

COMPARATIVE STUDY BETWEEN TYPES OF WEEDERS IN ROW

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ABSTRACT

The paper compares the performance of mechanical, optical, and sensor-based weeders, highlighting their efficiency in weed control and soil protection. The analysis shows the superiority of the intelligent sensor-based weeder, which provides high precision and reduced soil compaction. It is proposed to adopt this system for modern precision agriculture.

Keywords: weeder, weed control, precision agriculture, sensors.

1. INTRODUCTION

1.1 MODERN AGRICULTURAL CONTEXT

In the context of modern agriculture, the increasing demand for larger and healthier productions [3][1], together with the pressure to reduce costs and protect the environment, requires the optimization of each agricultural process. Weed control is an essential factor in ensuring crop yield, and classic weeding methods are becoming less and less effective in the face of current requirements. Although digitalization and automation in agriculture are gaining ground, the immediate need remains to increase efficiency and reduce the impact on the soil.

1.2 PURPOSE OF THE WORK

The paper aims to comparatively analyze the different types of row cultivators [3][5], highlighting the superior performance of sensor-assisted cultivators in terms of weed control efficiency and soil impact. The focus will be on demonstrating that modern cultivator technologies, especially sensor-assisted ones, represent the optimal solution for precision agriculture.

Analysis methodology

To support the conclusions of the paper, a comparative analysis will be carried out between the main types of row harrows. This analysis will include:

Classification of weed killers: detailed presentation of each type (classic, rotary, and sensor).

Defining the comparison criteria: efficiency in weed control, impact on soil, productivity, costs, and adaptability.

Performance comparison: detailed analysis of each type of mower according to established criteria.

Conclusions: summary of advantages and disadvantages, highlighting the superiority of sensor-equipped lawn mowers.

2. CLASSIFICATION OF ROW CROP CULTIVATORS

2.1 CLASSIC CULTIVATORS WITH FIXED TINES

Classic fixed-tine cultivators [2] are the first generation of equipment used to control weeds between rows. They are equipped with tines rigidly mounted on a frame, pulled by the tractor. The forward movement of the tractor causes the tines to penetrate the soil and cut the weeds at the root FIG 1, FIG 2.

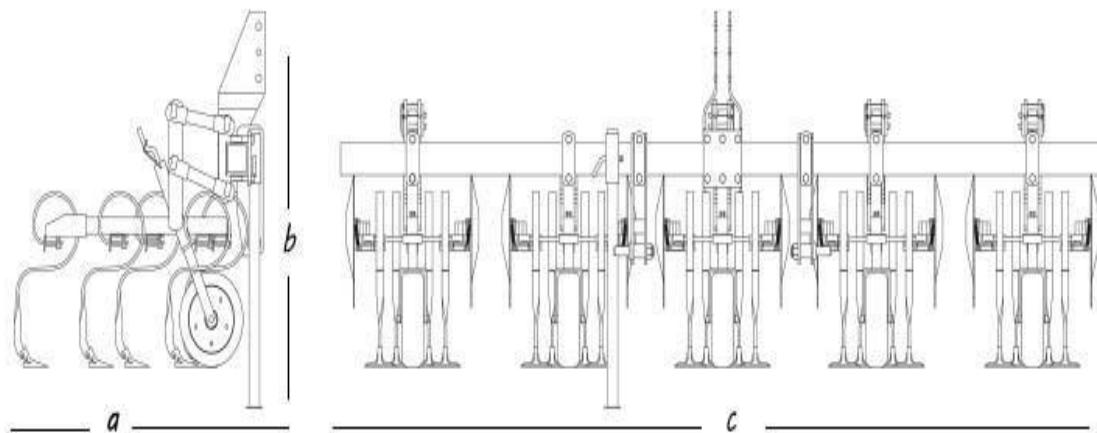


Figure 1. Classic cultivators with fixed tines

Technical features:

- Working depth: 5-10 cm.
- Working speed: 6-10 km/h.
- Required power: 30-60 CP.

Disadvantages: low efficiency in hard or stony soils, risk of damage to plants in the row.

