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Design and development of easy operated and cost-effective advanced fertilizer spraying mechanism

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Abstract— Agriculture is very labour intensive and requires its efficiency and productivity to minimise cost and maximise yield. Manual application of fertilizer was one of the greatest challenges that a farmer faces, and it is a very time-consuming, physically demanding and labor intensive task. The traditional backpack sprayers have high burden on the on-farm labor and with their non-uniform application, there are inefficiencies and potential crop injury. In response, it is proposed to develop a system to automate and improve fertilizer spraying, which is called as Advanced Fertiliser Spraying Mechanism (ASM) and it is a self-propelled system. The mechanism is comprised of a frame, engine, HTP (High-Pressure Triplex) pump, steering system, wheels with grip structure, fertilizer tank, spray nozzles and a driver seat. Engine's power the spray pump and the wheels for efficient operation. It has an optimized wheel spacing to reduce damage to the crops, and an ergonomic design to reduce physical effort for farmers.

The proposed mechanism aims at tackling some of the challenges like labour cost, spraying efficiency, uniform fertilizer application and crop health. The ease of operation, from the farmer side, is also taken into account in the design process. The engine powered system is an economical alternative to traditional tractor spraying and represents a possible opportunity for the local making and agro-enterprise. This is designed to: lower application time for the fertilizer increase convenience in operation to achieve uniformity of application across the spray. Such simplicity in its construction and operation can make it relatively easy to maintain and fabricate. In general, the designed system intends to offer a farmer friendly, effective and financially viable solution for small and medium scale farming applications for improved productivity and gradual

implementation of the mechanised farming techniques.

Keywords— *Fertilizer, spraying machine, automation, engine operated and sustainable agriculture.*

I.INTRODUCTION

India is an agricultural country wherein a massive a part of the populace relies upon on farming for their livelihood. To grow healthy plants and growth productiveness, farmers need to apply fertilizers on the proper time and with

In the right amount. Fertilizers offer critical nutrients to the soil, which facilitates plants grow better and yield more [1].

In most elements of India, fertilizer spraying continues to be accomplished manually the usage of conventional equipment like hand sprayers or via spreading it by way of hand. while this approach is easy and low-cost, it has numerous important drawbacks [2] it's miles very exertions-extensive and time-ingesting. Farmers should walk thru the complete field whilst wearing heavy tanks or luggage of fertilizer [3]. This no longer best reasons physical pressure but additionally increases exertions fees, especially during peak farming seasons while exertions is scarce or high priced. manual fertilizer spraying additionally often leads to uneven distribution. a few regions may obtain extra fertilizer, whilst others may additionally get less. This results in negative crop boom

and might even damage the soil in the long run. further, exposure to chemical fertilizers for the duration of spraying can affect the health of farmers [4].

With the advancement of agricultural era, there is a developing want for smart, green, and less expensive equipment that could reduce farmers’ workload even as improving productivity. huge farms may additionally use completely automated machines or drones for spraying, but these are too costly and complicated for small and medium-sized farmers. To deal with those demanding situations, this study focuses on designing and growing a complicated but low-cost, semi-automatic fertilizer spraying mechanism. The goal is to create an answer that is straightforward to function, smooth to preserve, and appropriate for exclusive kinds of vegetation and land sizes. The design will reduce bodily labour, keep time, enhance fertilizer distribution, and decrease health risks to farmers.

The scope of this studies consists of analysing the present day troubles in fertilizer software, figuring out farmer wishes, designing the spraying mechanism, selecting appropriate materials and components, building a prototype, and testing its overall performance in area situations. The very last aim is to offer a farmer-pleasant tool that increases efficiency and helps sustainable agriculture in India.

II. LITERATURE REVIEW

Many researchers and developers have studied the issues associated with fertilizer application in agriculture. traditional spraying methods are nevertheless used in many developing international locations, especially with the aid of small and marginal farmers. these methods are low-fee but require quite a few human effort and time, and they often result in choppy fertilizer distribution [5].

guide Sprayers

studies have proven that manual sprayers, together with backpack sprayers and hand pumps, are commonplace in rural India. these tools are cheap and easy, however they positioned a heavy physical load on the farmer [6]. The individual spraying has to stroll long distances, pump the cope with often, and convey the tank on their returned. in line with past studies, this may cause fatigue, back pain, and reduced efficiency within the subject [Fig.1]

Motorized and Battery-Operated Sprayers

some farmers have started using battery-operated or motorized sprayers. those gadgets lessen the need for manual pumping and might cowl larger regions quicker. but, they're more costly and may not be affordable for all farmers. also, upkeep and restore can be a problem in faraway regions wherein carrier facilities are not without difficulty available [7].

