J. Agric. Res. Technol., 51 (2) : 260-267 (2026) https://doi.org/10.56228/JART.2026.51216

Development of Light Weight Multi Crop Basin Lister Seeder

A. J. Darekar[1], P. B. Kadam[2], S. M. Nalawade[3], A. A. Walunj[4]
Dept. of Farm Machinery and Power Engineering, Dr. ASCAE & T,
Mahatma Phule Krishi Vidyapeeth, Rahuri - 413 722 (India)
Corresponding author Email : akshaydarekar794@gmail.com
(Received : 21.01.2026 Accepted : 28.04.2026)

Abstract

A lightweight multi-crop basin lister seeder was developed and evaluated for integration with the watercourse formation unit to enable simultaneous sowing, basin formation, and irrigation channel preparation in a single-pass operation without breaking the primary function of the basin lister. The seeder comprised a ground-driven seed metering mechanism, seed hopper, power transmission unit, furrow openers, seed covering device, supporting frame, and a hinge-based mounting system, allowing for effective operation on undulating terrain. It was specifically designed for efficient and uniform sowing of crops such as onion (Allium cepa) and maize (Zea mays) with reduced labor and input costs. Laboratory assessments included seed rate calibration, seed damage analysis, and seed distribution uniformity. Field evaluations considered parameters such as seed placement depth, seed rate, effective field capacity, field efficiency, draft, wheel slip, fuel consumption, and plant population. The seeder achieved seed rates of 4.01 kg ha^{-1} for onion and 23.03 kg ha^{-1} for maize, with minimal seed damage (1.48% and 2.37%, respectively). Effective field capacity increased from 0.31 to 0.51 ha h^{-1} for onion and from 0.32 to 0.52 ha h^{-1} for maize as forward speed increased from 2 to 3 km h^{-1}. Field efficiency ranged from 80.0% to 84.3% for onion and from 80.5% to 85.7% for maize. Draft requirement varied between 529-577 kgf for onion and 517-566 kgf for maize, while wheel slip ranged from 4.21% to 6.36%. Fuel consumption ranged from 8.32 to 9.42 l ha^{-1}. For onion, operational cost savings were Rs. 2,719.57 ha^{-1} at 2 km ha^{-1} and □3,679.17 ha^{-1} at 3 km ha^{-1}. For maize, savings were Rs. 2,796.95 ha^{-1} and Rs. 3,710.60 ha^{-1} at the respective speeds.

Key words : Basin lister, seeders, watercourse formation, seeding attachment.

Agriculture is a critical sector of the Indian economy, with 59% of the country's 307 million hectares classified as agricultural land (Anonymous (a), 2025). Despite contributing 17.66% to the Gross Value Added in 2024-25, the sector recorded only 1.4% growth, largely due to erratic monsoon conditions (Anonymous (b), 2025). While policy interventions and technological advancements have improved yields in certain regions, mechanization among smallholder farmers remains limited. High costs, small and fragmented landholdings, and poor access to appropriate equipment continue to hinder mechanization, highlighting the urgent need for affordable and efficient mechanized tools tailored to small-scale farming systems. To address these challenges, combine tillage systems have been introduced as an efficient solution, enabling multiple soil operations such as ploughing, harrowing, and seedbed preparation in a single pass. These systems reduce labor requirements, fuel consumption, and soil compaction while preserving moisture and improving soil structure (Prem et al., 2016). A notable development in this context is the basin lister, which is particularly useful in dryland agriculture. It forms shallow basins that help retain rainwater around the crop root zone, enhancing germination and early growth (Kadam et al., 2020). The integration of ridgers with basin listers allows furrow opening and basin formation simultaneously, thus preparing a moisture-conserving seedbed ideal for mechanized sowing (Pawar, 2022). However, sowing remains a crucial operation that significantly influences crop establishment and yield. Traditional sowing methods such as broadcasting and manual dibbling result in uneven seed placement, high seed wastage, and poor plant stands (Sahay, 2010). Mechanized seeders like fluted roller drills and pneumatic planters offer improved accuracy, but they are often costly, heavy, and lack the flexibility required for multi-crop use (Iqbal et al., 2011; Singh et al., 2015). Earlier attempts to integrate sowing with basin formation through a basin seeder showed functional potential but had drawbacks such as excessive weight, which led to structural damage and reduced field efficiency (Naik, 2023). These limitations underline the need for a refined solution that integrates sowing with water-conserving tillage, while maintaining light weight and adaptability.

To overcome these issues, the present study focuses on the development of a lightweight, adjustable basin lister seeder. The proposed design aims to improve sowing precision and reduce operational complexity while adapting to the requirements of different crops, particularly onion (*Allium cepa*) and maize (*Zea mays*), which vary in seed size, depth, and spacing. By reducing field operations, minimizing fuel consumption, and improving seed placement and moisture retention, the developed seeder is expected to provide a sustainable and cost-effective solution for enhancing sowing efficiency and crop establishment in smallholder farming systems.

