KT Journal of Mechanical Engineering

ISSN: 3048-9563

Key Tech Services Publication, India

http://www.ktjme.com
https://doi.org/10.64188/3048956325013
Vol.: 2, No. 3, 2025, Pages: 1-7

DESIGN AND DEVELOPMENT OF MULTIPURPOSE AGRICULTURE EQUIPMENT FOR TRACTOR

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Abstract

Mechanization in agriculture plays a crucial role in reducing labor and improving crop productivity. In conventional practice, tilling, furrow formation, and seed sowing are carried out separately, requiring more time, labor, and cost. This work presents the design and development of an attachment to a rotavator that performs multiple functions in a single pass. The proposed attachment can form furrows after rotor tilling and simultaneously sowing maize (corn) seeds on the sides of the furrows. The methodology includes conceptual design, CAD modeling, material selection, and prototype fabrication. Field trials demonstrated that the developed attachment reduces operation time by approximately 40% compared to traditional methods, ensures uniform seed placement, and is cost-effective. This innovation offers a simple yet efficient solution to small and medium-scale farmers. Overall, the developed equipment provides practical and efficient solution for small and medium scale farmers.

1. Introduction

In developing countries like India mechanization of agriculture was started with the use of improved hand tools and bullock drawn implements. Farm mechanization aims at higher production and reduction in human drudgery. There are certain difficulties in the way of mechanization of Indian agriculture. In the farming process, often used tilling, furrow formation and conventional seeding operations takes more time and labour. The time required for the

Received: 04.08.2025 Revised: 15.09.2025 Accepted:05.10.2025 Published Online: 15.10.2025
Keywords: Rotavator, Furrow formation, Seed sowing, Maize, Agricultural mechanization
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How to cite this article: Dhobale A. L., Salunke Yash, Pansare Rohan, Tavhare Rushikesh, Bangar Sahil, Design and development of multipurpose agriculture equipment for tractor, KT Journal of Mechanical Engineering, 2 (3) 2025, 1-7. https://doi.org/10.64188/3048956325013

operations tilling, furrowing, seeding which are performed separately is more the total cost of fuel as well as due to labor, hiring of equipments. Today's era is marching towards the rapid growth of all sectors including the agricultural sector. To meet the future food demands, the farmers must implement the new techniques which will not affect the soil texture but will increase the overall crop production [1-3]. Agriculture in India has a significant history. Today, India ranks second worldwide in farm output. Still, agriculture is demographically the broadest economic sector and plays a significant role in the overall socio-economic fabric of India. The traditional process of farming typically involves multiple steps soil tilling, creating furrows, and then planting seeds all of which require separate machinery and manual efforts. This leads to excessive time consumption, increased labour dependency, and higher fuel usage. The repetitive operation over the same field also causes soil compaction, which can negatively affect crop growth [4-5].

This project proposes a conceptual design for modifying an existing tractor rotor to perform all three operations rotary tilling, furrow formation, and seed sowing in a single pass. The focus is to provide a cost-effective, labour- saving, and efficient solution that enhances productivity. The comparison between the traditional sowing method and the new proposed machine both perform several simultaneous operations and has number of advantages. As day by day the labour availability, fuel cost and time becomes the great concern for the farmers, this enhancement to the rotavator reduces the time and fuel cost as the operations – tilling, furrowing seed sowing will be performed simultaneously in single pass. Sowing the seeds of different crop has vital importance in cultivation of crop, so many of the farmers prefer to use mechanical planters with automatic seed metering devices. As the farm inputs like seed, labour etc. are now a days very precious. So, the modern machines which can handle them efficiently must be used. For improving crop yield it is necessary to adopt new technology in farming rather than the local methods. In India though the population is growing faster there is a burning problem of labour required for farming. Farm production is directly related with the availability of power on the farm. In India, the bullock and tractor power are the major source of power on small and marginal farms. Tractor power is utilized on large farms. The higher contribution of power indicates the importance of improved agricultural machinery and equipment's in agriculture. Most of the farmers in a particular area take up farming operations separately. So, soil compaction and degradation take place it further affects crops. This can be overcome by introducing machines [6-7]. The implements and machineries introduced must be precise enough to compete with the human labour. Any machine introduced newly must satisfy the farmers by its advantage over the prevailing methodology. The elevation should be economical, reliable, and versatile. The application of such enhancement to the rotavator can play a key role providing saving in labour, fuel cost, and time of operation. The Indian farmers (small, marginal, small and marginal, semi-medium) are currently using separate equipments rotavator for tilling, furrows for furrow formation, and seed sowing machine or equipment. This each operation is performed separately. This performing of each operation takes more time as well as more fuel consumption. To overcome this problem, enhancement to the rotavator can be adopted. Rather it is a means to reduce fuel consumption and improve productivity by reducing soil compaction due

