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"Development and Performance Evaluation of a Multi-Purpose Power Tiller for Small-Scale Farming Applications"

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Abstract:

This project outlines the development and testing of a multi-purpose power tiller tailored for small-scale farmers. Designed to reduce labor and enhance productivity, the machine integrates features for ploughing, seedbed preparation, and lightweight transportation. Key parameters including depth of tillage, working width, and fuel consumption were evaluated during field trials and benchmarked against manual operations. Results highlight its efficiency and potential for improving rural agricultural practices.

Along with its primary functions, the machine has been developed with user-friendliness in mind, ensuring that even farmers with limited technical knowledge can operate it with ease. Its compact design makes it highly suitable for small and fragmented fields where large agricultural machinery is difficult to use. Additionally, the tiller is equipped with interchangeable attachments, allowing it to carry out a variety of farming operations using a single unit, which reduces the need for multiple machines.

Performance evaluation was conducted across different soil types to examine the machine's reliability and adaptability. The observations showed consistent operation under varied field conditions, along with finer soil breakup and improved land preparation when compared to conventional practices. The

decrease in time required for field operations enables farmers to perform tasks within the most suitable agricultural timeframes, which is essential for achieving better crop productivity.

Moreover, an economic assessment indicates that adopting this multi-purpose power tiller can help reduce overall farming expenses by lowering dependence on manual labor and increasing efficiency.

Keywords:

Power tiller, field capacity, small-scale farming, multi-purpose farming tool, ploughing, fuel efficiency

I. Introduction

Smallholder farmers in India frequently face limitations in access to affordable mechanization tools. Manual methods for land preparation are both time-intensive and physically demanding. Introducing a cost-effective, multi-purpose tiller can revolutionize productivity for these farmers. This project aims to design and test such a machine that performs key farming functions efficiently and affordably [1].

Additionally, the design of this tiller prioritizes user-friendliness, enabling even farmers with limited technical skills to operate it with ease. It is built to carry out a range of farming tasks, including ploughing, tilling, and weeding, which helps reduce reliance on labor-intensive traditional methods. By saving time and lowering operating expenses, it can enhance overall farm productivity and increase returns. Improvements in strength, longevity, and the ability to function effectively in different soil conditions further expand its usability across diverse regions. Altogether, this effort supports sustainable agricultural practices while contributing to better livelihoods for smallholder farmers [2].

Furthermore, introducing such equipment can promote the wider use of modern farming techniques in rural areas. It also opens the possibility for shared ownership or rental systems, allowing several farmers to use one machine and minimize individual costs. Faster and more efficient land preparation supports timely planting, which can lead to higher yields and more stable incomes. With ongoing development and proper support, this multi-purpose tiller can become an important tool in strengthening the productivity and resilience of small-scale farming systems [3].

II. Materials and Methods

2.1 Design Considerations

The tiller was designed for compatibility with a range of implements. A 9 hp petrol engine was selected based on its balance between performance and fuel economy. All structural and mechanical components were modeled in SolidWorks for precision fabrication.

The development of the power tiller focused on achieving a compact, efficient, and multipurpose machine suitable for small-scale agricultural operations. A key objective was to ensure that the tiller could support different types of farm implements, allowing it to perform various tasks such as ploughing, soil preparation, and material transport. This adaptability helps reduce dependency on multiple machines and improves cost-effectiveness for farmers [4].

The selection of the power source was based on performance requirements and operational efficiency. A **9 hp petrol engine** was chosen as it provides an appropriate balance between power output and fuel consumption while remaining lightweight and easy to maintain. This makes it particularly suitable for rural conditions where simplicity and reliability are essential.

Attention was also given to operator convenience and control. The walking-type configuration enables the user to guide the machine with ease, while integrated control systems allow smooth adjustment of speed and operation. This reduces operator fatigue and enhances overall usability [5].

To ensure dimensional accuracy and proper assembly, all parts of the tiller were designed using **SolidWorks**. The use of computer-aided design (CAD) software allowed detailed visualization of components, proper alignment checks, and identification of possible interferences before fabrication. This approach minimized errors during manufacturing and improved overall design efficiency [6].

Material selection was carried out with consideration of mechanical strength, availability, cost, and resistance to wear. Mild steel was selected for the primary structure due to its adequate strength, good weldability, and affordability [7].

2.2 Major Components

Frame: Mild steel U-channel (60 × 30 mm): The structural frame forms the base of the machine and supports all major components. It is fabricated using mild steel U-channels with dimensions of **60 × 30 mm**, providing sufficient strength to withstand operational loads and vibrations. The design ensures stability and durability during field use.

Engine: 4-stroke petrol engine, 9 hp: The machine is powered by a 4-stroke petrol engine rated at 9 hp. This type of engine is preferred for its efficient fuel usage, smoother operation, and lower emissions. It is securely mounted on the frame to maintain proper alignment with the transmission system.

