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Design and Fabrication of a Manual Multi-Functional Wheel Hoe for Simple Gardens

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Abstract:

Agricultural operations such as weeding, soil loosening, and furrow formation are essential intercultural activities that directly influence crop productivity. In many developing countries, small and marginal farmers still depend on traditional hand tools for these operations, which are labour intensive, time consuming, and physically demanding. This paper presents the design, fabrication, and performance evaluation of a manually operated multi-functional wheel hoe designed to reduce human effort and improve field efficiency. The developed system consists of a lightweight structural frame, wheel assembly, adjustable handle, and interchangeable attachments including a blade weeder, three-tine cultivator, and furrow maker. Structural design calculations and Finite Element Analysis (FEA) were performed to ensure adequate strength and safety under operational loads. The fabricated prototype weighs approximately 8–12 kg and incorporates ergonomic features to maintain upright working posture. Experimental evaluation indicates that the proposed device reduces manual effort and working time by approximately 30–40% compared with traditional hand weeding methods while maintaining effective soil penetration and weed removal. The developed system offers a low-cost, sustainable, and efficient solution suitable for small-scale agricultural mechanization.

Keywords — **Agricultural Tools, Wheel hoe, Manual Weeder, Ergonomic design, Finite Element Analysis.**

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I. INTRODUCTION

Agriculture remains the primary livelihood for a significant portion of the population in developing countries, particularly in rural regions where small and marginal farmers dominate agricultural production systems. These farmers typically rely on manually operated tools for intercultural operations such as weeding, soil loosening, and furrow formation due to limited access to advanced mechanized equipment.

Traditional hand tools such as hoes and spades require continuous bending and repetitive manual effort, resulting in high physical strain and reduced work productivity. These operations are labor intensive and time consuming, leading to increased labor costs and delayed field activities. Furthermore, prolonged use of traditional tools often causes musculoskeletal discomfort and fatigue among agricultural workers.

To address these challenges, there is a growing demand for intermediate mechanization solutions that bridge the gap between simple manual tools and expensive tractor-mounted implements. Manually operated wheel hoes represent a practical solution for small-scale farms because they combine mechanical advantage, rolling motion, and ergonomic design to improve operational efficiency.

This study presents the design and fabrication of a multi-functional wheel hoe equipped with interchangeable attachments for performing different intercultural operations. The proposed system aims to improve field productivity, reduce operator fatigue, and provide an affordable mechanization option for small farmers.

II. RELATED WORK

Mechanical weed control has gained considerable research attention due to the increasing demand for sustainable and labor-efficient agricultural practices. Several researchers have investigated manually operated weeders and wheel hoe mechanisms to improve field productivity while minimizing operator fatigue and labor requirements [1], [2].

Traditional hand weeding using hoes or spades requires continuous bending posture and repetitive manual effort, which often results in high physiological strain and musculoskeletal discomfort for agricultural workers. Studies have reported that manual weeding operations account for a significant portion of total labor requirements in crop production systems, thereby increasing production costs and reducing operational efficiency [3]. To address these limitations, manually operated mechanical weeders have been developed to improve working posture and reduce physical workload.

Wheel hoe implements utilize rolling motion and mechanical leverage to decrease soil resistance and improve soil penetration efficiency. Research studies indicate that wheel hoe based weeders can significantly improve weeding performance by reducing draft force and enabling better manoeuvrability between crop rows [4]. The rolling wheel mechanism helps minimize friction between the tool and soil surface, thereby reducing the energy required for operation.

Experimental investigations on mechanical weed control technologies have demonstrated that manually operated wheel hoes can increase field capacity by approximately 40–60% compared with conventional hand weeding methods [5]. Additionally, improved tool geometry, handle configuration, and depth control mechanisms contribute significantly to operator comfort and overall work efficiency.

Recent developments in agricultural implement design have focused on ergonomic considerations and modular configurations. Adjustable handle mechanisms, interchangeable tool attachments, and lightweight structural materials have been incorporated into modern wheel hoe designs to enhance usability under different field conditions [6]. These innovations allow farmers to perform multiple intercultural operations such as weeding, soil loosening, and furrow formation using a single implement.

