A Survey on Compact Multipurpose Agricultural Machines for Soil Cultivation and Seed/Fertilizer Dispensing

Mahesh Sanjay Patole[1], Yuvraj Namdev Kamerikar [2], Vastav Chandrakant Kavhtekar [3], Prathamesh Ishwar Kharat [4], Saipratik Dhanpal Admuthe[5], Julee Sudeep Kambale[6]

[1,2,3,4]Student, Department Of Mechanical Engineering Sanjay Bhokare Group Institutes, Miraj Mahashatra, India

[5,6] Lecturer, Department Of Mechanical Engineering Sanjay Bhokare Group Institutes, Miraj Mahashatra, India

Abstract

Small and medium-sized farms often prepare the soil, sow seed and apply fertilizer as separate operations. This increases time, labor and operating effort, while large multi-function machines are frequently too costly or too bulky for small plots. This paper surveys selected published work on multipurpose agricultural machines and on manually operated and low-cost seed and seed-cum-fertilizer drills. Seven studies published between 2013 and 2025 are reviewed and compared on machine concept, power source, crop, performance parameters and stated findings.

The survey shows that (i) affordability and multifunctionality are repeatedly identified as key needs of smallholders, (ii) metering design, outlet dimensions and calibration strongly influence sowing performance, and (iii) low cost alone is not sufficient, because field capacity, distribution uniformity, working depth, safety and maintenance must also be tested.

Keywords: agricultural mechanization, multipurpose machine, soil cultivation, seed metering, fertilizer dispensing, seed drill, low-cost fabrication

1. Introduction

Agriculture is an important sector in India and provides employment and livelihoods to many people. During crop production, farmers carry out several operations, including soil preparation, weeding, sowing and fertilizer application. When these are performed separately, they may require more time, repeated movement across the field and additional manual effort.

Mechanization can help farmers complete selected tasks more consistently and within suitable planting periods. However, large machines may be expensive or unsuitable for small plots. A compact machine that combines basic functions may therefore be useful where affordability, maneuverability and ease of maintenance matter most.

This paper surveys the literature relevant to such a machine: a compact unit that loosens topsoil with a cultivation mechanism while a hopper and metering mechanism release seed or granular fertilizer at a controlled rate. The survey was prepared to support the design, fabrication and testing of a Multipurpose Agriculture Machine prototype in the Department of Mechanical Engineering.

The objectives of this survey are:

- to review published work on multipurpose, manually operated and low-cost agricultural machines;
- to compare the performance parameters and evaluation methods used in these studies;
- to identify design requirements and research gaps relevant to a compact cultivation-and-dispensing machine; and
- to propose a framework for evaluating such a prototype.

2. Scope and Method of the Survey

The survey covers seven studies selected for their direct relevance to three themes: multipurpose or versatile agricultural machinery, manually operated or low-cost seed drills and metering mechanisms, and seed-cum-fertilizer

equipment. The studies were compared on the following attributes: purpose and machine concept, power source, crop or application, performance indicators reported, and relevance to a compact multipurpose prototype.

This is a focused survey rather than an exhaustive systematic review. The number of studies is limited, so the conclusions drawn here are indicative and should be read together with a wider literature search as the project proceeds. Figures quoted are those reported by the original authors under their own study conditions and are not directly transferable to other machines, crops or soils.

3. Background: Operations and Machine Categories

3.1 Conventional operations

A conventional sequence includes soil preparation, sowing and fertilizer application. Each is often a separate pass over the field. Manual sowing may give irregular seed spacing, and manual fertilizer application may lead to uneven distribution and wastage. Large equipment reduces these problems but can be unaffordable for small-scale farmers, and spare parts and maintenance facilities may be limited in some rural areas.

3.2 Categories of machines in the literature

The reviewed work falls into three broad categories:

- **Multipurpose or versatile machines** that integrate several farm functions on one frame or one power source.
- **Manually operated or low-cost seed drills** with a focus on metering design, calibration and field performance for specific crops.
- **Seed-cum-fertilizer and planter systems** that dispense seed and fertilizer together or form ridges and beds while planting.

4. Review of Selected Studies

4.1 Multipurpose and versatile machines

Radkar et al. (2021) discussed the need for affordable multipurpose agricultural equipment for farmers with small landholdings. They emphasize that the purchase and maintenance costs of large machines can limit mechanization among rural farmers. This directly supports the case for a compact, low-cost machine that can undertake more than one farming operation.

