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Design and Fabrication of Multipurpose Agriculture Machine

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Abstract: The farming and agricultural sector plays a vital role in human survival and economic sustainability. Over time, advancements in farming techniques and machinery have significantly improved crop quality and yield. However, these advancements have also increased the cost of cultivation, making modern agricultural equipment unaffordable for many small-scale farmers. This financial constraint highlights the need for cost-effective and time-efficient solutions in agriculture. This project presents the design, development, and testing of an autonomous multipurpose agricultural robot aimed at reducing cultivation costs while improving operational efficiency. The proposed robotic system is capable of performing essential agricultural tasks such as ploughing, seed sowing, and fertilizer spraying simultaneously, thereby minimizing manual labor and saving time. Designed for ease of operation by a single individual, the robot is particularly suitable for use in arid and semi-arid regions. The versatility of the system enables it to adapt to varying soil conditions and environmental factors. By moving precisely along crop rows, the robot performs multiple operations with minimal human intervention, enhancing accuracy and resource utilization. This approach not only improves productivity but also supports sustainable farming practices. Overall, the project aims to empower small-scale farmers by providing an affordable, efficient, and sustainable agricultural solution that enhances crop production, optimizes resource usage, and contributes to the modernization of the agricultural sector.

Keywords: Automation in Agriculture, Multipurpose Farming Machine, Cost-effective Farming