Despite these technological advancements, many mechanized weed control systems remain expensive and inaccessible for small and marginal farmers, particularly in developing countries. As a result, there is a continued need for low-cost, manually operated multi-purpose agricultural implements that can provide improved efficiency while maintaining affordability and ease of maintenance [7]. Therefore, the development of cost-effective manual wheel hoe machines remains an important research area for sustainable farm mechanization.

III. DESIGN METHODOLOGY

A. System Overview

The developed manual weeder machine consists of a structural frame, wheel assembly, handle mechanism, and interchangeable tools for different agricultural operations. The machine is manually pushed by the operator and the rotating wheel guides the implement along crop rows.

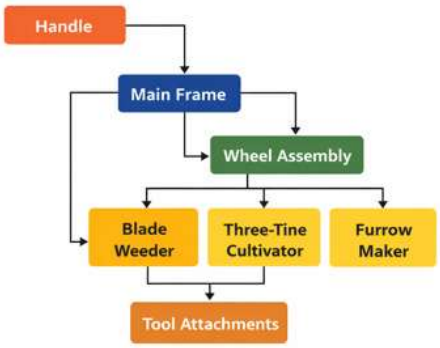

Fig. 1 Overall block diagram of the Manual Weeder System.

The system operates through a push–pull mechanism where the operator applies force through the handle while the front wheel guides the implement.

Fig. 2. Fabricated Manual Weeder

B. Design Input Parameters

The main design parameters used for the development of the machine are summarized in Table I.

Table 1 Design Parameters of the Wheel Hoe Machine

Parameter	Value
Operator Push Force	150 N
Soil Resistance	120 N
Working Depth	40 mm
Working Width	180 mm
Wheel Diameter	400 mm
Frame Material	Mild Steel
Factor of Safety	3

C. Frame Design

The frame forms the primary load-bearing structure of the machine and supports all other components including the handle, wheel assembly, and tool holder. Mild steel tubular sections were selected for their strength, weldability, and low cost. The important frame dimensions are listed in Table 2.

Table 2 Main Frame Dimensions

Component	Dimension
Frame Length	1200 mm
Frame Width	350 mm
Handle Height	950 mm
Pipe Diameter	25 mm
Wheel Diameter	400 mm

The frame structure ensures uniform load distribution and structural rigidity during operation.

D. Wheel Assembly

The wheel assembly converts sliding motion into rolling motion, reducing friction and improving stability. The wheel diameter ranges between 350 mm and 450 mm to minimize rolling resistance and improve maneuverability.

The hub and shaft were designed using EN8 steel to provide sufficient strength and fatigue resistance.

E. Blade Weeder Design

The blade weeder attachment is designed for shallow cutting of weeds between crop rows. The blade geometry is optimized to reduce soil resistance and improve cutting efficiency.

Fig.3. Blade Weeder Attachment

F. Three-Tine Cultivator

The cultivator attachment consists of three tines designed to loosen soil and improve aeration. The tines are designed to withstand soil draft forces and maintain structural stability during field operations.

Fig.4. Three-Tine Cultivator Attachment

IV. Finite Element Analysis

Finite Element Analysis (FEA) was performed to evaluate the structural performance of the frame under working loads. The analysis considered the following parameters:

Applied load = 300 N
Material = Mild steel
Yield strength = 250 MPa

The simulation results indicated that the maximum stress occurred near the handle-frame junction. The calculated von Mises stress was significantly lower than the material yield strength, confirming safe structural performance.

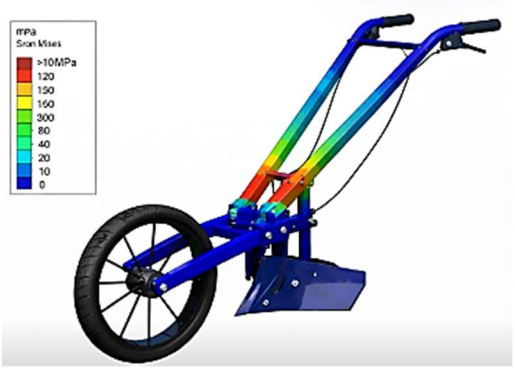

Fig.5. Stress Distribution Obtained from Simulation

The total deformation observed was approximately 1–2 mm, which is acceptable for agricultural equipment. The factor of safety obtained from the analysis exceeded the minimum design requirement.