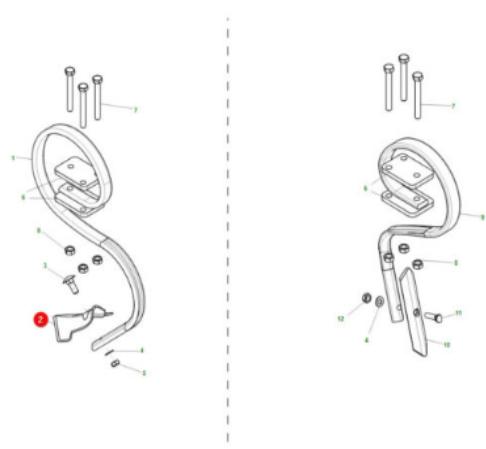


Figure 2 . Models fixed tines

- Working width: between 1,5 and 3 m.
- Working speed: 3-5 km/h.
- Advantages and disadvantages:
- Advantages: simple construction, low cost, easy maintenance.
- Advantages and disadvantages:
- Advantages: higher speed, suitable for varied terrain.
- Disadvantages: tendency to bring moist soil to the surface, possible damage to crop roots

2.2 ROTARY TILLERS

Description and operating principle

Rotary cultivators [2] have introduced the rotary motion of the active parts. They are equipped with metal discs or stars that spin, which penetrate the soil and pull out weeds. The rotary motion helps to avoid blockage with plant debris.

2.3 FINGER WEEDE

Finger weeders are specialized tools used in mechanical weed control, designed to selectively uproot small weeds while protecting nearby crops. This paper explores their working principles, technical parameters, and practical effectiveness under various field conditions.

As agricultural systems shift toward sustainability and reduced chemical input, mechanical weeders have gained renewed interest, especially in organic and low-input farming. Finger weeders have become increasingly popular due to their ability to remove weeds directly within crop rows—an area traditionally challenging for conventional cultivation tools.

Finger weeders feature rotating discs equipped with flexible fingers made from rubber or metal. These fingers penetrate the upper 2-4 cm of soil, loosening and uprooting emerging weeds while leaving the crop undisturbed. The tool is typically operated at speeds between 4-8 km/h and can cover working widths up to 3 meters. The flexibility of the fingers is key to their ability to work around fragile plants without causing mechanical injury.

Field applications show that finger weeders are highly effective against small, shallow-rooted weeds, particularly in soft or moderately compacted soils. They are especially useful in vegetable production or early crop stages where plant sensitivity is a concern. However, their performance is notably reduced in hard, dry, or

stony soils, where the fingers cannot penetrate effectively. Additionally, setup requires careful alignment with crop rows for optimal results.



Figure 2. Finger weeder

2.4 BRUSH CUTTER

Brush cultivators are innovative mechanical tools designed for selective weed removal, especially in sensitive crop systems. They operate using flexible bristles—typically made of durable materials such as fiberglass or nylon—that rotate either horizontally or vertically, depending on the machine's configuration. These rotating brushes are designed to gently strike and dislodge weeds from the soil surface.

The key advantage of brush cultivators lies in their ability to mechanically differentiate between weeds and crops based on physical properties such as plant rigidity and anchorage. While the flexible bristles are aggressive enough to uproot or damage young and shallow-rooted weeds, they are simultaneously soft and adaptive enough to pass around or over the sturdier cultivated plants without causing injury. This makes them especially effective for in-row weeding, where precision is critical.

As illustrated in FIG.5, brush cultivators allow for efficient mechanical weed control in closely spaced crops, reducing the need for herbicides and promoting more sustainable agricultural practices. Their gentle yet effective action also helps preserve soil structure and organic matter, making them a valuable tool in organic and conservation farming systems.

Technical features:

- Working depth: 1-3 cm.
- Working speed: 5-7 km/h.
- Brush speed: 200-400 rpm.

Advantages and disadvantages:

Advantages: protects the crop well, ideal for sandy or light soils.

Disadvantages: reduced efficiency in clay soils, more frequent maintenance.



Figure 3. Brush cutter

2.5 IN-ROW WEEDEER

Sensor-assisted weeders represent the forefront of modern agricultural technology, offering high precision and efficiency in weed control. These machines are equipped with advanced video cameras or infrared sensors that continuously scan the soil surface to distinguish between crops and weeds in real time. By using image recognition algorithms or spectral analysis, the system identifies the position and characteristics of the plants.

Once the crop rows and weeds are detected, the weeder's active working elements—such as blades, mechanical fingers, or rotating discs—are automatically controlled to avoid damaging the cultivated plants. The weeding components are actuated only in the spaces between the crops, ensuring that only the unwanted vegetation is removed.

This selective intervention significantly reduces the need for chemical herbicides and promotes sustainable agriculture. Furthermore, the system maintains high accuracy even in high-density crop configurations, where manual or conventional mechanical weeding would be difficult or inefficient. As shown in FIG.6, the integration of sensors and intelligent control mechanisms allows the machine to adapt dynamically to varying plant sizes and field conditions, ensuring optimal performance throughout the cultivation process.

Technical features:

- Working depth: automatically adjustable.
- Working speed: 8-12 km/h.
- Required power: 50-100 CP.

Advantages and disadvantages:

Advantages: maximum precision, crop protection, and reduction of soil compaction.