I. INTRODUCTION

Agriculture has long been recognized as the backbone of many nations across the globe, providing food security, employment, and economic stability. A significant portion of the world's population depends directly or indirectly on agricultural activities for livelihood. As the global population continues to grow, the demand for food production has increased substantially, placing immense pressure on traditional farming practices. To meet this growing demand, agriculture has continuously evolved through the adoption of new techniques, tools, and technologies aimed at improving productivity, efficiency, and sustainability. Over the years, scholars, engineers, and researchers have introduced various technological and mechanical interventions in agriculture to reduce human effort and enhance output. Despite these advancements, many agricultural tasks such as ploughing, sowing, fertilizer spraying, irrigation, pest control, and weed management remain labor-intensive, repetitive, and physically demanding. These challenges make it increasingly difficult to attract and retain agricultural labor, especially as younger generations move toward urban employment opportunities. As a result, mechanization and automation have become essential components in the modernization of agriculture. Agriculture forms the backbone of the Indian economy and continues to rely largely on traditional farming practices such as ploughing, sowing, and harvesting, as reported by S. S. Belsare et al. [1]. Despite gradual technological progress, the agricultural sector still faces major challenges related to minimizing post-harvest losses, increasing crop productivity, and reducing cultivation costs. To address these issues, the primary objective of the project is to design and develop a multipurpose agricultural machine capable of performing essential operations such as digging and seed sowing. The project focuses on fabricating a small, compact vehicle that simplifies cultivation while improving efficiency. The proposed design incorporates a suitable chassis, a rotary tiller (rotavator), an efficient power transmission system, and other essential machine components. By enabling multiple operations to be carried out simultaneously, the machine enhances productivity while reducing operational costs and labor dependency. The evolution of agricultural tools in India has historically been influenced by village artisanship. V. Maheswari et al. [2] highlighted the role of blacksmiths, carpenters, potters, and cobblers in developing early farm tools through indigenous knowledge and craftsmanship. Carpenters designed counterpoise mechanisms for irrigation, potters produced large earthen containers for grain storage, and cobblers utilized animal skins for water transportation. As agriculture remained the primary occupation of the population, there arose a need for improved hand tools to enhance labor productivity and quality of work. This led to the development of Multipurpose Agricultural Equipment (MAE) aimed at improving operational efficiency. Furthermore, the integration of information technology and intelligent machines has opened new opportunities to reduce energy consumption and optimize farming operations. Small, smart agricultural machines capable of performing tasks precisely at the right place and time represent a significant advancement in modern farming. The working conditions of agricultural laborers in India remain unsatisfactory, often resulting in wages below subsistence levels, as reported by Amrita Sneha et al. [3]. Traditional cultivation practices are still widely followed, with farmers relying on native ploughs and basic implements. The challenge is not the lack of modern agricultural machinery but the incompatibility of bulky machines with small landholdings. To overcome this limitation, advanced mechanization solutions tailored for small-scale farmers are being developed. One such system utilizes a 98 cc motorcycle engine for tilling and weeding operations, a 12 V battery-powered mechanism for seed sowing, and a manually operated base for ploughing and leveling. This multipurpose machine is capable of performing five agricultural operations and is particularly suitable for small-scale farming. The modular attachment system allows farmers to carry out various operations efficiently while significantly reducing time and cost. Radhika et al. [4] proposed the development of a compact multipurpose agricultural vehicle designed to perform major farming operations such as ploughing, seed sowing, and harvesting. The vehicle features a well-designed chassis for stable operation and incorporates an automatic seed sowing mechanism. The plough design was modified to withstand operational loads, while a harvesting unit based on the scotch yoke mechanism was developed for cutting operations. The objective of this project was to simplify cultivation processes and enhance the overall efficiency of agricultural operations. The importance of multipurpose agricultural equipment in achieving higher crop yields was emphasized by Venu K et al. [5]. Conventional farming methods often result in labor shortages and delays in agricultural activities. Their study focused on the design of a sprayer and crop cutter to reduce labor costs, minimize time consumption, and increase productivity. The research also aimed to improve the utilization of work bulls, traditionally used for land preparation, by integrating them into additional farming operations. This approach helps small landholding farmers enhance productivity while maintaining cost-effectiveness. In a similar context, Nzamwitakuze A. et al. [6] studied agricultural practices in Rwanda, where farming activities are predominantly manual. The physical strain associated with repetitive farming tasks necessitates the introduction of simple and affordable technologies. Their research focused on developing a seed drill suitable for the diverse topographical conditions of Rwanda, aiming to reduce labor fatigue and improve planting efficiency. Ayesha Akhtar et al. [7] reviewed various innovations in seed sowing machines used in plantation agriculture. Seed sowing plays a critical role in crop establishment, and advancements in this area significantly impact productivity. Cotton, being a globally important commercial crop, requires precise planting techniques. Their study proposed a new method of sowing cotton seeds using a punching mechanism, which improves seed placement accuracy and enhances germination rates. Weed management remains one of the most labor-intensive and time-consuming operations in vegetable production. Mohd. Taufik Ahmad et al. [8] examined the challenges associated with manual weeding, including high labor costs and physical strain. Although chemical weed control methods have reduced labor requirements, concerns regarding herbicide resistance, environmental impact, and the growing demand for chemical-free food have driven research into alternative weed control methods. Mechanical weeders, however, face limitations in controlling weeds close to crop rows, highlighting the need for improved intra-row weeding mechanisms. Kyada A. R. et al. [9] identified the fundamental requirements of small-scale agricultural machinery, emphasizing simplicity, versatility, and affordability. They designed and developed a manually operated template row planter to improve planting efficiency and reduce the drudgery associated with manual seed sowing. The planter allows seed placement at variable depths and spacing, accommodates different seed sizes, and enhances seed and fertilizer placement accuracy. Constructed from durable and low-cost materials, the device is well-suited for small-scale farmers. Ibukun B. Ikechukwu et al. [10] focused on the design and fabrication of a manually operated single-row maize planter capable of delivering seeds with uniform spacing and depth. The machine ensures precise seed placement in straight rows, thereby improving crop establishment and yield. This work demonstrates the effective application of engineering principles to reduce human labor while improving agricultural efficiency.

