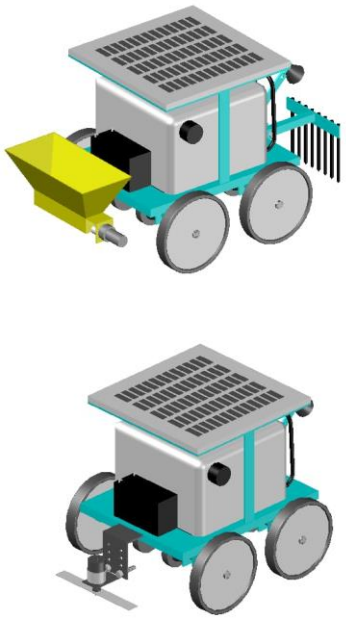

FIG.7: Assembly Cad Design.

VI. COMPONENTS

- **A.** 20*20 Mm Mild Steel Hollow Pipe
- **B.** 2 Mm Steet Metal
- **C.** Sleeves
- **D.** 20 Mm Shaft
- **E.** 8 Inch Wheels
- **F.** Shaft Bore
- **G.** Dc Motor
- **H.** Flat Bar
- **I.** Rs 775 Motor
- **J.** Mandrel Coupler
- **K.** Nuts And Bolts
- **L.** Can
- **M.** Pipes
- **N.** 12 Volt Pump
- **O.** Spray Nozzle
- **P.** Battery
- **Q.** Pvc Box
- **R.** Buck Converter
- **S.** Jumper Wires And Wires
- **T.** Battery Clips
- **U.** Arduino Uno
- **V.** Bluetooth Module
- **W.** Single Channel Relay
- **X.** Dc Motor
- **Y.** Paint And Primer
- **Z.** Solar Panel

VII. DESIGN CALCULATIONS

A. Speed of The Robot.

Wheel diameter = 8 in → circumference
$C = \pi D = \pi \times 8 = 25.1327$
C = Πd = $\pi \times 8 = 25.1327$ inches.
At 60 rpm, distance per minute: $25.1327 \times 60 = 1507.9647$in/min
Convert inches to meters (1in = 0.0254m)
$1507.9647 \times 0.0254 \approx 38.3$m/min.

B. Area Of Solution Sprayed/Minute.

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Speed of robot = 38.3 m/min (from previous calculation)
Width of spray = 30 cm = 0.30 m
Area sprayed per minute: Area = Speed × Width
Area = Speed × Width
Area = 38.3 × 0.30=11.49m2/min.

C. Area Of Grass Trimmed /Minute.

Robot speed = 38.3 m/min (from earlier calculation)
Blade cutting width = 18 cm = 0.18 m
Formula: Area per minute = Speed × Cutting width
Area per minute = Speed × Cutting width
Substitution: Area = 38.3×0.18 = 6.894m2/min
Area=38.3 × 0.18=6.894 m2/min.

D. Total Power Consumed.

Drive motors: 4 × (12 V, 3 A each) → assumed 3 A per motor
Spray pump: 12 V, 2 A.
Cutter motor: 12 V, 2 A.
Seeder motor: 12 V, 2 A
Arduino UNO, HC-05, 6 single-channel relay module(s), these electronics run at 5 V (via onboard regulators)
Arduino UNO ≈ 100 mA @ 5 V → 0.1 A
HC-05 ≈ 30 mA @ 5 V → 0.03 A
6 relays (typical relay module driver + coil) — assume 70 mA per relay @ 5 V → 6 × 0.07 = 0.42 A
Drive motors
Total current for 4 motors = 4 × 3A = 12A
Power1=12 V × 12 A = 144 W
Pump and cutter
Pump = 12V × 2 A = 24 W
Cutter = 12V × 2A = 24W
Seeder motor = 12V × 2A = 24W
Electronics (5 V devices) — convert to equivalent
Total electronics current at 5 V(Pe) = 0.10+0.03+0.42 = 0.55 A
Power at 5 V = 5V × 0.55A = 2.75W = Pe
Total power consumption = Power1 + Pump + Cutter + Seeder motor + Pe
Total power consumption = 144W + 24W + 24W + 24 + 2.75W
Total power consumption = 218.75Watts.

E. Batery Backup Time.

Backup time (hours) = Battery capacity (Ah)/Load current (A)
Backup time (hours) = 7.5/16.3318 ≈ 0.409hours
Convert to minutes: 0.409 × 60 ≈ 24.5minutes.

F. Battery Charging Time.

Time = Battery Energy/Panel Power = 90/20 = 4.5 hours.

