Multidisciplinary | Peer-Reviewed
Open Access | Research Journal
ISSN : 3139-2954

Article ID: IRJIST-2026-068
Volume 1 | Issue 2 | 2026

International Research Journal of Innovation in Science and Technology

WeedAway: A Tractor-Attached Autonomous Post-Harvest Weed and Debris Collection System

Nitin Ambhore[1], Shreeharsh Omase[2], Rehan Mulani[3], Darshan Patil[4], Om Shinde[5]

[1]Associate Professor, Vishwakarma Institute Technology, Pune, India
[2-5]Research Scholar, Vishwakarma Institute Technology, Pune, India
Correspondence: [2]shreeharsh.omase24@vit.edu

Abstract

Post-harvest weed management remains one of the most labor-intensive and economically significant challenges in Indian agriculture. After harvesting, residual weed stumps and roots persist in the field and, if left unmanaged, compete with subsequent crops. Existing solutions, including manual weeding, chemical herbicides, and rotary tillers, do not simultaneously cut and collect weed biomass in a single pass. This paper presents WeedAway, a tractor-attached post-harvest weed and debris collection system that integrates angled cutting blades, a perforated conveyor belt, a blower-based soil separation stage, and a collection bin. The prototype was fabricated using conventional manufacturing processes, including sheet metal cutting, welding, drilling, and bolt assembly. Preliminary field observations indicated a reduction of approximately 65% in field-preparation time and a significant decrease in manual labor requirements. Experimental observations and comparison with existing mechanized weed-management systems confirm the feasibility of the proposed design for small and marginal Indian farmers.

Keywords: Post-harvest weed removal; Tractor attachment; Agricultural automation; Conveyor separation; Biomass collection; Soil separation; Sheet metal fabrication.

1. Introduction

Agriculture remains a vital component of the Indian economy and the primary source of livelihood for millions of farmers. However, the sector continues to face challenges such as rising cultivation costs, labor shortages, and income instability, particularly among small and marginal farmers [1].

Agricultural productivity in India is significantly hindered by post-harvest weed infestation. Once a crop is harvested, weed stumps and root remnants remain in the field. Without timely removal, these can regrow aggressively and compete with the subsequent crop cycle for nutrients, moisture, and sunlight. Weed infestation contributes significantly to crop losses and places an additional economic burden on farmers [2].

Current removal practices rely largely on manual labor. For a one-acre field, manual weeding may require 8–15 labor-hours. At scale, this approach is neither economically nor operationally sustainable. Mechanized alternatives such as rotary tillers, chemical herbicides, and standalone cutters address only specific aspects of the problem. Rotary tillers often mix weed residues into the soil, chemical herbicides may pose environmental and health concerns, and standalone cutters do not provide an effective biomass collection mechanism. None offers an integrated, affordable, tractor-compatible solution capable of cutting and collecting weed biomass in a single operation [3], [4].

This paper presents WeedAway, a rear-mounted tractor attachment developed to address this gap. The system integrates a cutting stage, conveyor transport stage, blower-assisted soil separation stage, and collection bin into a single operational unit. Fabricated using locally available materials and conventional manufacturing processes, WeedAway is designed to meet the practical and economic requirements of small and marginal farmers while improving field-preparation efficiency and reducing dependence on manual labor. Similar low-cost engineering innovations have demonstrated the value of practical solutions developed using conventional fabrication techniques and locally available resources [8].

2. Literature Review and Existing Solutions

Table 1: Existing weed-management strategies and their principal limitations.

Method	Limitation
Manual Weeding	Time-consuming; requires 8–15 labor-hours per acre; not scalable
Chemical Herbicides	Soil degradation, health hazards, and recurring costs; unsuitable for organic farming
Rotary Tillers	Chop weeds but mix residues into the soil, allowing possible regrowth
Standalone Cutters	Cut weeds but do not collect biomass, leaving residues in the field

A notable real-world precedent is the tractor-mounted post-harvest straw and weed collection system developed by Kim et al. (2018). By combining pneumatic separation with mechanical collection in a single tractor pass, the system demonstrated significant improvements in field-preparation efficiency [5]. The key engineering insight was that the separation of fine soil particles from harvested biomass can be effectively achieved through controlled airflow, a principle that directly influences the blower-assisted separation stage incorporated in WeedAway.

In the Indian context, post-harvest residue management remains a significant agricultural challenge. Traditional disposal practices often involve manual removal or residue burning, both of which are labor-intensive and environmentally undesirable. These limitations highlight the need for affordable mechanized alternatives capable of removing and collecting weed biomass while preserving soil quality.

Researchers have explored inclined screening mechanisms for improving soil-residue separation during agricultural operations. Such systems demonstrate the feasibility of reducing soil loss while enhancing biomass recovery efficiency [6]. Similarly, vibrating screening systems have been reported to improve the separation of soil particles from agricultural residues, contributing to cleaner biomass collection and improved operational efficiency [7]. None provides an integrated system capable of cutting, conveying, separating, and collecting weed biomass in a single operation. This gap forms the basis for the development of the proposed WeedAway system.