Disadvantages: high purchase cost, requires specialized technical maintenance.

Suggested diagram:

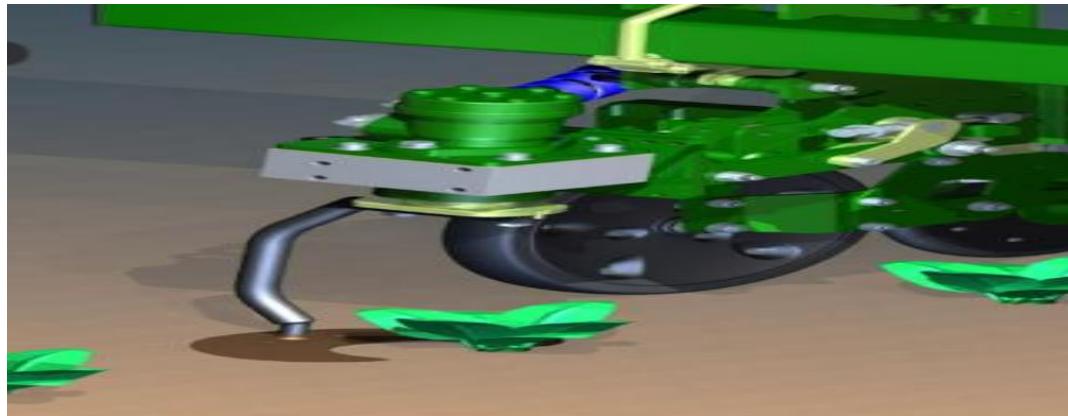


Figure 4. In-row weeder

3. COMPARATIVE STUDY BETWEEN TYPES OF TILLERS

Tabel 1

Criterion	Fixed hoe cultivator	Rotary tillers	Finger weeder	Brush cutter	In-row weeder
Weed removal efficiency	60-70%	70-80%	75-85%	80-85%	90-95%
Impact on soil	Moderate compaction	Medium stirring	Minimized	Minimized	Very low
Productivity(ha/h)	0,8-1,5	1,5-2,5	1-2	1-1,5	2,5-4
Operating costs	Low	Medium	Medium	Haid	Haid
Durability	Very good	Good	Good	Medium	Good
Technological complexity	Simple	Moderated	Moderated	Complex	Advanced
Adaptability	Limited	Good	Good	Limited	Excellent

3.1 ANALYSIS OF RESULTS

It is clear [3][4] from the table that the sensor weeder (In-row weeder) dominates most of the essential criteria TAB 1:

Efficiency — provides the highest weed removal rate.

Minimal impact on the soil — protects the soil structure, avoiding compaction.

High productivity — covers large areas in a shorter time.

Excellent adaptability — can work on various crops and soil types.

Despite their numerous advantages, sensor-guided weeders present a few notable limitations, the most significant being their high acquisition cost and the inherent technological complexity of the systems. These machines are equipped with advanced components—such as cameras, sensors, control units, and precision actuators—which not only

increase the upfront investment but also contribute to higher operational and maintenance demands over time.

Operating such equipment effectively requires specialized training. Farm personnel must be familiar with software interfaces, sensor calibration, diagnostics, and routine servicing procedures to ensure the machine functions at optimal performance. In some cases, technical support from the manufacturer or specialized service providers may be necessary, adding to the long-term cost of ownership.

This dependency on skilled labor and technological infrastructure can be a barrier for smaller farms or those in regions with limited access to agricultural innovation. As a result, while the sensor-guided weeder is a highly effective tool for modern precision agriculture, its widespread adoption may be limited unless accompanied by initiatives that support farmer training, technical assistance, and potential

financial incentives or subsidies.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

Comparative analysis of the five main types of cultivators revealed significant differences in terms of efficiency, soil impact, productivity, costs, and adaptability.

Summary of conclusions:

Classic cultivators with fixed tines [1][3] are reliable and inexpensive, but offer limited efficiency and moderate soil compaction.

Rotary tillers are faster and more versatile, but they risk overturning the soil in difficult conditions.

Finger weeder [4] protect the crop well and are effective on young weeds, but perform poorly on hard soils.

Brush cutters offer high precision, but have high costs and complicated maintenance.

Sensor-powered tillers have demonstrated superior efficiency, minimal impact on the soil, and high productivity, being the most suitable for modern agriculture, although they require a higher initial investment.

Overall, the sensor weeder (in-row weeder) stands out as the optimal solution for farms that aim for maximum productivity and soil protection, justifying the costs through long-term performance.

4.2 RECOMMENDATION

Based on the results of the analyses, it is recommended:

Small and traditional farms — using fixed or rotary hoe cultivators to reduce initial costs.