Materials and Methods

The lightweight multi-crop basin lister seeder was developed and evaluated through laboratory and field testing. The prototype comprised three primary functional units: the basin lister, the watercourse formation unit, and the lightweight multi-crop sowing unit.

Basin Lister : The basin lister, previously developed for *in-situ* moisture conservation in vertisol soils, comprises three functional components: a mainframe, lister mechanism, and stop-and-release system (Kadam et al., 2020). The mainframe, fabricated from a 75 x 40 x 5 mm C-channel, provides structural strength and serves as a mounting platform for the lister mechanism, trigger assembly, ridgers, and hitching parts. The lister mechanism consists of four scraper blades mounted perpendicularly on a 30 mm shaft, with one blade operating at a time to scrape and deposit soil for cross-bund formation. Each blade (1650 x 225 x 7 mm) is welded to mild steel bushes and arranged symmetrically to ensure balanced rotation. Blade engagement and release are controlled by a stop-and-release system composed of a spring-loaded trigger, lever-fulcrum assembly, and hand lever. Rotation is achieved through the forward motion of the tractor and reactive soil force, eliminating the need for external power transmission.

Watercourse Formation Unit : The watercourse formation unit, a ridger-type attachment, was developed to prepare longitudinal channels for efficient irrigation (Pawar, 2022). It is mounted on a telescopic frame adjustable from 600 to 900 mm to match different crop row spacings. Each ridger consists of a shank (40 x 25 mm), share (200 x 6 mm), curved fin, and landside, all fabricated from mild steel. During operation, the ridgers form channels parallel to the basins with depths of 200-220 mm and widths of 620-660 mm, depending on forward speed. This arrangement ensures uniform water conveyance and complements the basin and cross-bund formation achieved by the basin lister seeder.

Lightweight multi-crop sowing attachment : A lightweight multi-crop sowing attachment was developed to integrate sowing with basin and watercourse formation.

Seed box : The seed box, a critical component of the lightweight multi-crop sowing attachment, was provided in two capacities: a small hopper for small seeds and an extension hopper for large seeds. The extension unit was mounted above the smaller box to allow rapid transition between seed types.

Small seed box : The small seed box was developed to ensure uniform seed delivery and smooth flow for small seeds. It consisted of a rectangular upper section (150 x 75 x 50 mm) and a trapezoidal lower section tapering to 50 x 25 mm with a height of 60 mm. The box was fabricated from 2 mm mild steel, assembled by arc welding, and finished with polished inner surfaces to reduce friction and seed damage. Positioned directly above the metering drum, it facilitated accurate seed discharge.

The required capacity was estimated using the relation (Sharma, 2010):

Volume of seed box is given by :

Vb = 1.1 x V

= 1.1 x Weight of seed / Bulk density

where, V_b = volume of seed box, cm^3 and V_b = volume of seed, cm^3

The designed volume of the seed box was 1012.5×10^3 mm^3, which exceeded the theoretical requirement of onion seeds. The wall angle was maintained at 45°, greater than the angle of repose of onion (27°), maize (38°), and other selected seeds (22-30°), ensuring smooth gravitational flow and preventing clogging (Borkar et al., 2018).

Extension seed box : The small seed box was suitable for small seeds with lower bulk densities, whereas large seeds such as chickpea, soybean, and maize, with bulk densities of 0.709, 0.745, and 0.750 g cm^{-3}, respectively (Anonymous, 2025), required higher seed holding capacity. To meet this requirement, an extension seed box was designed and mounted above the primary hopper. The required capacity was estimated using the relation (Sharma, 2010):

Volume of seed box is given by:

V_b = 1.1 x V

= 1.1 x Weight of seed / Bulk density

The extension box was fabricated from 2 mm mild steel and comprised a rectangular section (150 x 150 x 50 mm) and a trapezoidal section tapering to 150 x 75 mm with a height of 60 mm. The designed capacity of 2137.5×10^3 mm^3 exceeded the theoretical requirement, making it suitable for bold seeds such as chickpea, soybean, and maize, and ensuring uninterrupted operation during sowing.

Seed box cover : The seed box cover, fabricated from Polyphthalamide (PPA) for strength and durability, was made transparent for seed-level monitoring. It ensured easy handling, cleaning, and a secure fit to prevent spillage. Two sizes were provided: 155 x 80 x 10 mm for the small box and 155 x 155 x 10 mm for the extension box.

Seed metering mechanism : The mechanism comprised a rotor, casing, brush, detaching blade, and bush, ensuring uniform seed delivery, preventing clogging, and enabling accurate placement for different seed types.

