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Development and evaluation of a manually operated twin wheel weeder with adjustable blades

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Abstract

Weeding is an essential and labor-intensive task in agriculture, often requiring significant time, labor, and resources to manage unwanted plants that compete with crops for essential resources. The traditional methods, particularly hand weeding, while effective, are inefficient and costly. This research focuses on the development and evaluation of a manually operated twin-wheel weeder with adjustable blades, designed to improve weed control efficiency while minimizing labor costs and environmental impact. Unlike traditional chemical herbicides, this mechanical solution offers a more sustainable and safer alternative. The developed weeder is equipped with adjustable blades, allowing it to adapt to varying soil conditions, crop spacings, and weed densities. Results showed that the new weeder outperformed traditional twin-wheel weeders in key performance metrics such as soil mass manipulation, weeding efficiency, and plant injury. The manually operated twin-wheel weeder with adjustable blades demonstrated a weeding efficiency of 90.90%, compared to 88.33% with existing models. The developed weeder caused less plant injury (5.45% vs. 9.09%) and manipulated more soil (6000 cm³ vs. 2808 cm³ per 200 cm run). These findings indicate that the newly developed weeder is more efficient, cost-effective, and adaptable to different agricultural environments, making it a promising solution for modern weed management.

Keywords: Twin-wheel weeder; manually operated weeder; weed control; field efficiency; sustainable farming

Introduction

Weeding is a fundamental and challenging task in agricultural practices, particularly in crop cultivation. It requires considerable time, labor, and resources to remove unwanted plants or weeds that compete with crops for essential resources such as water, nutrients, and sunlight. Weeds not only hinder crop growth but can also contribute to the spread of pests and diseases, affecting the overall productivity and quality of the crops (Sims *et al*., 2018; Monteiro and Santos, 2022) [9, 6]. Traditionally, farmers have relied on manual labor to control weeds, which, while effective, is an arduous and time-consuming process (Khattak *et al*., 2024) [5]. In many cases, hand weeding becomes inefficient, leading to increased labor costs and reduced overall productivity (Gao and Su, 2024) [1].

To address this challenge, various methods for weed control have been developed, including chemical herbicides, mechanical tools, and manual weeding (Zawada *et al*., 2023) [10]. Chemical herbicides have been widely adopted due to their effectiveness in controlling weeds; however, they pose significant risks to both the environment and human health. The widespread use of herbicides has led to concerns over soil contamination, pesticide resistance, and the potential harm to non-target organisms (Pathak *et al*., 2022) [7]. These concerns have prompted many farmers to seek alternative, more sustainable methods of weed control, such as mechanical weeders. Mechanical weeders, which do not rely on harmful chemicals, offer a promising solution by effectively controlling weeds while reducing the need for labor-intensive hand weeding and minimizing environmental impact.

Over the years, several mechanical weeders have been developed and tested to improve weeding efficiency. Jiao *et al*. (2022) [4] designed a mechanical weeder for rice cultivation, which was found to offer similar effectiveness to chemical weeding in improving grain yield and rice quality, while also significantly reducing herbicide usage. Their study concluded that mechanical weeders could be a viable alternative to chemical herbicides, promoting more sustainable agricultural practices. Similarly, Guru *et al*. (2018) [2] developed a power-operated single-row dry land weeder, which demonstrated greater efficiency and less plant damage compared to traditional manual methods. This weeder also reduced operational costs and labor requirements, further highlighting the benefits of mechanization in weeding operations. Studies by other researchers such as Paul *et al*. (2025) [8], Zhang *et al*. (2022) [11], and Hossen *et al*. (2021) [3] have also underscored the advantages of mechanical weeding, including improved weeding efficiency and cost reduction.

Among the various mechanical weeders, the twin-wheel weeder is widely used to remove weeds between crop rows. While this design has proven effective, many existing twin-wheel weeders lack flexibility, as they tend to work well only under specific conditions, such as certain soil types, crop spacings, or weed densities. As a result, farmers are often unable to use the same weeder across different fields or crops, leading to inefficiencies. To address this limitation, this research focuses on developing a manually operated twin-wheel weeder with adjustable blades. The goal is to design a weeder that can be easily modified to suit varying conditions, such as different crop types, row spacings, and weed growth patterns. By incorporating adjustable blades, this weeder can be tailored for use in a range of farming environments, offering greater versatility and improved weeding performance.