Jeyakumar et al. (2020) presented a versatile agricultural machine concept that integrates several agricultural functions using a common power source and transmission arrangement. Their study illustrates the potential of multifunctional machinery to reduce reliance on separate implements. The configuration they discuss is tractor-driven, which differs from a compact machine whose power source and final dimensions are still to be selected.

4.2 Manually operated and low-cost seed drills

Ghosal and Pradhan (2013) developed and field-tested a low-cost, manually operated cup-feed seed drill for green gram. They reported a field capacity of 0.063 ha/h and a field efficiency of 78.75%. Their findings show the importance of selecting suitable metering dimensions and of evaluating seed distribution and operating cost for small farmers.

Shambhu and Thakur (2018) designed and fabricated a manually operated seed drill for jute and tested its calibration and field performance. Their trials reported an effective field capacity of approximately 0.162–0.176 ha/h. The work shows that crop-specific seed properties, outlet dimensions and calibration affect practical sowing performance.

4.3 Comparative evaluation of seed drills

Jayaprakash et al. (2015) compared five seed drills for Bengal gram, including seed-cum-fertilizer equipment. They evaluated field capacity, seed rate, crop yield and cultivation cost, and found differences between machine designs.

The study supports judging a machine on dispensing performance and economic feasibility rather than only on the number of functions it performs.

4.4 Seed-cum-fertilizer and planter systems

Sawant et al. (2019) evaluated an IARI wheat seed-cum-fertilizer plot drill for raised-bed cultivation. Their work demonstrated integrated metering of seed and fertilizer and reported a field efficiency of 80% under the study conditions. The findings highlight the need to match opener design, power requirements and feed mechanisms to field conditions.

Kumar et al. (2025) optimized a manually operated ridger planter with inclined-plate seed metering for smallholder use. They reported improved seed-spacing consistency and approximately 80% field efficiency in their trials. The study is relevant because compact machines must balance accurate dispensing, manageable operator effort and fabrication simplicity.

5. Comparative Summary

Study	Machine / focus	Power	Crop / application	Reported findings
Radkar et al. (2021)	Multipurpose agriculture machine	Not specified here	Small landholdings	Need for affordable multipurpose equipment; cost of large machines limits mechanization
Jeyakumar et al. (2020)	Versatile agricultural machine	Common power source and transmission (tractor-driven)	Multiple farm functions	Potential to reduce reliance on separate implements
Ghosal & Pradhan (2013)	Manual cup-feed seed drill	Manual	Green gram	Field capacity 0.063 ha/h; field efficiency 78.75%
Jayaprakash et al. (2015)	Five seed drills compared, incl. seed-cum-fertilizer	Not specified here	Bengal gram	Differences in field capacity, seed rate, yield and cultivation cost between designs
Shambhu & Thakur (2018)	Manual seed drill	Manual	Jute	Effective field capacity about 0.162–0.176 ha/h
Sawant et al. (2019)	IARI seed-cum-fertilizer plot drill	Not specified here	Wheat, raised-bed system	Integrated seed and fertilizer metering; field efficiency 80%
Kumar et al. (2025)	Manual ridger planter, inclined-plate metering	Manual	Smallholder planting	Improved seed-spacing consistency; about 80% field efficiency

6. Discussion

6.1 Common themes

Three themes recur across the studies. First, **affordability and multifunctionality** are treated as central needs for smallholders (Radkar et al., 2021; Jeyakumar et al., 2020). Second, **metering design and calibration** determine practical sowing performance, and are crop-specific (Ghosal & Pradhan, 2013; Shambhu & Thakur, 2018; Kumar et al., 2025). Third, **performance must be measured, not assumed**: field capacity, field efficiency, seed rate, yield and cost are used by the studies to compare designs (Jayaprakash et al., 2015; Sawant et al., 2019).

6.2 Implications for a combined cultivation-and-dispensing machine

The reviewed studies suggest that integration of functions and low cost are important design considerations. Combining soil cultivation with controlled seed or granular fertilizer dispensing adds further engineering requirements: adequate frame strength, controllable working depth, metering accuracy, drive coordination between the cultivation and dispensing units, operator safety and ease of maintenance. These are design considerations for the proposed machine and are not performance outcomes established by the cited papers.