Seed rotor casing : The seed rotor casing, made of mild steel, housed the metering rotor and guided seed discharge. It was a cylindrical body (100 mm ID, 85 mm length, 4 mm thickness) with a curved slot for flow regulation, a 10 mm detaching blade opening, and bushings for shaft support. End plates (100 mm x 4 mm) with a 25 mm central hole allowed shaft movement, with rear provision for the covering device and front adjustment using three 15 mm bolts.

Seed rotor : The rotor was developed for multi-crop adaptability, ensuring uniform seed delivery and mechanical reliability. Round-shaped seed cells were used to suit the near-spherical geometry of onion and maize seeds, minimizing bridging and ensuring consistent discharge (Verma et al., 2021). Based on seed dimensions, cell diameters of 3.0 mm for onion and 10.0 mm for maize were selected, with 16 cells provided for onion and 5 cells for maize to maintain proper spacing. The rotor, fabricated from nylon (64 mm diameter x 40 mm length), incorporated longitudinal flutes for volumetric metering. A 10 mm deep, 1 mm wide groove accommodated a rotating blade to prevent clogging. Ground-wheel-driven operation ensured synchronization between forward motion and seed discharge, resulting in uniform seed placement, accurate spacing, and minimal damage.

Brush mechanism : The brush mechanism, positioned near the small seed box, regulated seed flow and prevented clogging. It comprised a nylon bar (75 x 16 x 8 mm) with a central cut (45 mm deep, 2 mm thick) for secure fitting. Fine brush teeth swept the rotor surface, while a spring-loaded system with a 4 mm nut and 30 mm spring lock allowed pressure adjustment, improving metering precision across crops (Ahmad et al., 2007).

Seed detaching blade : The seed detaching blade, fabricated from 0.5 mm sheet steel, was mounted on the metering frame with its edge extending into a groove in the rotor. Constant contact with the rotor surface dislodged lodged seeds, ensuring uniform flow and minimizing blockage. A similar principle was reported by Hu et al. (2022) using dual scrapers.

Power transmission unit : The power transmission unit transferred motion from the ground wheel to the seed metering system, ensuring synchronized seed discharge. It consisted of a ground wheel and a main shaft, enabling efficient, slip-free operation.

Ground wheel : The ground wheel was fabricated from mild steel with a 380 mm diameter, 140 mm width, and 4 mm rim thickness, optimized for stability without excessive penetration. For traction, 20 mm x 3 mm ribs were welded around the periphery. A 100 mm square hub (25 x 25 mm), fixed with two 14 mm bolts on each side, and secured the wheel. Ground wheels on both shaft ends transmitted motion to the metering mechanism.

Main shaft : The main shaft, fabricated from a 1524 mm x 25 mm x 25 mm mild steel square bar, transmitted rotational motion from the ground wheel to the seed metering system. This design synchronized forward travel with seed dispensing, ensuring uniform placement. A similar ground wheel-driven mechanism was reported by Adekanye and Akande (2015) in manually operated planters.

Furrow opener : A hoe-type furrow opener was employed to create narrow, uniform furrows for precise seed placement. Suitable for light to medium soils, it ensured required penetration depth with minimal soil disturbance, promoting effective seed-soil contact. The opener was fabricated from mild steel with a 3 mm thick blade, designed to withstand field stresses without deformation. Based on strength analysis, a 65 mm x 3.5 mm mild steel flat was selected to ensure structural integrity. Its adjustable design allowed depth variation as per sowing requirements, while the sharp, angled edge with strong welds enhanced durability and consistency in seed placement.

Seed covering device : The seed covering device, made of mild steel, was mounted at the rear of the sowing unit with a spring mechanism. It provided uniform soil cover over seeds, maintaining seed-soil contact without displacement or excessive compaction, thus ensuring effective germination (Adekanye and Akande, 2015).

Supporting frame : The supporting frame provided structural stability and alignment for the sowing attachment. It comprised a seed box support mechanism and a square pipe framework.

Seed box support mechanism : The seed box was supported on a 200 mm long, 35 x 35 mm mild steel square pipe. One end was welded to a 3 mm flat plate with two 8 mm bolt holes for mounting on the rotor chassis, while a 10 mm top hole connected to the rotor housing with a star nut and bolt. Square cuts (22 x 22 mm) on both sides allowed hinge-type attachment to the basin lister for alignment and ease of assembly.

Square pipe framework : The sowing units were mounted on a 1524 mm x 20 x 20 mm mild steel square bar, providing high strength and rigidity. Its adjustable design allowed modification of sowing unit positions as per crop spacing. The square profile ensured stable mounting, secured with nuts and bolts for easy assembly and adjustment.