This study aims to evaluate the effectiveness and adaptability of the newly developed twin-wheel weeder with adjustable blades, comparing its performance with traditional weeding methods. The findings are expected to contribute to the development of more efficient and sustainable mechanical weeding solutions, ultimately supporting the reduction of labor and chemical herbicide use in crop production.

Material and Methods

Description of study area

The field experiment was conducted at the Research Farm of the Main Maize Research Station, located within the campus of the College of Agricultural Engineering and Technology (CAET), AAU, Godhra. The experimental site lies approximately 4 km from Godhra in the Panchmahal district of Gujarat. The region is characterized by a semi-arid climate with sub-humid weather conditions, experiencing distinct seasons: winter, summer, and monsoon. The annual rainfall in the area is approximately 1047 mm, with winter temperatures ranging between 15°C and 30°C, and summer temperatures ranging from 30°C to 42°C. Weather parameters, including temperature, rainfall, and relative humidity, were recorded using an Automatic Weather Station during the maize growing season.

Fabrication of weeder

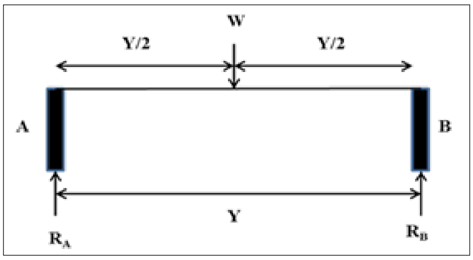
The fabrication of the components for the Manually Operated Twin Wheel Weeder with Adjustable Blades was carried out at the Workshop of the Farm Machinery and Power Department, CAET, AAU, Godhra. Key fabrication processes, including cutting, welding, grinding, forging, and drilling of mild steel strips, were performed. In order to reduce both cost and weight, small-sized wheels made of plastic fiber material were selected.

Design analysis

The design of the shaft for the wheel was based on calculating the torsional strength, considering the drive torque of the rotating shaft, which is subjected to both twisting and bending forces. Modifications to the design eliminated the shaft and replaced it with mild steel components. The design was further optimized based on the bending moments at the rod, calculated using standard engineering principles.

To determine the forces acting on the machine, the following equations were employed:

- Total weight of the weeder: X kg
- Total weight applied on the wheel: W kg
- Span between the two wheels: Y mm



For equilibrium, the force balance at the two support points R_A and R_B is given by:

$$R_A + R_B = W$$

Calculations for the moment at point A yield:

$$\left(W \times \frac{Y}{2}\right) - (R_B \times Y) = 0 \implies R_B = \frac{W}{2}$$

Substituting the values in Equation, the bending moment is calculated by taking moments at point X:

$$M_x = 0 = W \times \frac{Y}{2} + W \times \frac{Y}{2}$$

Design specifications

The fabricated manually operated twin-wheel weeder with adjustable blades was designed and assembled as per the specifications given in Table 1. The dimensions and features of the machine were optimized for efficient operation.

Table 1: Specification of the developed weeder

Sr. No.	Details	Particulars
1	Type of hand hoe	Manual
2	Overall dimensions (L×B×H), cm	160 × 60 × 121
3	Weight (kg)	5.8
4	Working width, cm	40
5	Height of handle from ground level, cm	138 (Adjustable)
6	Overall blade dimensions, cm	11.5 × 4.2 × 0.06
7	Diameter of ground wheel, cm	22
8	Width of ground wheel, cm	22.8