to multiple passes. For improving crop yield it is necessary to adopt new technology in farming rather than the local methods [8-10]

2. Materials and Methods

a] Design Approach:

- CAD modeling of rotavator attachment.
- Stress analysis of frame and seed box mounting.
- Adjustable seed metering unit for maize seeds.

b] Main Components:

Main frame: The main frame assembly consists of angle frame made of 1300x860x50 mm M.S. angle. It also consists of channels of size 50x50x5 mm for mounting furrow openers. It can accommodate five furrow openers with spacing 310 mm and can be mounted in between the channels with the help of nuts and bolts. The cultivator tines are mounted on main frame having sweep type furrow openers. The seed and fertilizer hoppers are mounted on main frame with support [11].

C] Power transmission unit (Motor): The ground wheel is replaced by motor provided on either side of the frame form the functional component of power transmission unit. Rotation of motor shaft causes the rotation of seed rotors through bevel gears and chain and sprocket arrangement.

Figure1. Power transmission unit (DC motor)

D] Seed Metering Device: It comprises following sections 1. Seed box 2. Seed metering mechanism i) Rotor body ii) Rotor iii) Rotor shaft

1. Seed box: The box was located above the base frame supporting the furrow openers and transport cum depth control beam. A partition is provided along the length of the box to separate seed. The seed partition is again given more partition so that mixed properly. Cropping can be done. The seed hopper is made of G.I. sheet of 1.0 mm thickness. The volume of each hopper is 0.005382 cu. m. The total carrying capacity of seed hopper is 12 kg. The hoppers are placed closed to the ground level to reduce the time of travel of seed from the metering unit to the furrow to a minimum and to drop seeds at low terminal velocity [12].

2. Seed metering mechanism: The mechanism used for metering of seed is of 'Vertical roller with cells' type. The cells on the vertical roller i.e. plastic rotor are located at the periphery. The seed is picked up in each cell from the hopper and then dropped into the seed tube. Separate rotors of different cell sizes are used for different crops. Meter seeds of different sizes and shapes. Functions of seed metering device, Place the seed in the acceptable pattern of distribution in the field; Place the seed accurately and uniformly at the desired depth in the soil; and cover the seed and compact soil around it to enhance the germination emergence i) Rotor body: For every compartment of the seed box, separate metering mechanism is used out of the box. The rotor body is made of high-density molded plastic. The plastic seed rotor is placed in this body for metering and dropping the seed. The seed tubes are mounted on this discharge chute for carrying the seed to the boot of furrow opener. ii) Rotor: A plastic molded rotor is used for metering the seed. The cells are provided on the periphery of the vertical rotor. This rotor rotates in the rotor body with the help of shaft.

- **Furrow Formers:** Fixed on the mainframe with the help of U-clamp designed to channel soil into furrows of uniform depth and the distance between furrow is adjustable.
- **Seed Sowing Mechanism:** Side-mounted seed tubes connected to a hopper with a metering mechanism. Seeds drop at the furrow edges simultaneously.
- **Frame and Mounting:** Fabricated from mild steel, attached directly to the rotavator's chassis.

3. Testing Methodology:

- Conducted on a small farm plot with a maize crop.
- Parameters measured: furrow depth, seed spacing, time taken, and labour requirement.
- Performance compared with traditional 3-step method (tilling → furrowing → sowing) [13].