G. Payload Capacity Of The Robot.

Motor torque given = 3.4 N•m (per motor) and directly applied to wheel (no gearbox).
Four identical motors, each driving one wheel.
Wheel diameter = 8 in = 0.2032 m → radius r = 0.1016 m
Gravitational acceleration g = 9.81 m/s2
Tractive force per wheel
Wheel Force = T/r = 3.4N-m/0.1016m ≈ 33.46 N
Total tractive force (4 wheels)
Total Force = 4 × 33.46 ≈ 133.86 N
Wheels will slip if tractive force exceeds friction: Total Force $\le \mu m g \Rightarrow m \le$ Total Force $/\mu g$
Using reasonable friction coefficients (μ) for rubber on firm ground:
μ = 0.6 → m ≈ 22.7kg,
μ = 0.5 → m ≈ 27.3kg,
μ = 0.4 → m ≈ 34.1kg
This traction-limited estimate gives realistic maximum masses before wheels slip.

VIII. FABRICATION

Process of Fabrication

A. **Material Selection and Cutting** – Mild-steel hollow rectangular pipes are selected and cut to required dimensions as per the CAD design.

B. **Surface Preparation** – Cut sections are cleaned to remove rust, dust, and burrs for proper welding and fitting.

C. **Layout and Alignment** – All sections are arranged on a flat surface and aligned accurately using measuring tools.

D. **Tack Welding** – Temporary welds are applied at joints to hold the structure and allow minor adjustments.

E. **Final Welding** – Continuous welding is performed on all joints, and cross-members are added to improve rigidity.

F. **Motor Mount Design and Installation** – Motor mounting brackets are fabricated and welded to the chassis.

G. **Motor Coupling with Shaft** – The motor shaft is coupled with the driven shaft using a suitable coupler for power transmission.

H. **Drilling, Mounting, and Functional Fittings** – Holes are drilled and mounts for mechanisms and accessories are installed.

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I. **Grinding, Painting, and Final Finishing** – Welded joints are ground smooth and the chassis is painted for corrosion protection.

FIG.8: Fabrication

IX. WORKING PRINCIPLE

The Bluetooth-controlled multipurpose agricultural robot operates through the coordinated action of mechanical, electrical, and wireless control systems. The entire system is powered by a 12 V lead-acid battery, which supplies energy to the drive motors, grass cutter motor, seed sowing motor, spray pump, and control electronics. The battery can be charged using a conventional charger or a 20 W solar panel mounted on the robot.

Robot movement is achieved using a four-wheel drive system powered by 12 V DC motors. Directional control is provided through an Android mobile application using Bluetooth communication. The HC-05 Bluetooth module receives commands, which are processed by the Arduino UNO to control motors and mechanisms via relay circuits.

The grass cutting unit uses a high-speed DC motor coupled with a cutting blade to trim grass efficiently. The seed sowing mechanism employs a motor-driven metering shaft to ensure uniform seed distribution. The spraying system consists of a liquid tank, DC pump, and nozzle to spray water, manure, pesticide, or weedicide uniformly. A buck converter steps down 12 V to 5 V for safe operation of the Arduino, Bluetooth module, and relays. All operations can be controlled independently or simultaneously, enabling efficient and flexible agricultural tasks with reduced manual effort.

X. RESULTS & DISCUSSION

A. Expected Outcome Results.

The Agribot is expected to perform grass cutting smoothly and uniformly using the RS-775 cutter motor, reducing manual labour and providing even cutting with minimal vibration. The seed sowing mechanism should place seeds at uniform spacing and depth, resulting in improved germination and consistent seed flow during movement. The spraying system is expected to deliver water, manure, pesticide, or weedicide uniformly with adjustable pressure to suit different field conditions. The Bluetooth-based wireless control should allow quick and smooth response to all movement and operation commands with minimal delay. The solar-assisted power system is expected to extend battery life by charging during operation, enabling the robot to function for about 1–2 hours on a full charge depending on the load.

FIG.9: Expected Outcome

B. Conclusion.

The developed Agribot successfully performs grass cutting, seed sowing and spraying using a single compact machine. It reduces labour, cuts operational cost and increases safety by avoiding direct chemical exposure. With Bluetooth control and solar charging, the system becomes efficient, user-friendly and suitable for small farming applications. The project demonstrates a practical step toward affordable smart agriculture.

C. Future Scope.

In the future, the Agribot can be upgraded with GPS-based autonomous navigation and path-planning algorithms to operate without manual control. Soil sensors can be added for smart irrigation and fertilizer spraying based on real-time field conditions. The seed-sowing and spraying systems can be improved with adjustable mechanisms and electronic control to support multiple crops and reduce chemical wastage. IoT and AI technologies can be integrated for remote monitoring, data logging, and obstacle detection. Further enhancements include improved solar power systems, modular tool attachments, and lightweight materials to increase efficiency and operating time.

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