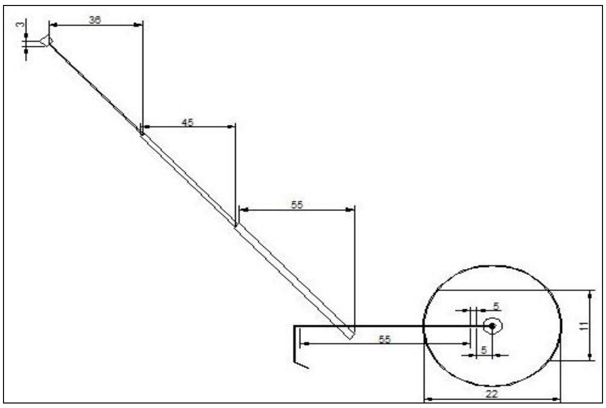


Fig 1: Drawing of the weeder

Fig 2: Manually operated twin wheel weeder with adjustable blades

Field evaluation

The newly developed manually operated twin wheel weeder was tested in the field alongside the existing twin-wheel weeder. Various performance parameters were studied to assess the machine's efficiency and effectiveness in different field conditions. These parameters included:

Soil moisture content

Soil moisture content was measured using a fully digitalized TDS Soil Moisture Meter. The field was irrigated once, and soil moisture content was calculated by taking multiple readings at different points in the field.

Soil mass manipulation

Soil mass manipulation refers to the total amount of soil disturbed during the weeding operation. The soil mass manipulated was calculated using the following formula:

$$SMM = W \times d \times 100$$

Where:
SMM = Soil mass manipulated (cm^3)
W = Width of operation (cm)
d= Depth of operation (cm)

Field Efficiency

Field efficiency was assessed in terms of field capacity, both theoretical and effective. Theoretical field capacity (TFC) is the rate at which the weeder covers the field if it operates at its maximum capacity without interruptions:

$$TFC = \frac{S \times w}{10}$$

Where:
S = Average speed of the implement (km/h)
w = Rated width of the implement (m)

The effective field capacity (EFC), which accounts for less-than-ideal operating conditions, was calculated as:

$$EFC = \frac{w \times l}{t \times 10}$$

Where:
l = Length of the field covered (m)
t= Time taken for the operation (hours)

Weeding Efficiency
Weeding efficiency was calculated by comparing the number of weeds before and after the weeding operation. The formula used to calculate weeding efficiency (WE) is:

$$WE = \frac{(W_1 - W_2)}{W_1} \times 100$$

Where:
W_1 = Number of weeds before weeding
W_2 = Number of weeds after weeding

Plant injury

Plant injury was calculated as the percentage of crop damage caused by the weeder during its operation. The formula for calculating plant injury is:

$$\text{Percentage of Plant Injury} = \frac{q}{p} \times 100$$

Where:
q = Number of plants in a 10-meter row length after weeding
p = Number of plants in a 10-meter row length before weeding

Results and Discussion

The manually operated twin wheel weeder with adjustable blades was developed and tested under field conditions to evaluate its performance, and its results were compared with the existing twin wheel weeder. The data gathered from these trials was analyzed to assess the operational efficiency, soil manipulation capabilities, weeding efficiency, and plant injury are shown in Table 1.

Design analysis

The load-bearing capacity of the manually operated twin wheel weeder with adjustable blades frame was evaluated across three different weight scenarios: 6 kg, 8 kg, and 10 kg. For the 6 kg load, the forces on the shaft were calculated, and the bending moments at various points were analyzed. The shaft design demonstrated adequate strength to withstand the applied loads. When subjected to an 8 kg load, similar calculations confirmed the design's ability to maintain structural integrity, with the bending moments remaining within safe operational limits. For a 10 kg load, the design was further tested for higher bending moments, and the shaft still exhibited sufficient strength to handle these increased loads, ensuring reliable performance during field operations. These analyses validate the robustness of the frame design under varying operating conditions, confirming its suitability for diverse workload demands.

Soil moisture content

The moisture content of the soil was measured at different locations and ranged between 27.42% and 33.84%, with an average moisture content of 30.89% (wet basis). The moisture level plays a crucial role in determining the soil's response to the weeder's action and the overall efficiency of weed control. The consistent moisture content across the field indicated stable soil conditions, allowing for accurate comparisons between the weeder models.

