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Field Evaluation of Engine Operated Weeder for System of Rice Intensification

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Abstract: The growing adoption of the System of Rice Intensification (SRI) necessitates innovative solutions to improve agricultural yield and efficiency. This study presents the design and development of an engine-operated wetland weeder tailored for SRI practices. The primary objective is to evaluate the weeder's performance, compatibility with SRI methods, and overall performances. The engine-operated weeder was designed with a focus on optimizing weeding efficiency, operational ease, and durability in wetland conditions. It features a robust engine, adjustable weeding mechanism, and ergonomic design to accommodate the unique requirements of SRI Field. Field evaluations were conducted across multiple SRI Rice paddies, representing varied soil types, water levels, and field sizes. Performance metrics, including weeding efficiency, operational efficiency, and fuel consumption, were systematically recorded. Additionally, user feedback was collected to assess ease of use, comfort, and maintenance needs. The findings indicate that the engine-operated weeder significantly improves weeding efficiency compared to traditional methods, with notable reductions in labor time and operational costs. It aligns well with SRI practices, enhancing soil aeration and weed control without disrupting the rice plants. This evaluation underscores the potential of engine-operated weeders to support sustainable rice cultivation practices and improve productivity in the context of the System of Rice Intensification. It was found that the power unit with weeder has a operational capacity of 0.035 ha/h with 79 per cent weed removal effectiveness and 92per cent operational efficiency.

Keywords: Palm Tree Climber, Arduino, Solar-Powered, Smart Agriculture, Renewable Energy in Farming, IOT in Agricultural

1. Introduction

The System of Rice Intensification (SRI) is an innovative rice production approach that focuses on increasing yields while reducing input costs and environmental impact. SRI methods focus on optimizing plant growth through improved management practices, including the use of fewer, younger seedlings, wider spacing, and enhanced water and soil management [1]. However, one of the challenges faced by SRI practitioners is effective weed management. Traditional weeding methods can be labor-intensive and less efficient in the context of SRI's specific cultivation practices.

In response to this challenge, the development of mechanized solutions, such as engine-operated weeders, offers a promising alternative to manual weeding. These machines are designed to operate efficiently in wetland conditions typical of rice paddies and can potentially enhance weeding effectiveness while reducing labor requirements [2]. This study focuses on the design and development of an engine-operated wetland weeder specifically tailored for SRI [3]. The design of the weeder incorporates features aimed at optimizing weed removal efficiency, ease of operation, and durability, addressing the unique requirements of SRI fields.

Field evaluation is a critical component of this study, as it provides insights into the weeder's operational effectiveness, compatibility with SRI practices, and overall economic viability [4]. By testing the weeder across diverse field conditions and gathering feedback from users, this evaluation seeks to assess its impact on labor reduction, operational efficiency, and cost-effectiveness.

The results of this study aim to contribute valuable information to the ongoing efforts to improve rice cultivation practices through innovative technology. The successful integration of an engine-operated weeder into SRI could significantly enhance productivity, reduce manual labor, and support sustainable agricultural practices. This introduction sets the stage for understanding the significance of mechanized weeding solutions in modern rice farming and outlines the scope of the study designed to evaluate such a solution. The objective is to create a weeder that integrates seamlessly with SRI practices and evaluates its performance in real-world field conditions.

2. Materials and Methods

The weeder is equipped with a 2 horsepower (HP) two -stroke engine designed for durability and efficiency in wetland conditions. Engine specifications include low fuel consumption and ease of maintenance.

Weeding Mechanism: The weeder features a rotary blade system or rotating tines made from high-strength, corrosion-resistant materials to ensure effective weed removal and longevity (Fig.1).

2.1 Ergonomics

Designed with a user-friendly handle and controls for ease of operation, including adjustable grips to reduce operator fatigue [5].