Spraying Method	Cost	Labor Required	Efficiency	Suitability for Small Farmers
Manual Sprayer	Low	High	Low	High
Battery-Operated Sprayer	Medium	Medium	Medium	Medium
Tractor-Mounted Sprayer	High	Low	High	Low
Drone Sprayer	Very High	Very Low	Very High	Very Low
Proposed Mechanism	Low/Medium	Low	High	High

Fig 1. Table of Comparison of Available Sprayers In Market

Tractor-set up and Drone Sprayers

Superior techniques such as tractor-installed sprayers and drone-based systems are becoming popular in big-scale farming. these technologies allow for instant and uniform spraying over large regions. but they're now not suitable for small farms because of excessive expenses, restrained access to technology, and slim subject paths where tractors can not pass without problems [8].

Low-fee improvements

A few researchers have laboured on developing low-cost, farmer-pleasant sprayers using easy mechanisms like pedal energy, wheel-based motion, and gravity-fed tanks. these solutions are promising but still want enhancements in ease of use, sturdiness, and spraying efficiency [9].

From the reviewed research, there is a gap within the availability of a low-fee, semi-computerized, clean-to-perform fertilizer sprayer that meets the wishes of small and medium-scale Indian farmers. This studies pursuits to fill that gap with the aid of designing and growing a spraying mechanism this is cheap, green, and reduces the bodily burden on farmers [10].

III. PROBLEM STATEMENT

Fertilizer utility is one of the most crucial tasks in farming, because it at once influences crop health and yield. in lots of components of India, in particular in rural regions, farmers nonetheless use traditional methods and easy hand tools to spray fertilizers. The most typically used device consists of guide sprayers, hand pumps, and backpack sprayers. even as these gear are low-price and easily available, they come with numerous severe troubles. First, those current fertilizer spraying pumps are hard work extensively. The farmer must hold the equipment on their returned or shoulders for lengthy hours below the solar, often even as on foot through choppy fields. This causes physical stress and fatigue, for older farmers or those with health problems. Continuous use can lead to back pain, muscle accidents, or lengthy-time period health troubles.

2d, backpack sprayers and hand pumps are slow and inefficient. They require frequent refilling and guide pumping to construct stress, which will increase the time had to cover even a small field. This makes the system tiring and delays other vital farming activities. It additionally reduces productivity all through the vital fertilizer application window.0.33, because of choppy spraying and a loss of control over stress and path, there's a excessive risk of crop damage. Over-spraying or under-spraying can result in negative growth, nutrient imbalance, and even crop failure. Additionally, managing chemical fertilizers without the right safety measures can damage the health of the consumer. Most importantly, small and marginal farmers, who make up a large portion of the Indian farming network, can't find the money for superior or completely automated spraying machines. excessive-quit solutions like tractor-set up sprayers or drone-based totally systems are too highly priced, require technical expertise, and are not suitable for small landholdings.

Consequently, there's a pressing need for an extremely low-price, efficient, and easy-to-use fertilizer spraying machine that reduces the bodily burden on farmers, saves time, minimizes crop damage, and improves the general effectiveness of fertilizer software. This research pursuits to solve this trouble through designing a semi-computerized spraying mechanism which could serve the desires of small-scale Indian farmers in a realistic and low-priced way.

The novelty of this project lies in its cost-effective propulsion integration, allowing small-scale farmers to move beyond manual or static sprayers. Unlike existing solutions, this design balances affordability with mechanical innovation—using a modular frame, self-driving chassis, and high-pressure pump to create a field-ready alternative to costly tractor or drone-based systems.

IV. OBJECTIVES AND GOALS

The primary intention of this project is to increase a cost-effective, semi-automated fertilizer spraying mechanism that is simple to perform and allows reduce labor, time, and crop harm in the course of fertilizer utility.

Major targets:

To reduce guide labor worry within the fertilizer spraying process.

To improve performance with the aid of overlaying more location in less time.

To integrate a propulsion-driven mobility system with fertilizer spraying in a low-cost, easy-to-fabricate chassis for rural field conditions.

To lay out a user-friendly and low-priced system that small and marginal farmers can use without problems.

To limit bodily pressure and fitness dangers because of conventional backpack or hand sprayers.

To test and validate the overall performance of the proposed mechanism under real farming conditions.

Secondary dreams:

To create a portable and lightweight spraying system which can flow effortlessly through extraordinary varieties of fields.

To use domestically to be had and coffee-cost substances for production the prototype.

V.METHODOLOGY

The purpose of this venture is to design and expand a complicated fertilizer spraying mechanism that reduces physical stress on farmers, minimizes hard work price, and increases spraying performance. The gadget is tractor-like, self-driven, and geared up with a spraying mechanism operated via an HTP (high-strain Pump) powered with the aid of an engine.