Soil mass manipulation

The manually operated twin wheel weeder with adjustable blades demonstrated effective soil mass manipulation, with an average depth of weeding of 1.5 cm, compared to 1.4 cm for the existing twin wheel weeder. Although the difference was not significant, the adjustable blades in the new design allowed for slightly more consistent soil disturbance. In terms of soil mass manipulation, the manually operated twin wheel weeder handled 6000 cm³ of soil per 200 cm run, whereas the existing twin wheel weeder only manipulated 2808 cm³ over the same distance. The increased soil mass manipulation of the new weeder indicates superior soil coverage, potentially leading to more efficient weed control across a larger area.

Field capacity

The manually operated twin wheel weeder with adjustable blades exhibited a field efficiency of 88.33%, which is higher than the existing twin wheel weeder's efficiency of 85.29%. This was calculated based on theoretical and effective field capacities. The increased field efficiency of the new weeder can be attributed to its slightly greater working width and operational speed, as reflected in the higher effective field capacity. This translates into a more productive weeding process, reducing the total time required for operations on large fields.

Weeding efficiency

The manually operated twin wheel weeder with adjustable blades achieved an average weeding efficiency of 90.90%, outperforming the existing twin wheel weeder, which had an average weeding efficiency of 88.33%. The weeding efficiency was calculated based on the number of weeds before and after operation. The higher weeding efficiency of the new model can be attributed to its adjustable blades, which allowed for more precise and thorough weed removal across varying soil conditions.

Plant injury

The plant injury resulting from the operation of the manually operated twin wheel weeder with adjustable blades was found to be 5.45%, which is lower than the 9.09% injury observed with the existing twin wheel weeder. The lower plant injury in the new weeder can be attributed to the design of the adjustable blades, which allowed for better control over the depth and angle of operation, thus minimizing damage to non-target plants. The manually operated twin wheel weeder demonstrated superior ergonomics and a more efficient weed removal process, causing less harm to the plants in the field, which is a crucial factor for ensuring crop health.

Table 2: Field performance results of developed weeder in comparison to existing weeder

Machines	Field parameters			Performance results						
	Soil moisture content (%) (w/w)	Speed of operation (m/s)	Number of weeds present before operation (m2)	Depth of operation (cm)	Working width (cm)	Soil mass manipulation in 200 cm run (cm)	Theoretical field capacity (ha/h)	Effective field capacity (ha/h)	Field efficiency (%)	Weeding efficiency (%)
Developed weeder	30.89	0.60	123	1.5	40	6000	0.0453	0.0406	88.34	90.90
Existing weeder	30.89	0.68	115	1.4	18	2808	0.04406	0.03758	85.29	88.33

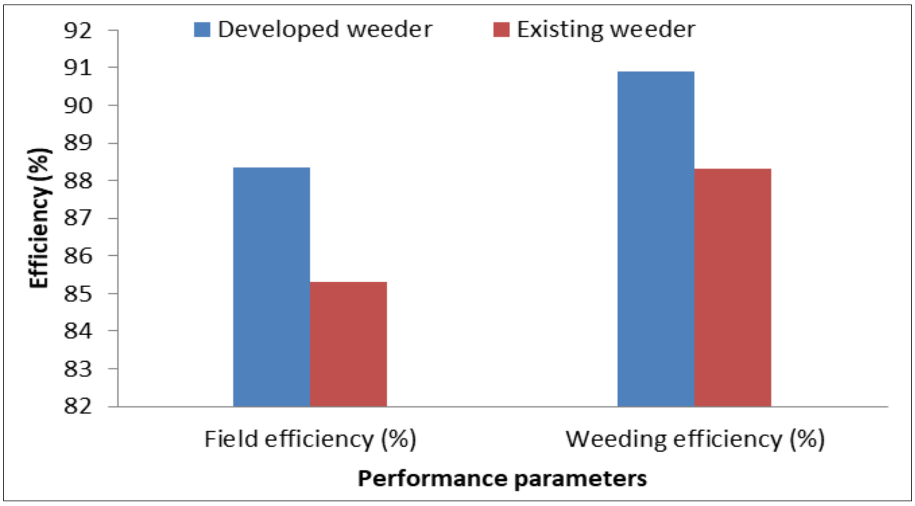


Fig 1: Performance results of developed weeder in comparison to existing weeder

The results from the tests show that the manually operated twin wheel weeder with adjustable blades outperforms the existing twin wheel weeder in several key areas, including soil mass manipulation, weeding efficiency, field efficiency, and plant injury. The new weeder's adjustable blades allow for more precise control over weeding depth and blade adjustment, leading to improved soil coverage and weed control efficiency.