II.METHODOLOGY

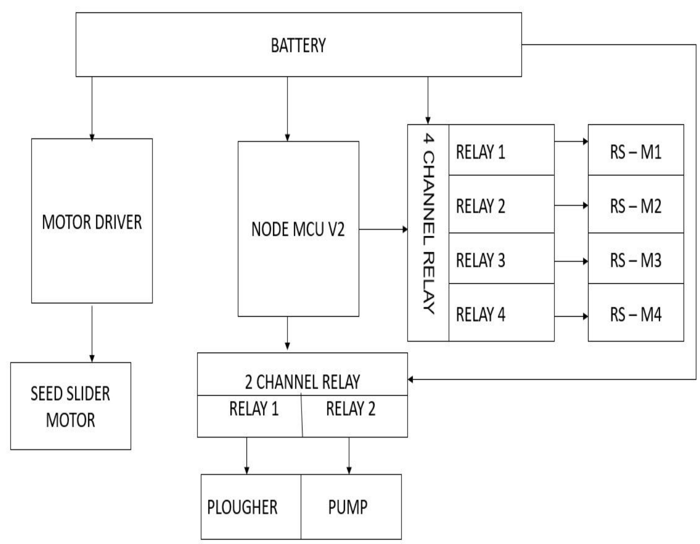

Figure 1: *Block* diagram *showing the working principle of multipurpose agriculture machine*

To initiate the development of the proposed multipurpose agricultural robot, the required farming operations were first identified. Based on practical agricultural needs, ploughing, seed sowing, and fertilizer spraying were selected as the primary functions to be integrated into the system. The design process began with the development of the ploughing mechanism, as it determines the overall configuration and dimensions of the machine. For small-scale farming applications, it was observed that the average spacing between adjacent seed rows typically ranges from 3 to 5 cm. Accordingly, the spacing of the shovel teeth was calculated to match the seed row pattern. Four shovel teeth were incorporated into the design, which consequently defined the effective working width of the vehicle. This configuration ensures uniform soil preparation while maintaining proper row spacing for subsequent sowing operations. Material selection for the robot body and chassis was carried out by comparing two feasible options: aluminum and mild steel. Mild steel was selected due to its widespread use in automobile chassis and structural frames, easy availability, lower cost, and excellent weldability. Additionally, mild steel provides adequate strength and durability for field applications. A square cross-section was chosen for the chassis members, as it offers high structural strength along both the X–X and Y–Y axes and provides superior torsional rigidity compared to I, L, and C sections. The chassis was fabricated using mild steel square-section rods. After accurate measurement and cutting of the rods, the welding process was carried out to assemble the chassis. Upon completion of the structural framework, the mechanical fabrication of the robot was finalized. Subsequently, the required electronic components were procured and integrated into the system. Programming of the microcontroller was carried out to control the robot's operations, and a user-friendly mobile application interface was developed using the Blynk platform for remote monitoring and control. A detailed circuit diagram was prepared, and all electronic components were connected accordingly. After completing the wiring, the program execution and component functionality were thoroughly tested. Finally, the electronic components were securely mounted onto the robot, followed by comprehensive testing and necessary adjustments. The system was evaluated to ensure proper coordination between mechanical and electronic subsystems, resulting in a fully functional multipurpose agricultural robot capable of performing the intended operations efficiently.

The circuit diagram illustrates the control architecture of the proposed multipurpose agricultural machine, which is designed to automate key farming operations. The control system is centered around the NodeMCU V2 microcontroller, which functions as the main processing and control unit. It coordinates the operation of various mechanical and electrical components through relays and motor driver modules.

A battery serves as the primary power source for the entire system, supplying electrical energy to the microcontroller, relays, motor driver, and actuators. The NodeMCU V2 interfaces with two relay modules: a 4-channel relay module and a 2-channel relay module. These relay modules act as electrically operated switches, enabling safe and reliable control of high-power devices using low-power control signals from the microcontroller.

The 4-channel relay module is used to control four individual motors, designated as RS–M1, RS–M2, RS–M3, and RS–M4. These motors are responsible for various mechanical functions of the machine, such as vehicle movement, directional control, and other operational tasks. Independent control of each motor allows the system to execute multiple actions either sequentially or simultaneously, depending on the operational requirements.

The 2-channel relay module is connected to two critical agricultural components: the ploughing mechanism and the pump unit. The ploughing mechanism is used for soil preparation, while the pump facilitates water or fertilizer spraying. The relay-based control enables the machine to selectively activate these components as per the desired operation, thereby enhancing the versatility and efficiency of the system.