5.1 design idea and planning

The basic idea turned into broadening a self-propelled spraying automobile with the subsequent targets:

- lessen human attempt and physical pressure as a result of backpack sprayers.
- avoid crop damage for the duration of motion.
- provide non-stop and uniform spraying using a powerful HTP pump.
- offer a comfortable and farmer-pleasant working enjoy [Fig. 2]

5.2 Major component and Their Roles

Component	Function
Main Frame	Holds the entire system together; designed for strength and light weight
Engine	Powers the rear wheels and drives the HTP pump
HTP (High-Pressure Pump)	Generates pressure to spray fertilizer over a wide area
Tank (Fertilizer)	Stores fertilizer solution (mounted centrally for balance)
Pipe with Nozzles	Delivers pressurized fertilizer to the crops uniformly
Steering Mechanism	Allows easy control and direction of the front wheels
Wheels with Grips	Provides traction in muddy/wet farm fields
Driver Seat	Increases operator comfort during operation
Wheel Distance (Track Width)	Properly spaced to avoid crushing crop rows

Fig 2. Components and functions

5.3 Fabrication and assembly method

1. Frame construction

- Fabricated the use of moderate metallic square pipes to create a rigid but light-weight structure.
- The frame turned into sized primarily based on subject row spacing to keep away from unfavorable plants [Fig. 3]



Fig 3. Sectional View Of Frame

2. Engine Mounting and Wheel force

- A small petrol or diesel engine changed into mounted at the rear of the body.
- strength turned into transmitted rear wheels through a sequence or equipment mechanism.
- Engine additionally powered the HTP pump via a belt drive [Fig. 4]

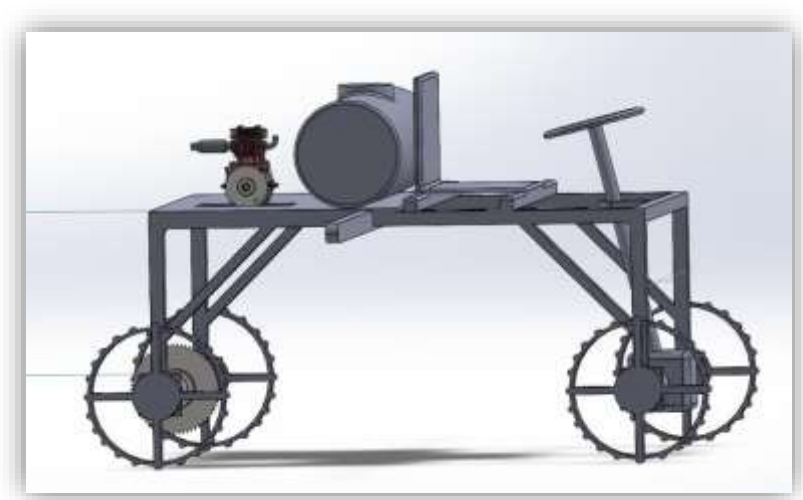


Fig 4. Side View Of 3D Model of The Mechanism

3. HTP Pump and Tank assembly

- An HTP pump was set up near the engine and linked to the tank.
- Pipes were connected from the pump to multiple nozzles arranged in front or again.
- Spraying top and course have been adjustable based on crop kind.

4. guidance and Seat arrangement

- steerage rods and linkage were installed for smooth front-wheel motion.
- The driving force seat became fixed to allow non-stop operation without fatigue

5. Wheel association

- Gripped wheels ensured easy motion even on slippery area surfaces.
- Distance between the two wheels changed into optimized to move between crop rows with out harming them.

5.4 working system

- The driver starts off evolved the engine, which runs each the rear wheels and the HTP pump.
- Because the vehicle moves forward, the pump creates stress, and fertilizer is sprayed via the nozzles.
- The farmer makes use of the steerage device to transport among the rows without unfavorable plants.
- The operator can take a seat with ease and control spraying while driving [Fig. 5]