Although the differences in depth of weeding and soil mass manipulation were marginal, the increased efficiency and reduced plant injury suggest that the new design is more suited to modern agricultural practices, where minimizing crop damage and increasing operational efficiency are essential.

The manually operated twin wheel weeder with adjustable blades represents a significant improvement over the existing models, offering better performance, higher efficiency, and greater adaptability to varying field conditions. The promising results indicate that this weeder could be a valuable tool for improving weed management in agricultural fields.

Conclusion

The study on the manually operated twin wheel weeder with adjustable blades revealed that it performs significantly better than the existing twin wheel weeder in terms of weeding efficiency and soil mass manipulation. The new weeder demonstrated better soil mass manipulation (4480 cm^3) compared to the existing model (2808 cm^3), indicating improved soil engagement during operation. The weeding efficiency of the new weeder (90.90%) was higher than that of the existing one (88.33%), making it more effective at removing weeds. Plant injury was also minimized with the manually operated twin wheel weeder with adjustable blades (5.45%), in contrast to the higher injury observed with the existing model (9.09%). The design of the new weeder also made it easier to transport due to its lightweight construction and adjustable accessories, while its low-cost manufacturing (500 rupees) makes it an affordable option for small-scale farmers. manually operated twin wheel weeder with adjustable blades proves to be a more efficient, cost-effective, and user-friendly alternative for weed control in agriculture.

Reference

1. Gao WT, Su WH. Weed management methods for herbaceous field crops: A review. Agronomy. 2024;14(3):486.
2. Guru PK, Patel SP, Nayak AK, Kumar A, Lal B, Gautam P. Development and evaluation of power operated weeder in rice. *Oryza* - An International Journal on Rice. 2018;55(2):317-323.
3. Hossen A, Islam S, Paul H, Shahriyar M. Design, fabrication, and performance evaluation of a multi-rows power operated weeder for line transplanted rice field in Bangladesh. Asia-Pacific Journal of Science and Technology. 2021;27(3).
4. Jiao JK, Wang ZM, Luo HW, Chen GL, Liu HL, Guan JJ, *et al*. Development of a mechanical weeder and experiment on the growth, yield and quality of rice. International Journal of Agricultural and Biological Engineering. 2022;15(3):92-99.
5. Khattak WA, Sun J, Hameed R, Zaman F, Abbas A, Khan KA, *et al*. Unveiling the resistance of native weed communities: insights for managing invasive weed species in disturbed environments. Biological Reviews. 2024;99(3):753-777.
6. Monteiro A, Santos S. Sustainable approach to weed management: The role of precision weed management. Agronomy. 2022;12(1):118.
7. Pathak VM, Verma VK, Rawat BS, Kaur B, Babu N, Sharma A, *et al*. Current status of pesticide effects on environment, human health and its eco-friendly management as bioremediation: A comprehensive review. Frontiers in Microbiology. 2022;13:962619.
8. Paul S, Nath BC, Huda MD, Bhuiyan MGK, Paul H. Assessment of mechanical weeders in paddy fields: A study on operational effectiveness in Bangladesh. Heliyon. 2025.
9. Sims B, Corsi S, Gbehounou G, Kienzle J, Taguchi M, Friedrich T. Sustainable weed management for conservation agriculture: Options for smallholder farmers. Agriculture. 2018;8(8):118.
10. Zawada M, Legutko S, Gościańska-Łowińska J, Szymczyk S, Nijak M, Wojciechowski J, *et al*. Mechanical weed control systems: Methods and effectiveness. Sustainability. 2023;15(21):15206.
11. Zhang Y, Tian L, Cao C, Zhu C, Qin K, Ge J. Optimization and validation of blade parameters for inter-row weeding wheel in paddy fields. Frontiers in Plant Science. 2022;13:1003471.