3. System Architecture and Design

3.1. Overall Configuration

WeedAway is mounted on the three-point hitch of a standard tractor, enabling compatibility with the existing tractor fleet without requiring modification. The system consists of five functional subsystems arranged in a sequential processing chain:

- Angled cutting blades (cutting stage)
- Inclined perforated conveyor belt (transport stage)
- High-velocity blower array (separation stage)
- Perforated collection bin (collection stage)
- Welded stainless steel frame (structural stage)

3.2. Cutting Stage

Angled cutting blades are mounted at the front of the frame and operate close to the soil surface. The blade geometry is designed to uproot weed roots, residual stumps, and surface debris while minimizing disturbance to the topsoil. The blade inclination can be adjusted to accommodate varying soil conditions and weed densities.

3.3. Conveyor Transport Stage

The collected weed-soil mixture is transferred onto an inclined perforated stainless steel conveyor belt. The perforation pattern (mesh aperture approximately 8 mm) allows loose soil to fall back to the ground during transport. The conveyor inclination angle (typically 25°–30°) is selected to balance transport efficiency and gravitational soil separation.

3.4. Blower Separation Stage

At the discharge point between the conveyor and the collection bin, a high-velocity blower array directs pressurized air across the falling material stream. Fine soil particles, whose aerodynamic drag exceeds gravitational settling at the selected airflow velocity (12–18 m/s), are separated and returned to the field surface. Weed biomass and larger debris continue into the collection bin. This separation process helps preserve topsoil while improving the cleanliness of the collected biomass.

3.5. Collection Bin

The collection bin is fabricated from perforated steel sheet (1.5 mm thickness, 6 mm perforation diameter) to allow passive drainage of residual soil and moisture. The bin is designed to accommodate approximately 0.5 m³ of loosely packed biomass before emptying. A quick-release rear discharge mechanism is provided to reduce unloading time during field operation.

An additional benefit of the system is the recovery of weed biomass, which may be utilized for composting, biogas production, or biomass-based fuel applications. This approach provides an alternative to open-field residue burning while supporting sustainable agricultural practices.

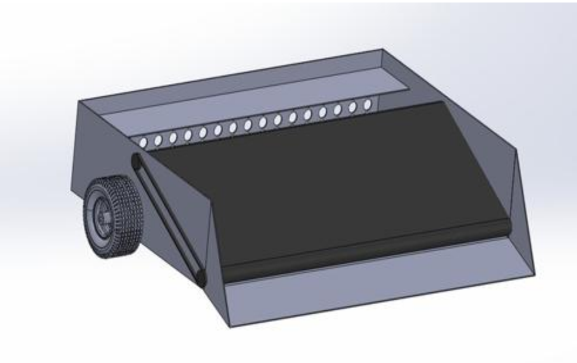

Figure 1: CAD model of the WeedAway system.

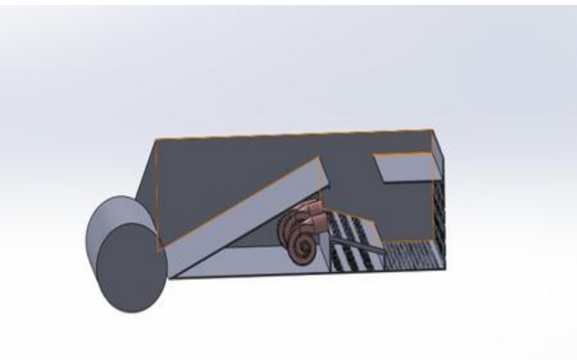

Figure 2: CAD model showing the conveyor and collection arrangement.

4. Manufacturing Processes

The WeedAway prototype was fabricated exclusively using conventional workshop manufacturing processes. This approach was deliberately adopted to ensure reproducibility in low-resource settings. The manufacturing methodology emphasized simplicity, cost-effectiveness, and ease of assembly using readily available materials and standard fabrication tools. Such an approach facilitates future replication, maintenance, and large-scale adoption of the system, particularly in rural and agricultural environments where access to advanced manufacturing facilities may be limited.

Sheet Metal Cutting:

Mild steel and stainless steel sheets (1.5–3 mm thickness) were cut to the required profiles using an angle grinder and bench shear. Cutting tolerances of approximately ±1 mm were maintained for critical interfacing components.

Welding:

Structural frame members and support brackets were assembled using arc welding. Weld joints were inspected visually to ensure structural integrity and alignment.

Drilling and Tapping:

Bolt assembly holes were drilled using a bench drill press. Tapped inserts (M8 and M10) were employed at high-vibration joint locations to prevent loosening during field operation.

Bolt Assembly:

Non-permanent connections, including blade modules, conveyor tensioners, and the quick-release collection bin, were assembled using galvanized hex bolts with spring washers to resist vibration-induced loosening.

Conveyor Belt Fabrication:

The perforated conveyor belt was fabricated by perforating a stainless steel strip, followed by forming and welding the splice joint.