Drive System: Chain and sprocket with two-stage reduction: Power from the engine is transmitted through a chain and sprocket mechanism incorporating a two-stage reduction system. This setup decreases rotational speed while increasing torque, which is necessary for performing heavy-duty agricultural tasks. The chain drive is simple in construction and allows easy maintenance.

Attachments: Moldboard plough, rotavator, trolley hitch: The tiller is designed to work with multiple implements, making it versatile in application:

- A moldboard plough is used for primary tillage and soil turning.
- A rotavator is utilized for secondary tillage, helping to break down soil into a finer texture.
- A trolley hitch enables the machine to transport loads, increasing its utility beyond field operations.

Steering Mechanism: Dual-handle walking system with clutch and throttle control: The machine is controlled using a dual-handle steering arrangement, allowing the operator to walk behind and guide its movement. The handles are equipped with throttle and clutch controls, providing precise regulation of speed and power transmission. This setup enhances maneuverability and operational control, especially in confined agricultural fields [8].

2.3 Performance Evaluation

The performance of the equipment was evaluated through field trials conducted on loamy-sandy soil, chosen for its moderate fertility, good drainage, and suitability for agricultural operations. The objective of these trials was to assess the operational efficiency and effectiveness of the equipment under varying working conditions [9].

Three different speed settings were tested during the trials. For each speed, a set of key parameters was systematically recorded to provide a detailed assessment of performance:

- **Depth and Width of Cut:** The depth and width of the soil cut were measured to determine how effectively the equipment engages the soil. Uniform and consistent cutting indicates proper soil penetration and efficient operation.
- **Operating Speed:** The actual forward speed of the equipment was monitored. Variations in speed directly influence soil processing quality, fuel consumption, and overall productivity.
- **Fuel Consumption:** The volume of fuel used during each test was recorded. This parameter provides insights into the energy efficiency of the equipment, helping to identify the most economical operating conditions.
- **Time Taken:** The total time required to complete a specific field operation was documented. This metric is essential for evaluating operational efficiency and estimating labor requirements.
- **Field Capacity:**
    - *Theoretical Field Capacity* represents the area the equipment can cover per unit time under ideal conditions, without accounting for losses such as turning, acceleration, or interruptions [10].
    - *Effective Field Capacity* reflects the actual area covered per unit time under real field conditions, including operational delays. Comparing effective and theoretical capacities helps quantify operational efficiency and practical limitations [11].

By analyzing these parameters, the study provides a comprehensive evaluation of the equipment's performance. The results help identify optimal speed settings, improve fuel efficiency, and enhance overall field productivity [table 1].

Table 1: Summary of Performance Parameters:

Parameter	**Value**
Average Depth of Cut	14.5 cm
Average Width of Cut	28 cm
Operation Speed	3.4 km/h
Effective Field Capacity	0.078 ha/h
Fuel Consumption	1.85 l/h
Field Efficiency	87%

III. Results

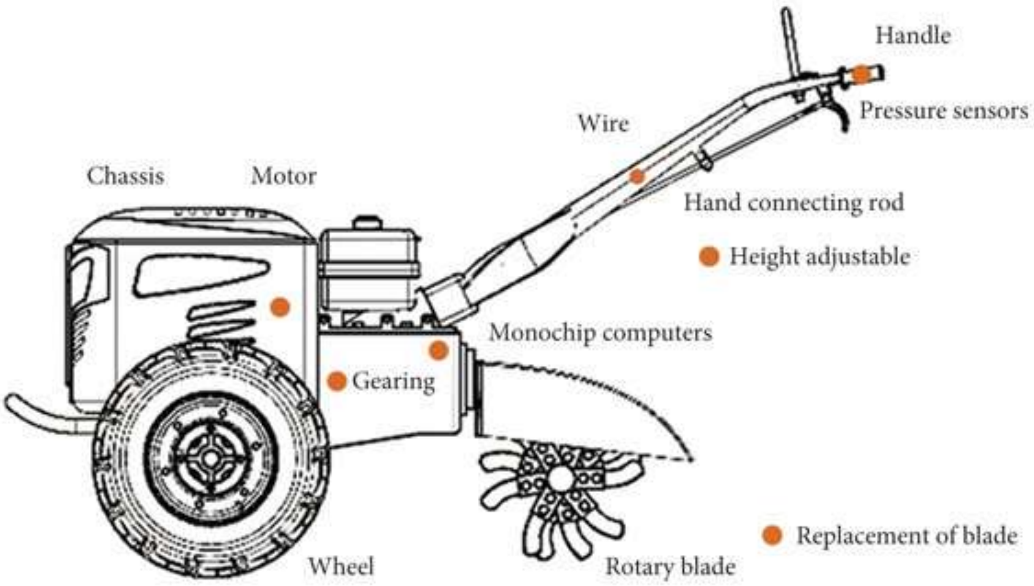
The multi-purpose tiller achieved a consistent working depth and width across test conditions. Fuel consumption remained within practical limits, and operational efficiency was high relative to manual processes. Overall, the machine delivered reliable performance under real-world soil and crop preparation conditions.

