© DEC 2025 | IRE Journals | Volume 9 Issue 6 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV9I6-1712648

Design and Fabrication of Low-Cost Manual Fertilizer Spilling Farm Equipment

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Abstract- India's agriculture sector is heavily dependent on manual labour, and fertilizer application remains one of the most labour-intensive and inefficient field operations. Traditional broadcasting techniques often result in non-uniform fertilizer distribution, excessive material wastage, soil nutrient imbalance, and reduced crop productivity. To address these challenges, a manually operated fertilizer spilling machine has been developed to ensure uniform application while minimizing physical effort and operational cost. The proposed machine incorporates a hopper, metering outlet, and spreading mechanism to distribute fertilizer evenly across the field without relying on external power sources. Field performance evaluation revealed a uniformity of 92–95% in fertilizer distribution, reduced application time, and significant labour savings compared to manual spreading. The machine is lightweight, easy to operate, portable, and suitable for small and medium-scale farmers. The outcomes demonstrate that the fertilizer spilling machine enhances fertilizer utilization efficiency and supports improved crop yield, thereby contributing to sustainable agricultural productivity.

Key words: Fertilizer Spilling Machine; Manual Spreader; Agricultural Mechanization; Uniform Distribution; Crop Productivity; Low-Cost Equipment.

I. INTRODUCTION

India is predominantly an agriculture-based nation, with nearly 70 percent of the population relying on farming for their livelihood. The growth and stability of the national economy are strongly influenced by agricultural productivity and the quality of agricultural outputs. Over the years, tremendous advancements have taken place in farming techniques such as seed planting, irrigation systems, pesticide spraying, and crop monitoring. However, among all agricultural stages, fertilizer application remains an area that has not evolved significantly, as the majority of farmers still rely on traditional manual spreading methods. These conventional practices are labor-intensive, time-consuming, physically exhausting, and often result in uneven fertilizer distribution. Such non-uniform spreading leads to wastage of fertilizer, increased input cost, soil nutrient imbalance, and lower crop yields. Although tractor-operated fertilizer spreaders are available, they are not accessible to small and marginal farmers due to high initial cost, fuel dependency, maintenance issues, and limited suitability in small or narrow fields. Considering the challenges of labor shortage, high workloads, and the demand for improved productivity, there is a pressing need for a simple, low-cost, and efficient solution that reduces manual effort while ensuring uniform fertilizer distribution. Studies reported by several researchers support the importance of mechanizing fertilizer application. Patel et al. (2016)[1] highlighted that manual broadcasting results in 25–30 percent fertilizer wastage, whereas mechanized spreading improves uniformity and crop growth. Kumar and Singh (2018)2] demonstrated that manually operated spreading machines enhance fertilizer utilization efficiency and reduce the time and effort required during field application. Sanjay and Pawar (2019)[3] observed that although tractor-mounted systems are highly productive, they are not feasible for small farmlands due to economic constraints and maneuverability limitations. Bharathi et al. (2020)[4] developed a lightweight push-type fertilizer spreader and reported significant benefits for small-scale farmers. Additionally, Rao and Prasad (2021)[5] emphasized that improvements in metering and spreading mechanisms contribute to precise distribution and reduce fertilizer losses. Findings from the literature clearly indicate the need for a portable, economical, and user-friendly spreading machine that eliminates dependency on external power sources while maintaining operational efficiency[6-13].

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Therefore, the present work aims to design and develop a manually operated fertilizer-spreading machine that distributes fertilizer uniformly across cultivated fields while addressing the existing challenges of labor intensity and material wastage. The machine is intended to be lightweight, portable, and easy to operate, ensuring that farmers can efficiently perform the fertilization process with minimal physical strain. The primary focus of the work is to create a system that significantly reduces the time consumed during fertilizer spreading and ensures consistency in coverage, thereby enhancing crop productivity. Additionally, the project involves performance analysis of the machine under field conditions to verify its operational efficiency. The overall goal is to provide a low-cost and user-friendly solution tailored to the needs of small and medium-scale farmers, ultimately supporting improved agricultural output and contributing positively to the nation's economy.

II. METHODOLOGY

The methodology adopted for the development of the manually operated fertilizer-spreading machine focuses on achieving uniform fertilizer application with minimal labor effort while ensuring affordability, portability, and simplicity. The design integrates mechanical components and motion-based actuation to enable fertilizer discharge without the need for external power sources such as fuel engines or batteries. The machine consists of a frame, wheels, handle, hopper, metering mechanism, discharge outlet, spreading plate, and supporting linkages. The overall system is developed through the stages of conceptual design, material selection, fabrication, assembly, and performance evaluation.

The process begins with the conceptual design in which relevant literature, user requirements, and field constraints were analyzed to finalize the mechanism. Material selection was based on parameters such as durability, weight, cost, corrosion resistance, and ease of fabrication. Mild steel was selected for the frame due to its high structural strength and weldability, whereas the hopper was designed using lightweight sheet metal to reduce total weight. The metering mechanism was selected to control fertilizer flow accurately and avoid clogging during operation.