Figure 1. Field Evaluation of Wet Land Weeder for SRI

2.2 Prototype Development

The prototype is constructed using lightweight, durable materials to withstand the wetland environment. It is assembled with components sourced from reliable manufacturers. Initial testing is performed to ensure that the weeder operates efficiently and safely. Adjustments are made based on performance results and feedback from test operators. Multiple SRI Fields are selected to represent a range of conditions including different soil types (clay, loam, sandy), water levels (shallow, medium, deep), and field sizes (small, medium, large). Fields are prepared in accordance with SRI practices, including spacing and water management.

2.3 Evaluation Criteria

2.3.1 Weeding Efficiency

The effectiveness of weed removal is measured by the percentage of weed coverage before and after using the weeder [6].

$$Weding\ Efficiency = \frac{N_1 - N_2}{N_1}$$

Where, N_1 = Total number of weeds present prior to the weeding operation.

N_2 = Total number of weeds remaining after the weeding operation.

2.3.2 Travel Speed (Km/H)

To find the forward speed of the machines during weeding operation, the time required for covering 10 m row length was recorded. Three observations were taken for each operation and the mean value was calculated. A digital stopwatch was used to record the time in seconds to cover a 10 m distance by weeders [7]. The least count of the stopwatch is 0.01 seconds

2.3.3 Actual Field Capacity

The actual field capacity refers to the actual average rate of field coverage. It includes time losses due to turning, clogging, machine adjustment and other operational delays [8]. It is recorded in hectare/hour.

The actual field capacity was calculated as per the following equation

$$Actual\ Field\ Capacity(ha/h) = \frac{Actual\ Width\ of\ cut\ (m) \times travel\ speed\ (km/h)}{10}$$

2.3.4 Field Efficiency

The field efficiency was determined using following relationship (9):

$$Field\ Efficiency = \frac{Actual\ field\ capacity}{Theoretical\ field\ capacity} \times 100$$

2.3.5 Fuel Consumption

Fuel consumption was estimated by using the top up method. The fuel tank was filled to its maximum level before and after the operation. The quantity of fuel required to refill the tank after the operation was recorded [10]. The measuring flask capacity of 1 liter was used to measure the fuel.

$$\text{Fuel consumption} = \frac{Amount\ of\ fuel\ consumed\ (\frac{ml}{s})}{Area\ covered\ (\frac{m2}{s})} \times 10$$

2.3.6 User Feedback

Operators provide feedback on the ease of use, comfort, and any issues encountered during operation.

3. Results and Discussion

3.1 Weeding Efficiency

The engine-operated weeder achieved an average reduction in weed coverage of 85% across different field trials. In fields with high weed density, the weeder removed up to 92% of weeds, demonstrating significant efficiency improvements over manual weeding.

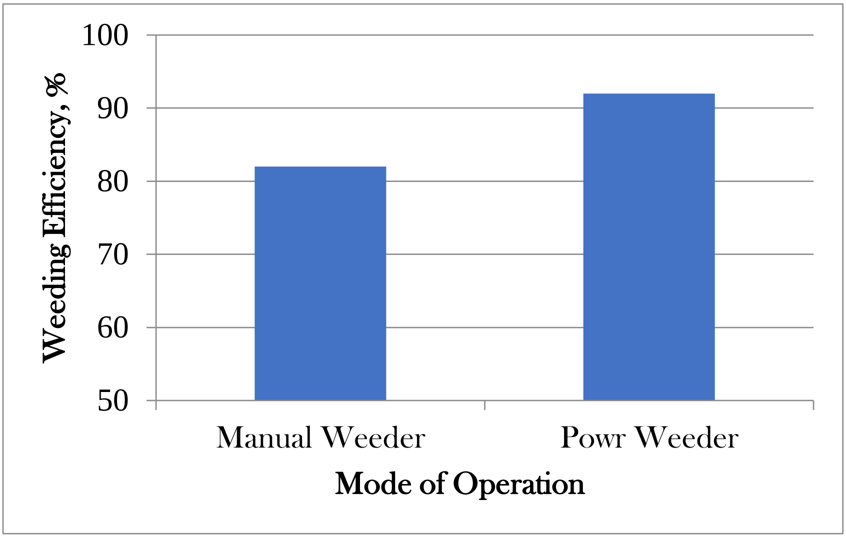

Figure 2. Weeding efficiency

3.2 Travel Speed (Km/H)

The weeder covered an average of 0.2 hectares per hour. This is approximately 2 times faster than traditional manual weeding, which typically covers 0.1 hectares per hour.