In addition to relay-controlled devices, a motor driver module is employed to regulate the operation of the seed slider motor. This motor is responsible for dispensing seeds during the sowing process. The motor driver provides precise speed and directional control, ensuring uniform seed flow and consistent spacing between seeds. This automation improves planting accuracy and contributes to improved crop establishment.

Overall, the integrated control system enables coordinated operation of multiple agricultural functions, resulting in a compact, efficient, and automated multipurpose farming machine.

Figure 2: Base Frame of Machine

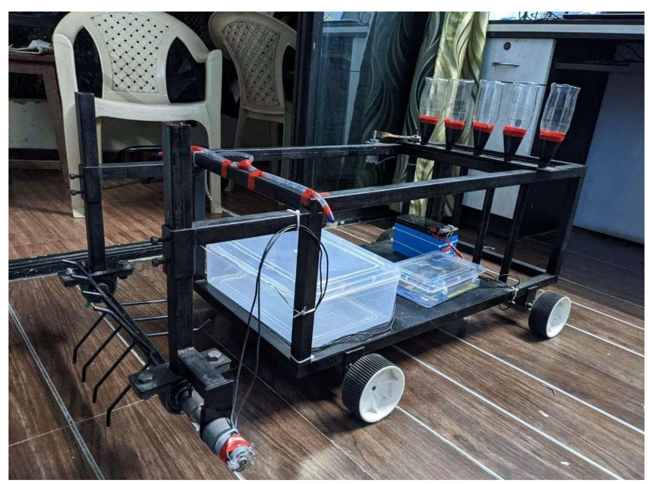

Figure 3: Complete Design

III.DESIGN CALCULATION

Force Calculation

Force exerted on the Shovel is $D = K_o \times w \times d$

Where D = Total Draft Force, Kgf

K_o = Specific soil resistance

w = Width of shovel

d = Depth of shovel

Tractive Force

Total Tractive Effort (T_f) = Force Necessary to overcome rolling resistance (R_r)

Rolling resistance (R_r) is the force necessary to propel a vehicle over a particular surface.

Therefore,

R_r = Total Vehicle Weight × Surface Friction

Total Vehicle Weight = Weight of motors + weight of battery + Weight of Chassis Frame + Weight of Seeder Mechanism + Weight of Seed Storage Box (kg) + weight of wheel + Weight of Plougher + Weight of fertilizer tank

Table 1: List of component

Sr. No.	Name of Components
1	DC MOTOR
2	LITHIUM ION BATTERY
3	OMRON PCB RELAY
4	CHANNEL RELAY
5	L293D MOTOR DRIVER
6	NODE MCU V2
7	BALL BEARING
8	CONNECTING WIRES
9	SUBMERSIBLE PUMP

IV.CONCLUSION

The demonstrative model of the proposed multipurpose agricultural robot was fabricated as per the planned design, and all integrated operations were found to function efficiently. The robot successfully performs the essential farming activities of ploughing, seed sowing, and fertilizer spraying, thereby addressing several fundamental challenges associated with traditional farming practices. By automating these operations, the system significantly reduces dependence on manual labor, resulting in improved efficiency and cost-effectiveness. The implementation of this robotic system helps lower overall cultivation costs, enabling farmers to achieve better economic returns. The reduction in labor requirements directly addresses labor shortages while improving operational consistency. The robot is controlled through a mobile application, providing ease of operation and greater comfort to the farmer. Handling fertilizer tanks poses health risks due to their weight and the presence of harmful chemicals. The proposed system minimizes direct human exposure to these chemicals, thereby improving occupational safety and reducing health-related issues among farmers. By automating fertilizer spraying, the robot ensures safer and more uniform application. This multipurpose agricultural machine has strong potential to transform small-scale and home-based farming. Its affordable and user-friendly design makes it accessible to farmers with limited resources, while its multifunctional capability saves time and enhances productivity. The adaptability of the system to smaller farming setups also supports home gardeners, encouraging sustainable and resource-efficient agricultural practices.

Overall, the proposed machine offers a practical, economical, and efficient solution for simplifying agricultural operations. It enhances productivity, promotes farmer safety, and supports sustainable farming initiatives, making it a valuable tool for modern agriculture on a budget.

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