3. Results and Discussion

The multipurpose equipment performs three operations (tilling, seed sowing, and spraying) in a single pass. Compared to conventional single-purpose methods that require three separate passes, the multipurpose machine offers significant savings.

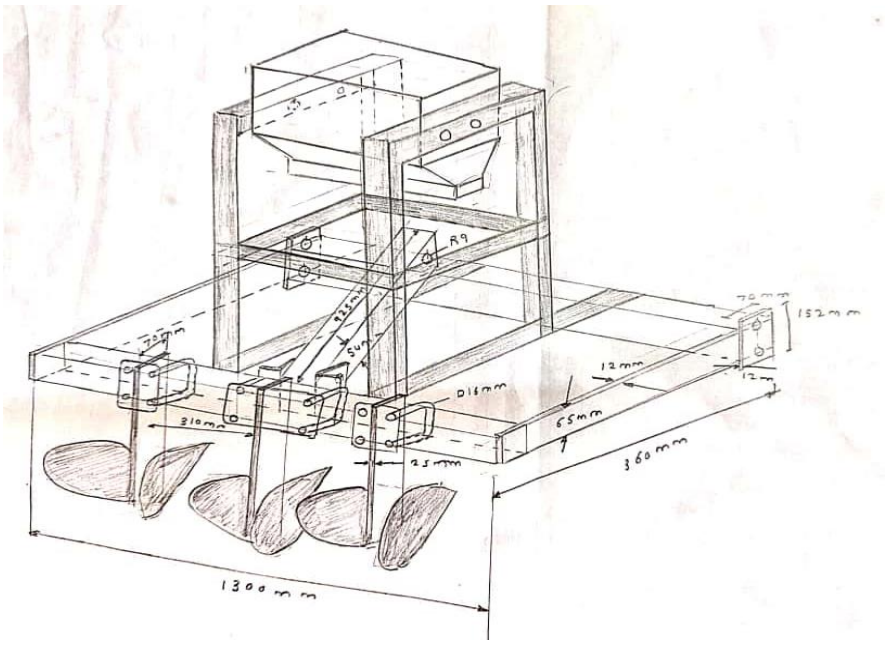

Figure 1. Conceptual sketch of multipurpose agricultural equipment with dimensions (Length = 1300 mm, Width = 860mm)

Table 1. Single vs three passes

Parameter	Conventional (3 passes)	Multipurpose (single pass)	Improvement (%)
Time taken per field (hrs)	9.0 (3 × 3.0 hr passes)	3.9 (single pass)	56.7
Fuel consumption per field (litres)	13.5 (3 × 4.5 L per pass)	3.2 (single pass)	76.3
Labor effort (person-hours)	15 (3 × 5 person-hrs)	9 (single pass, 3 persons × 3 hr)	40.0
Seed distribution uniformity	Moderate	High	Improved
Coverage efficiency (ha/hr)	0.12	0.28	133.3

Notes: Conventional values assume three separate passes for each operation. Improvement (%) = (Conventional - Multipurpose)/Conventional × 100.

4. Conclusion

The proposed project aims to address critical challenges faced by farmers during primary tillage and sowing operations by integrating multiple functions into a single tractor mounted attachment. By modifying the rotor of the tractor to perform soil tilling, furrow formation, and seed planting simultaneously, this system is expected to save time, reduce labour dependency, and lower fuel consumption. The design promotes ease of use and cost-effectiveness for small to medium-scale farmers. Although still in the conceptual phase, the project has high potential to support

mechanized farming and boost agricultural productivity through the integration of smart, efficient tools. Successfully demonstrate increased productivity, reduced labor, and lower production costs by combining multiple farming functions into one modular, affordable machine

Abbreviations

RPM – Revolutions Per Minute
HP – Horsepower
CAD – Computer-Aided Design

Nomenclature and Units

L = Length [1300 mm]
W = Width [860 mm]
D = Diameter of shaft [mm]
t = Thickness of frame [mm]

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