Sowing Attachment Fitment to Basin Lister : The lightweight sowing attachment, integrated with the basin lister and watercourse unit, enabled simultaneous basin formation, watercourse preparation, and precise sowing in a single pass.

Hinge-type attachment : The hinge-type attachment allowed smooth pivoting of the sowing device over cross-bunds, ridges, and uneven terrain, ensuring uninterrupted operation and preventing mechanical damage (Naik, 2023). It consisted of a 25 mm diameter, 50 mm long pipe welded to a 200 x 50 x 10 mm flat plate, connected to a 63.5 mm angle section with four bolt holes for adjustment. Additional holes on the flat plate secured the shaft while permitting movement, combining strength with flexibility to adapt to field conditions.

Fig. 1. Light weight multi crop basin lister seeder.

Performance evaluation of light weight multi crop basin lister seeder

Laboratory tests : Laboratory tests were conducted to evaluate the performance of the sowing attachment under controlled conditions. The parameters studied included seed rate calibration, seed damage, germination percentage, and seed distribution uniformity. Calibration was performed to verify that the seed delivery matched recommended rates. Seed damage was assessed under full and half hopper conditions, while germination was tested using the paper towel method. Distribution uniformity was determined by analyzing seed-to-seed spacing on a grease-coated board.

Field tests : Field evaluation of the basin lister seeder was carried out on onion and maize crops to assess its operational performance. The parameters observed included soil properties, depth of seed placement, seed rate, row spacing, plant population, and emergence percentage. Functional performance was evaluated in terms of draft requirement (measured with a digital dynamometer), wheel slip, fuel consumption, theoretical and effective field capacity, and field efficiency. In addition, the geometry of basins, cross-bunds, side ridges, and watercourses formed by the machine was

Table 1. Comparative field performance, operational cost, and economic benefit of the developed lightweight multi-crop basin lister seeder for onion and maize

Parameter	Onion (2 km.h^{-1})	Onion (3 km.h^{-1})	Maize (2 km.h^{-1})	Maize (3 km.h^{-1})
Effective Field Capacity (ha.h^{-1})	0.31	0.51	0.32	0.52
Field Efficiency (%)	80.00	84.33	80.50	85.70
Draft Requirement (kgf)	529	577	517	566
Wheel Slip (%)	6.36	4.21	6.21	4.48
Fuel Consumption (l. ha^{-1})	9.42	8.32	9.39	8.64
Plant Population (plants. ha^{-1})	730000	730000	86000	86000
Operating Cost (Rs. ha^{-1})	2,476.38	1,516.78	2,399.00	1,485.35
Traditional Cost (Rs. ha^{-1})	5,195.95	5,195.95	5,195.95	5,195.95
Net Cost Saving (Rs. ha^{-1})	2,719.57	3,679.17	2,796.95	3,710.60

Table 2. Basin geometry formed by the light weight multi crop basin lister seeder

Parameter	Onion (2 km.h^{-1})	Onion (3 km.h^{-1})	Maize (2 km.h^{-1})	Maize (3 km.h^{-1})
Basin Length (mm)	6080	6170	6090	6150
Basin Width (mm)	1820	1840	1830	1840
Crossbund Height (mm)	176.5	197.4	191.7	222
Crossbund Width (mm)	794.3	810	776.8	809
Side Ridge Height (mm)	120.7	105.2	133.8	131
Side Ridge Width (mm)	286	293	280.2	305
Watercourse Depth (mm)	221.7	205.2	211.2	205
Watercourse Width (mm)	619.8	639.5	639.3	660

recorded to determine its suitability for moisture conservation and irrigation efficiency.

Economic analysis : The cost of operation was estimated by accounting for both fixed and variable costs, including depreciation, fuel consumption, labor charges, and repair and maintenance. The economic advantage of the developed basin lister seeder was assessed by comparing its operational cost with conventional sowing practices for onion and maize.

Results and Discussion

The light weight multi crop basin lister seeder was evaluated for onion and maize under field conditions to determine its functional suitability and operational effectiveness.

Fig. 2. Maize crop field condition after operation with the newly developed prototype.

Fig. 3. Onion crop field condition after operation with the newly developed prototype.

Fig. 4. Maize crop field.

Fig. 5. Onion crop field.

Conclusion

The light weight multi crop basin lister seeder demonstrated effective performance for onion and maize cultivation. It achieved precise seed placement, appropriate seed rate, and recommended crop geometry, thereby ensuring uniform crop establishment. Field evaluation indicated higher efficiency, reduced fuel consumption, and lower operational cost compared to conventional methods. Additionally, simultaneous basin, ridge, and watercourse formation enhanced soil moisture conservation. Overall, the seeder provides a cost-effective and sustainable mechanization option for smallholder farmers.

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