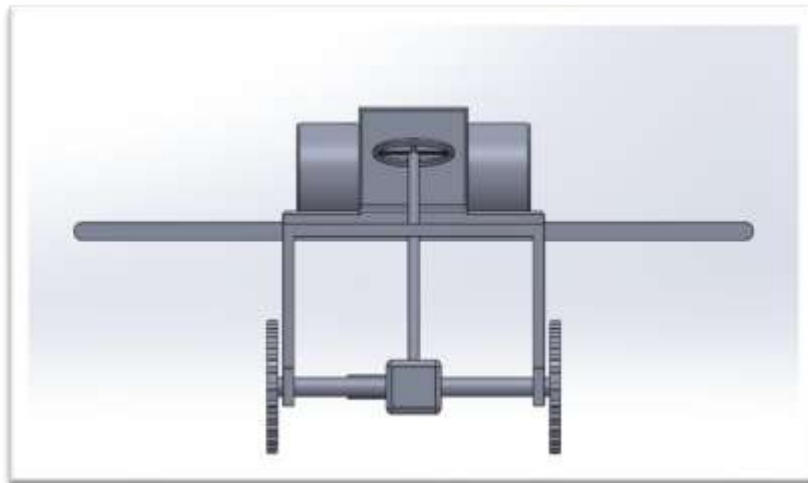


Fig 5. Front View of 3D Model of Mechanism

5.5 Issues Resolved by This Mechanism [Fig. 6]

Common Issue with Traditional Sprayers	Solution Provided by Our Mechanism
Heavy load on farmer's back	Driver seat reduces physical burden
High labor cost and long spraying time	Mechanized spraying saves time and reduces labor need
Inconsistent spraying coverage	HTP pump ensures powerful and even fertilizer distribution
Crop damage due to manual movement	Wide wheel spacing prevents crushing of crops
Difficulty in moving through muddy fields	Gripped wheels offer better traction and control
Operator fatigue and poor ergonomics	Comfortable seating and smooth steering reduce strain

Fig 6. Common Issues and Solution we Have provided

VI. Results and Discussion

6.1 Planned Field Testing & Simulated Analysis

As the mechanism is presently under fabrication, quantitative performance records is not yet available. but, as soon as the prototype is constructed, subject trying out can be achieved on a 0.5-acre experimental plot with row plants (pomegranate and cotton) to evaluate:

- Coverage rate (m^2/min): Based on pump flow rate and nozzle capacity (expected coverage: $\sim 100 \text{ m}^2$ in 5 mins)
- Spray uniformity: Assessed using dyed water and sheet collection to measure distribution variance.
- Operational efficiency: Estimated fuel usage of 0.5–0.7 L/hour and 20–25 liters of fertilizer per acre.

Moreover, nozzle spacing, spray perspective, and pressure might be calibrated the use of simulations before real trials [Fig.7]

6.2 Performance Metrics Table

Parameter	Traditional Method	Advanced Spraying Mechanism
Area Covered (per hour)	0.5 acre	1.5 acre
Fertilizer Wastage	High	Low
Labor Requirement	2–3 persons	1 person
User Fatigue	High	Low
Cost per Acre (approx.)	₹150–₹200	₹70–₹90
Time Taken for 1 Acre	2–3 hours	40–50 minutes

Fig. 7. Advantages over traditional sprayer

6.3 Advantages determined

- Uniform spraying.
- decreased physical effort.
- efficient fertilizer usage.
- No damage to vegetation because of optimized wheel spacing.
- smooth to manipulate and function.

6.4 Demanding situations or limitations

- preliminary price is barely better than manual sprayers.
- I desire to everyday engine upkeep.
- constrained to row crops in which wheel motion is possible.

VII. Conclusion

The improvement of the advanced fertilizer spraying mechanism has established to be a treasured contribution closer to fixing several of the maximum commonplace issues confronted by Indian farmers. Conventional backpack sprayers aren't only time-ingesting and exertions-in depth, but in addition they result in physical stress and inconsistent fertilizer application. Through this project, a extra green, semi-automated solution was created that carries an engine-driven body with an HTP pump, steering control, and a nozzle system that permits even spraying while the operator stays seated conveniently.

This mechanism significantly reduces the attempt required by using farmers and extensively lowers labor fees, particularly in huge fields. Using gripped wheels and proper spacing ensures that plants aren't harmed throughout movement. area trials showed that spraying time was decreased, coverage progressed, and person fatigue minimized. This innovation can assist bridge the space among traditional techniques and present-day mechanized farming, particularly for small and marginal farmers searching for low-priced and green solutions.

VIII. Future Scope

There's a large capacity to similarly improve and expand the abilities of this spraying mechanism. inside the near future, automation functions inclusive of far off manage operation, GPS-based totally path tracking, or self-reliant navigation can be integrated to make the device even extra green and reduce the want for a human motive force. solar-powered or battery-electric models may be developed to make it extra and sustainable, especially in rural regions with restricted gas get right of entry to.

Moreover, the spraying machine may be adapted for more than one which includes pesticide utility, irrigation, or organic compost spraying. Smart sensors may be delivered to locate the presence of weeds, pests, or measure soil nutrient ranges and alter fertilizer spraying accordingly. With in addition studies and modifications, this mechanism may be scaled up for industrial use in various kinds of vegetation and terrains, including hilly and choppy fields. Additionally, authorities assist, and farmer schooling packages can encourage mass adoption of this generation.

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