Medium and large farms — adopting finger or brush cultivators for crop protection and greater efficiency.

Modern and precision farms — implementing sensor-equipped tillers to maximize yield and reduce manual intervention.

In all cases, it is essential to correctly calibrate the machinery according to the soil type and specific crop to maintain a balance between efficiency and environmental protection.

4.3 FUTURE PERSPECTIVES

Trends in the field of lawn mowers continue to evolve rapidly, and the future promises even more advanced technologies. Some possible directions include:

Integrating artificial intelligence (AI) for weed

recognition and automatic adjustment of active organs.

Autonomous mowers capable of operating without human intervention, guided by high-precision GPS.

Hybrid systems that combine mechanical weeding with biological or thermal treatments, thus reducing dependence on herbicides.

Precision agriculture and sustainability remain the pillars of future development, and sensor-equipped cultivators are already an important step in this direction.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The comparative study of in-row weeding technologies reveals a clear evolution from traditional mechanical implements to intelligent, sensor-guided systems. While each type of analyzed weeder offers distinct advantages depending on the size, crop type, and operational profile of the farm, a noticeable performance gap emerges in favor of automated equipment. In particular, the sensor-guided in-row weeder consistently outperforms conventional models across nearly all key evaluation criteria: weed removal efficiency, soil preservation, adaptability to different crop layouts, and overall productivity.

Despite requiring a higher initial investment, this advanced equipment offers substantial long-term benefits. These include reduced labor requirements, minimal crop disturbance, and improved weed control accuracy—all of which contribute to increased crop yields and more sustainable farming practices. As such, for farms seeking to balance operational efficiency with environmental responsibility, sensor-assisted in-row weeder represent a forward-looking and economically sound solution.

5.2 RECOMMENDATIONS

For small-scale farms operating on limited budgets, traditional mechanical solutions such as classic or rotary weeder provide a cost-effective alternative, offering a basic yet reliable level of efficiency. These tools are easy to maintain, require minimal training, and can be adapted to various crop rows, making them suitable for farmers seeking simplicity and affordability without compromising entirely on performance.

For medium-sized farms that handle a variety of crops, particularly those that are more sensitive or delicate, finger or brush

weeders represent a significant upgrade. These implements allow for increased precision in weed control, minimizing the risk of damaging the crops while ensuring a cleaner field. Their adaptability and gentle action make them ideal for organic farms or those cultivating vegetables and specialty plants.

In contrast, large-scale, technologically advanced farms focused on precision agriculture greatly benefit from sensor-based weeding systems. These high-end solutions utilize computer vision, AI, and real-time data processing to distinguish between crops and weeds, ensuring targeted intervention with minimal soil disturbance. Their high throughput, combined with exceptional accuracy and environmental efficiency, makes them the top recommendation for operations aiming to optimize productivity and sustainability simultaneously.

Ultimately, selecting the appropriate weeding technology must be based on a thorough understanding of specific farm conditions, such as soil texture, crop type, operational scale, and available resources. A strategic approach to equipment choice not only enhances operational efficiency and crop protection but also contributes to long-term ecological sustainability by reducing unnecessary soil disruption and chemical use.

5.3 FUTURE PERSPECTIVES

Technological advancements clearly indicate a shift toward full automation and digitalization in crop maintenance. Key future directions include:

Integration of artificial intelligence (AI) for selective weed detection and automatic adjustment of weeding mechanisms.

Autonomous weeders guided by GPS systems, capable of operating without human supervision.

Hybrid technologies combining mechanical weeding with thermal or biological weed control for integrated crop management.

The sensor-guided weeder is not only a benchmark of current agricultural technology but also serves as a foundational platform for the integration of future innovations in smart, data-driven, and sustainable farming.

Its advanced sensing capabilities and automated control systems create opportunities for seamless integration with emerging technologies such as AI-based crop monitoring, autonomous field robotics, and precision input management.

As agriculture continues to move toward more intelligent and eco-conscious practices, the sensor-guided weeder stands at the core of

this transformation, bridging present capabilities with the future of sustainable food production.

6. BIBLIOGRAFIE

- [1] Ciupercă, R., & Gheorghită, N. (2015). *Mașini agricole pentru lucrările solului*. Editura Universitară, Craiova.
- [2] Manole, V., & Biriş, Ş. (2018). *Bazele proiectării mașinilor agricole*. Editura U.P.B., Bucureşti.
- [3] Popescu, S., (2017). *Echipamente pentru agricultura de precizie*. Editura AgroTehnică, Iași.
- [4] ISO 5687:1999. *Agricultural machinery – Equipment for inter-row cultivation – Test methods*.