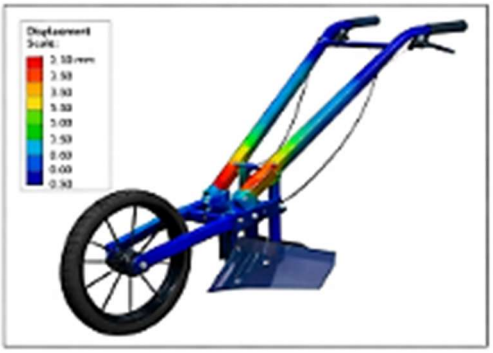

Fig.6. Deformation analysis of the Frame

The maximum stress obtained from the analysis was well below the yield strength of mild steel, indicating safe operation.

V. Manufacturing and Assembly

The manufacturing process involved standard fabrication techniques suitable for small-scale workshops.

Major manufacturing steps include:

- Material cutting and preparation
- Frame fabrication through welding
- Blade shaping and sharpening
- Wheel assembly and axle installation
- Surface finishing and painting
- Final assembly and functional testing

These processes ensure cost-effective production while maintaining structural reliability.

VI. Results and Discussion

The performance evaluation results obtained during field testing are summarized in Table 3.

Table 3 Performance Results of Manual Weeder

Parameter	Conventional Method	Proposed Machine
Working Time	60 min	35 min
Labor Effort	High	Moderate
Area Covered	0.02 ha/hr	0.04 ha/hr
Operator Fatigue	High	Low

The results show that the proposed manual weeder improves operational efficiency compared with traditional weeding tools. The machine provides effective weed removal between crop rows with a uniform soil penetration depth of 30–50 mm and smooth forward motion with minimal clogging. Overall, the developed system reduces working time by approximately 30–40% compared with conventional hand weeding methods.

.Ergonomic Benefits

The developed manual weeder provides several ergonomic benefits, including reduced bending posture, lower operator fatigue, and improved working comfort during field operations. The push force required for operation ranged between 120 N and 170 N, which lies within acceptable ergonomic limits for manual agricultural tools.

VII. CONCLUSION

The manual multi-functional wheel hoe was successfully designed, fabricated, and tested for agricultural applications. The developed system demonstrated satisfactory performance in terms of structural stability, operational efficiency, and ergonomic comfort.

The experimental results confirmed that the machine effectively reduces labor intensity and improves field productivity compared to traditional hand weeding methods. The lightweight design, interchangeable attachments, and simple fabrication process make the system suitable for small and medium-scale agricultural operations.

Future improvements may include adjustable working depth mechanisms and additional attachments to enhance functionality under varying soil conditions.

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REFERENCES

[1] [1] R. Kumar, S. Singh, and A. Pandey, “Performance evaluation of manually operated weeders for small farms,” Agricultural Engineering International: CIGR Journal, vol. 21, no. 2, pp. 34–42, 2019.
[2] [2] S. Tiwari and P. Singh, “Design and development of manual wheel hoe for intercultural operations,” International Journal of Agricultural Science and Research, vol. 8, no. 3, pp. 125–132, 2018.
[3] [3] H. Singh and M. Singh, “Ergonomic evaluation of agricultural tools used for weeding,” Journal of Agricultural Engineering, vol. 54, no. 4, pp. 56–63, 2017.
[4] [4] A. S. Sahay and B. K. Sharma, “Development and evaluation of improved wheel hoe for weed control,” Agricultural Mechanization in Asia, Africa and Latin America, vol. 47, no. 1, pp. 62–67, 2016.
[5] [5] R. Verma, P. Kumar, and S. Patel, “Field performance analysis of manually operated weeders,” International Journal of Agricultural Engineering, vol. 10, no. 1, pp. 101–108, 2017.
[6] [6] J. Melander, P. McCollough, and B. Christensen, “Advances in mechanical weed control technology,” Weed Research, vol. 58, no. 4, pp. 248–258, 2018.
[7] [7] A. Pandey and R. Singh, “Low cost farm mechanization tools for small scale farmers,” Journal of Farm Machinery and Power Engineering, vol. 55, no. 2, pp. 89–96, 2020.