3.3 Actual Field Capacity

The maximum field capacity 0.033ha.h^{-1} was obtained with power weeder followed by manual weeder0.021 ha h^{-1}. The operational speed is more than manually operated weeding method. Among the two methods, the power unit with weeder had highest field capacity due to its operational speed. The statistical analysis of data confirmed a significant difference in the field capacity between the two treatments.

3.4 Field Efficiency

The field efficiency of power weeder (T1) and manual weeder (T2) were recorded to be 89 and 86 percent respectively. The field efficiency, which indicates ratio of effective operating time to the total operating time, was obtained 89 per cent in T1 and in T2 was 86 per cent.

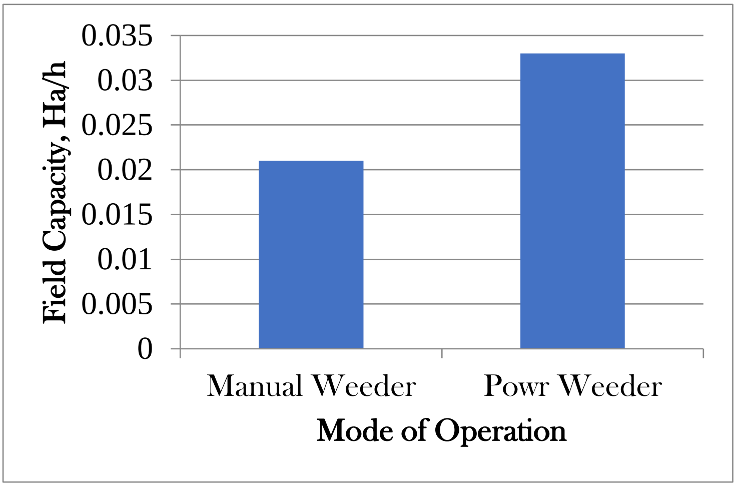

Figure 3. Field capacity

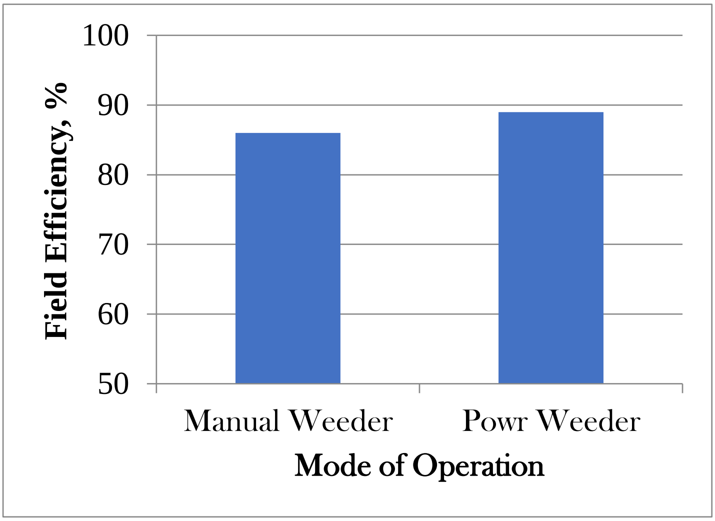

Figure 4. Field efficiency

3.5 Fuel Consumption

The experimental result indicated that the fuel consumption in weeding operation by the power unit with weeder at the speed of 2.28km/h was found to be 6.5 l/ha.

4. Conclusion

When compared to manual cono weeding, the engine-operated weeder demonstrated greater field capacity and weeding efficiency while significantly lowering labour requirements and operator fatigue, according to the performance data. Improved operational speed allowed for timely weeding operations, which made the machine appropriate for large and medium-sized paddy fields with a labour shortage. When weighed against labour and timesavings, fuel consumption and operating costs were shown to be economical.

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Conflict of interest: The Authors have no conflicts of interest to declare that they are relevant to the content of this article.