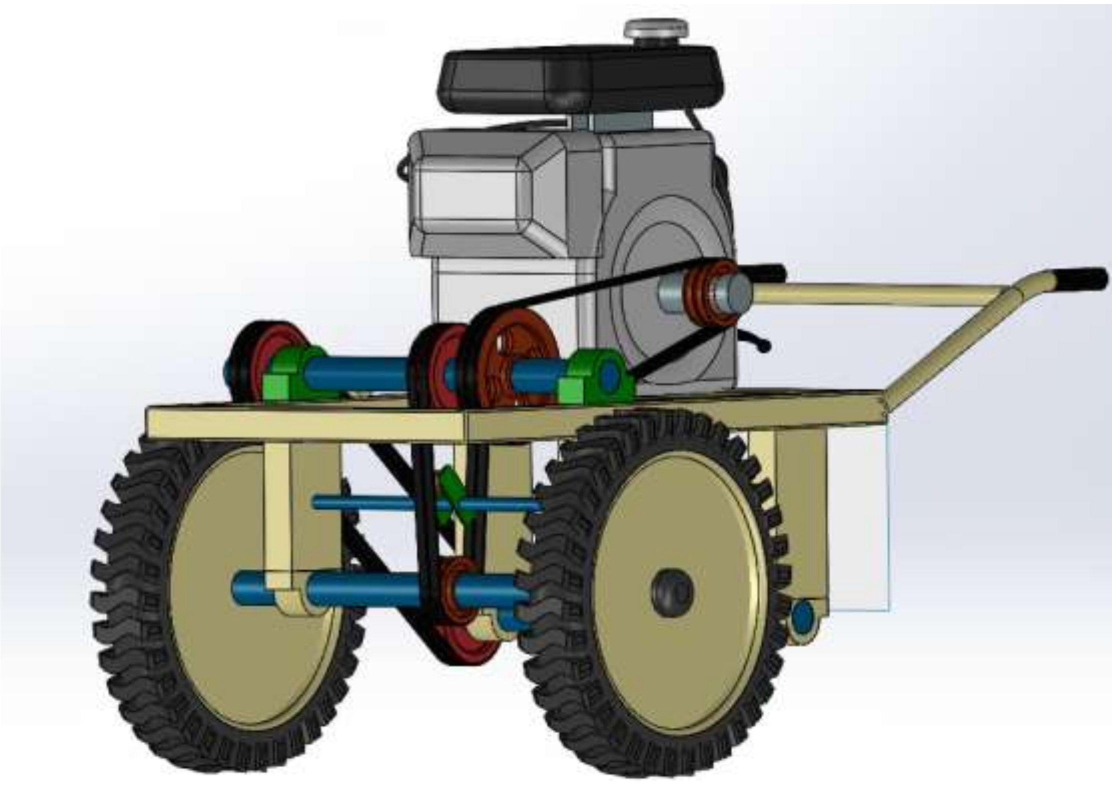
IV. Discussion

Compared to manual tillage, the developed power tiller demonstrates multiple clear advantages that can substantially improve agricultural efficiency and farmer well-being:

- **Time Efficiency:** Field tests showed that the machine covers larger areas in a fraction of the time required by manual methods. Specifically, operation speeds were observed to be up to four times faster than traditional hand tillage, which significantly shortens the time between land preparation and sowing. This can be especially critical during peak planting seasons when timely operations directly affect crop yield.
- **Labor Reduction:** Unlike conventional tillage that often requires several workers, the power tiller can be efficiently managed by a single operator. This reduction in labor not only decreases operational costs but also addresses labor shortages that many farmers face, particularly in rural areas during busy farming periods [12].
- **Consistency and Quality:** One of the key advantages of mechanized tillage is the uniformity it provides. The developed machine maintains a consistent depth and width throughout the field, leading to better seedbed preparation. Uniform tillage depth improves water infiltration and nutrient distribution, resulting in more even crop emergence and healthier plants.
- **Adaptability:** The design incorporates interchangeable attachments, enabling the power tiller to perform multiple agricultural tasks. Beyond ploughing, it can be used for rotavating, harrowing, or even basic material transport. This versatility reduces the need for multiple machines, making it a cost-effective investment for small and medium-scale farmers [13].
- **Ergonomics and Operator Comfort:** The walking-handle design minimizes operator fatigue by providing better posture support and reducing the strain associated with repetitive manual labor. This ergonomic consideration not only enhances comfort during prolonged use but also reduces the risk of musculoskeletal injuries, which are common in traditional hand tillage.
- **Environmental and Soil Benefits:** Although not the primary focus, mechanized tillage allows for more precise soil turnover and can reduce soil compaction compared to repeated manual trampling. The controlled depth and speed help preserve soil structure and organic matter, which is beneficial for long-term soil fertility [14].