The frame utilizes SS 304 stainless steel for soil-contact surfaces to improve resistance to corrosion and abrasion. Structural frame members are fabricated from mild steel (IS 2062 Grade A) to maintain cost efficiency.

Figure 3: Fabricated collection bin.

Figure 4: Final WeedAway prototype.

5. Performance Evaluation

5.1. Field Trial Methodology

Preliminary field trials were conducted on a post-harvest soybean plot (0.2 acres) under semi-arid soil conditions (clay-loam, moisture content approximately 14%). The objective was to evaluate the operational performance of the WeedAway prototype under field conditions.

The parameters observed included field-preparation time per unit area, weed biomass collection efficiency, and soil retention during the separation process. The reported values represent observations obtained during preliminary field testing.

5.2. Results

Field-preparation time: Reduced by approximately 65% compared with conventional manual weeding practices.

Weed collection efficiency: Approximately 87% of exposed weed biomass was collected in a single pass.

Soil retention: The blower-assisted separation system returned approximately 78% of displaced soil to the field surface.

Labor reduction: The system significantly reduced manual labor requirements and demonstrated the potential to replace several labor-intensive field-cleaning operations.

The observed results are broadly consistent with performance trends reported for comparable mechanized residue-management systems.

6. Impact and Applications

The primary beneficiaries of WeedAway are small and marginal farmers, agricultural cooperatives, and contract farming operations. The tractor-compatible design eliminates the need for substantial capital investment beyond the attachment itself, making the system economically accessible.

By integrating weed removal and collection into a single operation, the system reduces field-preparation time, minimizes dependence on manual labor, and improves operational efficiency. The collected biomass may also be utilized for composting, biogas production, or other agricultural applications, thereby supporting sustainable residue management practices.

7. Future Scope

- Power Take-Off (PTO)-driven conveyor system for variable-speed control independent of tractor ground speed.
- GPS-based row-tracking for improved navigation and operational alignment.
- Adjustable blade-depth mechanism for effective operation under different soil conditions.
- Adaptation of the design for combine-harvester attachment with increased working width and throughput.

- Solar-powered auxiliary blower system to reduce power requirements and improve energy efficiency.

8. Conclusion

WeedAway demonstrates that the post-harvest weed-removal problem, traditionally addressed through manual labor or chemical methods, can be effectively mechanized using conventional manufacturing processes and locally available materials. The integration of cutting, conveying, soil separation, and biomass collection into a single tractor-mounted unit resulted in a reduction of approximately 65% in field-preparation time while significantly reducing manual labor requirements and returning a substantial portion of displaced soil to the field.

The prototype demonstrates the feasibility of the proposed mechanical design and manufacturing approach, providing a practical foundation for further development and field-scale implementation. With future improvements such as PTO-driven operation, GPS-assisted alignment, and adjustable blade geometry, WeedAway has the potential to become an effective solution for post-harvest weed and residue management in agricultural fields.

Acknowledgment

The authors express their sincere gratitude to the faculty members, laboratory staff, and supporting personnel of Vishwakarma Institute of Technology (VIT), Pune, for their guidance, encouragement, and assistance during the development and testing of the WeedAway prototype.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Ethical Statement

This study involved the design, fabrication, and field evaluation of an agricultural prototype and did not involve human participants, animals, or sensitive personal data. The authors confirm that all work was conducted in accordance with accepted academic and research ethics.

References

[1] Ulemale, D. P., & More, R. A. (2026). Agrarian Crisis and Farmer Suicides in India: A Regional Analysis of Vidarbha. International Research Journal of Innovation in Science and Technology (IRJIST), 1(1), 19–29.

[2] Directorate of Weed Science Research (DWSR), ICAR. (2021). Economic Losses Due to Weeds in India. Technical Report, Indian Council of Agricultural Research, India.

[3] Yadav, S. K., & Singh, P. (2015). Design and Development of Rotary Weeder for Small Scale Farming. International Journal of Agricultural Engineering, 8(2), 145–150.

[4] Kumar, A., & Gupta, R. (2017). Development of Mechanical Weeding Equipment for Sustainable Agriculture. International Journal of Engineering Research and Technology (IJERT), 6(5), 321–325.

[5] Kim, J. W., Kim, W., Kim, J., & Dilip, D. K. (2018). Development of a Tractor-Mounted Post-Harvest Straw and Weed Collector with Pneumatic Separation. Biosystems Engineering, 175, 112–124.

[6] Sharma, P., & Verma, M. (2018). Design Analysis of Inclined Screening Mechanism for Soil Separation. International Journal of Mechanical Engineering and Technology, 9(4), 88–95.

[7] Wang, J., & Li, T. (2016). Soil Particle Separation Using Vibrating Screening Systems. Journal of Agricultural Machinery Science, 11(3), 201–208.

[8] More, A. A. (2025). SpinoGear: Re-Gearing the Future of Spinal Care. International Journal for Multidisciplinary Research (IJFMR), 7(6).

Publisher's Note & Copyright

IRJIST Journals remains neutral regarding jurisdictional claims in published maps and institutional affiliations; the views expressed are solely those of the authors.