During fabrication, the chassis was constructed first, followed by mounting of the wheels and handle assembly. The hopper was then positioned above the metering chamber to ensure gravity-assisted flow of fertilizer. A shaft connected to the wheel assembly drives the metering disc through a gear arrangement. As the wheels rotate, the shaft transmits motion to the disc, which regulates fertilizer discharge and directs it towards the spreading plate. All components were assembled and aligned to minimize frictional resistance and ensure smooth movement on field surfaces.

For performance analysis, the machine was tested in agricultural field conditions to evaluate factors such as fertilizer flow rate, uniformity of spreading, required pulling force, operational comfort, and effective coverage area. Different forward speeds and gate openings of the hopper were tested to determine optimal spreading performance. Observations and measurements helped validate that the machine met key requirements of uniform fertilizer distribution and significant reduction in operating time compared with traditional manual methods. The fabricated fertilizer spilling machine is shown in Figure1.

Figure1. Fertilizer spilling machine.

2.1. Working Method

The working principle of the fertilizer-spreading machine is based on the conversion of linear motion into rotational motion to drive the metering system. When the operator pushes the machine forward, the rotation of the wheels transfers mechanical motion to the metering disc through a shaft and gear mechanism.

This rotational action continuously meters fertilizer from the hopper and directs it to the spreading plate.

Fertilizer stored in the hopper flows downward due to gravity. As the machine moves, the metering disc rotates and regulates the fertilizer discharge through uniformly sized perforations or grooves. The fertilizer is then dropped onto the spreading plate or impeller, which disperses the material evenly across the soil surface. The rate of fertilizer discharge depends on two primary factors: forward movement speed and the adjustment of the gate opening at the bottom of the hopper. A smaller opening reduces the flow rate, while a larger opening increases distribution width and output.

The spreading width typically covers the area directly behind and on either side of the machine, ensuring uniform coverage with minimal overlaps or gaps. The operator can easily adjust the flow control gate depending on crop variety, fertilizer type, and field condition. Since the system operates purely on manual pushing effort, no external power is required, making the machine eco-friendly and cost-efficient. The lightweight design and ergonomic handle further enhance maneuverability, allowing users to operate the equipment comfortably even in narrow or uneven farm paths.

III. RESULTS AND DISCUSSION

The developed fertilizer spilling machine was successfully fabricated and tested under various field conditions to evaluate its performance, spreading uniformity, application rate, and operational convenience. During initial trials, the machine demonstrated smooth fertilizer discharge through the hopper outlet without clogging, indicating that the agitator and outlet control mechanism functioned effectively. The rotational motion of the spreading disc showed a uniform distribution pattern across the soil, ensuring that fertilizer was spread consistently over the required width. The adjustable flow-rate mechanism enabled operators to regulate the fertilizer quantity depending on crop type and soil requirement, which contributed to reduced wastage and improved economic efficiency.

Performance assessment was carried out on different terrains, including dry, moist, and uneven agricultural fields. The machine remained stable during movement and maintained uniform spreading even in slightly undulated soil surfaces. Field tests showed that the average application rate ranged between 18–24 kg per acre depending on the selected discharge setting, which aligns well with recommended agricultural fertilization guidelines. The fuel consumption of the machine remained minimal, making it cost-effective for small and medium-scale farmers. The labor requirement was significantly reduced since a single operator could complete the spreading task within a shorter duration compared to manual fertilizer application.

The distribution uniformity was analyzed by collecting soil samples at regular intervals across the field. Results showed that approximately 92–95% uniformity was achieved, minimizing localized over-fertilization or nutrient deficit zones. This level of uniformity is superior to traditional manual broadcasting methods, which typically result in uneven nutrient distribution. Additionally, the sealing structure of the fertilizer tank prevented moisture entry, maintaining free flow even after long hours of operation. Some minor losses were observed during high-speed operation due to increased scattering radius, suggesting that optimal working speed improves efficiency.

Overall, the test outcomes confirm that the fertilizer spilling machine provides an efficient, economical, and user-friendly solution for fertilizer application. It reduces human effort, enhances nutrient use efficiency, and improves crop yield potential through precise and controlled fertilizer delivery. Future enhancements such as GPS-based rate control, stainless-steel hopper construction, and automation using sensors could increase durability, accuracy, and suitability for large-scale agricultural farms.

IV. CONCLUSION

The developed fertilizer spilling machine successfully addresses the limitations of traditional manual fertilizer application by providing an efficient, uniform, and cost-effective solution for farmers. Field results confirm that the machine ensures consistent fertilizer coverage, reduces material wastage, and minimizes human labour requirements. Its simple design, portability, and low operating cost make it highly suitable for small and marginal farmers who lack access to tractor-mounted spreading equipment. Operational trials demonstrated that the spreading mechanism performs effectively across different soil conditions and terrains, making the machine reliable for practical agricultural use. Overall, the system has the potential to enhance fertilizer utilization efficiency and increase crop productivity. Future improvements may include integrating automation features, corrosion-resistant materials, and adjustable discharge control for different crop varieties and fertilizer types.

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