Despite these advantages, minor efficiency losses were observed during gear shifting and when making tight turns. However, these limitations are relatively insignificant compared to the substantial gains in productivity, labor savings, and ergonomic benefits. Overall, the developed power tiller represents a practical, versatile, and sustainable solution for modern smallholder and commercial farming systems.





IV. Conclusion

The multi-purpose power tiller showcased strong performance across essential agricultural operations. Its compact design, affordability, and versatility make it an attractive solution for small-scale farmers. With further refinements such as electric start, optimized blades, and modular attachment systems, it can offer even greater value in diverse farming conditions.

Additionally, the machine is simple to operate, which reduces the need for advanced training and helps farmers adopt mechanized practices with greater ease. Its low upkeep demands and efficient fuel usage make it especially suitable for areas with limited resources. By handling a variety of tasks such as ploughing, tilling, weeding, and even transport, it reduces reliance on multiple machines and helps cut overall expenses. Ongoing enhancements in strength, user comfort, and compatibility with different soil conditions can further boost its efficiency, decrease dependence on manual labor, and establish it as a dependable and sustainable option for small-scale farming.

V. References

[1] Kantchede, C. N., Ahouansou, R. H., Ajav, E. A., & Bizimungu, G. (2022). Development of a small-scale power tiller for farmers in developing countries: A case study of Benin. Journal of Agriculture and Food Research, 10, 100441. https://doi.org/10.1016/j.jafr.2022.100441

[2] Kumar, S., Mahapatra, M., Behera, D., Pradhan, P. L., & Swain, S. K. (2021). A comprehensive review on versatility of power tiller. AMA, Agricultural Mechanization in Asia, Africa & Latin America, 51(3), 1482–1500.

[3] Adamu, F. A., Jahun, B. G., & Babangida, B. (2014). Performance evaluation of power tiller in Bauchi State Nigeria. International Journal of Engineering Research and Applications, 4(9), 29–34.

[4] Mandal, S. K., & Maity, A. (2011). Development and performance evaluation of a lightweight power tiller. In National Conference on Machines and Mechanisms (NaCoMM2011-35) (pp. 1–8).

[5] Shanker, T. P., & Varshney, C. (2002). Effect of forward speed on field performance of power tiller with and without operator's seat. Indian Journal of Agricultural Sciences, 72(3), 151–155.

[6] Dayou, E. D., Zokpodo, K. L. B., Atidegla, C. S., Dahou, M. N., Ajav, E. A., & Bamgboye, A. I. (2021). Analysis of the use of tractors in different poles of agricultural development in Benin Republic. Heliyon, 7(2), e06145. https://doi.org/10.1016/j.heliyon.2021.e06145

[7] Pradhan, P., Verma, A. K., Naik, R. K., & Guru, P. K. (2017). Draftability of power tiller with different lug angle of cage wheels in puddle soils for paddy. International Journal of Bio-resource and Stress Management, 8(1), 79–84. https://doi.org/10.23910/IJBSM/2017.8.1.1766

[8] BABA Z. *DEVELOPMENT AND PERFORMANCE EVALUATION OF A PROTOTYPE POWER TILLER INCORPORATED WITH SPRAY GUN IRRIGATION SYSTEM* (Doctoral dissertation).

[9] Arya KT, Shaji James P. Design and development of a multipurpose tool carrier for homestead agriculture. Department of Farm Power Machinery and Energy; 2019.

[10] Singh SU. *Design, development and performance evaluation of tractor operated multipurpose tool frame with attachments for sugarcane cultivation. Un-published Ph. D* (Doctoral dissertation, thesis. Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj, UP India).

[11] Mahapatra MA, Chattopadhyay PS. Design, development and evaluation of a power tiller operated vegetable transplanter. Int. J. New Technol. Sci. Eng. 2018;5(9):92-112.

[12] Paman U, Inaba S, Uchida S. Working performance and economic comparison of three power tiller types for small-scale rice farming in the Kampar region of Indonesia. Journal of the Japanese Society of Agricultural Machinery and Food Engineers. 2015 Sep 1;77(5):363-70.

[13] Raju K, Ajay Kumar M, Sherwin C. Arduino-Based Battery-Operated Multipurpose Portable Seed-Sowing Machine. Digital Convergence in Intelligent Mobility Systems. 2025 Aug 7:1-23.

[14] Sharma A, Khar S. Current developments in vegetable transplanters in developing countries: a comprehensive review. International Journal of Vegetable Science. 2022 Sep 3;28(5):417-40.