6.3 Research gap

The surveyed work addresses either multifunction concepts (often with a common, tractor-type power source) or the performance of seed and seed-cum-fertilizer drills. Within this set of studies, there is limited evidence on whether a compact machine that couples soil cultivation with controlled dispensing on a common frame can carry out both operations reliably under defined field conditions. This is the gap that the proposed prototype is intended to examine. Taken together, the studies indicate that low cost alone is insufficient, and that field capacity, metering uniformity, cultivation depth, safety and maintenance must also be tested.

6.4 Problems and expected benefits

The problems identified from the literature and from conventional practice are: separate operations that increase time and effort, higher labor requirement, high equipment cost, limited maintenance support in some rural areas, uneven seed distribution, fertilizer wastage, and the need for compact multipurpose equipment.

The benefits that a compact multipurpose machine may offer are fewer repeated field passes and shorter operating time, reduced manual effort, lower equipment and operating cost, more uniform distribution through a calibrated mechanism, suitability for small fields, easier maintenance with simple and locally available components, and a modular design that can be adjusted or upgraded. These are possible benefits only. They are hypotheses to be tested, and no improvement percentage is assumed in advance.

7. Proposed Machine and Design Considerations

The prototype that this survey supports is a compact machine on a common frame. Its main elements and their roles are:

- **Supporting frame:** structural support for all components.
- **Wheels and handles:** movement, direction control and easy handling.
- **Cultivation unit:** blades or tines that loosen the soil as the machine moves, with an arrangement for adjusting depth.
- **Hopper:** storage for seeds or granular fertilizer.
- **Metering mechanism:** control of the quantity and rate of dispensing.
- **Drive arrangement:** transmission of motion or power to the operating mechanisms.
- **Safety and maintenance provisions:** guards, regular inspection, cleaning and lubrication.

During forward movement, the cultivation unit loosens the soil while the dispensing system releases seed or fertilizer. The final dimensions, working width, working depth, power source and feed rate are to be fixed during design and prototype testing, taking into account field conditions, budget, safety and the available workshop facilities.

8. Proposed Evaluation Framework

Drawing on the performance indicators used in the surveyed studies, the prototype will be evaluated on:

- **Time efficiency:** operating time for a defined field area.
- **Distribution uniformity:** seed spacing or fertilizer distribution consistency, after calibration of the feeding mechanism.
- **Cultivation depth:** measured working depth of the cultivation unit.
- **Working performance:** soil loosening, machine movement and handling.
- **Reliability:** vibration, clogging, component wear and operational faults.
- **Cost analysis:** fabrication, maintenance and operating cost.

Comparison with a conventional approach will be made only after field testing.

The work is planned in four modules: (1) supporting frame and mobility system, (2) soil cultivation system, (3) seed and fertilizer dispensing system, and (4) system integration, testing and evaluation. The expected outcome is a functional prototype whose performance is verified through field trials.

9. Feasibility Considerations

- **Technical:** the machine can be designed and fabricated with commonly available mechanical components and workshop facilities.
- **Economic:** the design aims to minimize fabrication and operating cost, making it potentially affordable for small-scale farmers.
- **Operational:** simple controls and a compact structure are expected to ease operation and maintenance.
- **Environmental:** combining operations may reduce repeated field passes and associated energy consumption.
- **Maintenance:** locally available components and simple construction may allow easy servicing and replacement.

These statements are expectations at the design stage and will be confirmed or revised after testing.

10. Limitations and Future Scope

This survey is limited to seven studies and to the parameters those studies report. The studies use different crops, soils, power sources and test conditions, so their numerical results cannot be compared directly. Future work should widen the literature base to include soil-engaging tools and cultivator design, power transmission for small machines, and ergonomic and safety evaluation. For the prototype itself, future work includes calibration and field trials, comparison against separate conventional operations, and possible extension to additional crops or attachments.

11. Conclusion

The surveyed literature shows a consistent need for affordable, compact machinery for small and medium-sized farms, and demonstrates that sowing performance depends on metering design, calibration and field conditions. It also shows that a machine should be judged on measured performance and cost, not on the number of functions alone. Evidence on compact machines that combine soil cultivation with controlled seed or granular fertilizer dispensing is limited in the reviewed set, which motivates the proposed prototype. Its performance, reliability, safety and cost-effectiveness will be established through calibration and field trials, and no benefit is claimed before that testing.

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