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Performance Evaluation of a 100 kg/h Rice Threshing Machine Powered by a 6 HP Gasoline Engine

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ABSTRACT

This study aims to analyze the performance of a rice threshing machine with a 100 kg/hour capacity driven by a 6 HP gasoline engine on Ciherang rice variety. The main parameters observed were working capacity, threshing efficiency, yield loss, and fuel consumption. The experiment was conducted under five rotational speeds (600–1400 rpm). The results showed that the highest efficiency of 88% was achieved at 1200 rpm, with the lowest yield loss of 12%. At higher speeds, efficiency decreased due to grain breakage and increased losses. The optimal operational point of this machine was achieved at 1200 rpm, where performance, fuel economy, and grain quality were balanced

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INTRODUCTION

Rice threshing is a crucial stage in the post-harvest process aimed at separating the rice grains from the panicles. The efficiency of the threshing process determines the final yield and the quality of the rice obtained by farmers. Most farmers in rural areas of Indonesia still rely on traditional methods such as beating or striking, which have low capacity and require significant time and labor (Achmad et al., 2022). Manual threshing methods are only capable of achieving a capacity of 20–30 kg/hour and are associated with a high level of grain loss.

To increase productivity, a toothed-cylinder type rice threshing machine powered by a gasoline engine is employed. A 6 HP gasoline engine is selected because it is widely available, lightweight, and provides sufficient power to drive the threshing cylinder with a capacity of 100 kg/hour. According to the Ministry of Agriculture, threshing machines with a power range of 5–6.5 HP are capable of achieving efficiencies above 95%, provided that the rotational speed is properly adjusted to the material conditions (Akendola et al., 2025).

The Ciherang variety was selected in this study because it is a nationally superior rice variety with medium-sized grains and a relatively stable moisture content of 14% (Susiyanti et al., 2020). Ciherang also has a panicle morphology that is highly suitable for a toothed-cylinder threshing system, allowing grain losses to be reduced to below 3%. The objective of this study is to analyze the relationship between the shaft rotational speed and threshing efficiency as well as grain loss (Yustina et al., 2024).

LITERATURE REVIEW

Rice threshing is a critical post-harvest operation that directly affects grain yield, quality, and overall productivity. The transition from traditional manual threshing methods to mechanical threshing machines has been widely studied as a means to reduce labor requirements, processing time, and post-harvest losses. Manual threshing methods typically exhibit low capacity and high grain loss, making them inefficient for large-scale or time-sensitive harvesting operations (Singh et al., 2020).

Mechanical rice threshing machines, particularly the toothed-cylinder type, are commonly used due to their simple construction, ease of operation, and relatively high threshing efficiency. Several studies have reported that the performance of threshing machines is strongly influenced by operational parameters such as cylinder rotational speed, feed rate, grain moisture content, and crop variety. Among these parameters, cylinder speed plays a dominant role in determining threshing efficiency and grain damage (Looh et al., 2025).

Previous research indicates that increasing cylinder speed generally improves threshing efficiency by enhancing the impact and rubbing action between the teeth and the panicles (Riaz et al., 2017). However, excessive rotational speed may lead to increased grain breakage, higher grain loss, and greater fuel consumption. Therefore, determining an optimal rotational speed is essential to achieve a balance between efficiency and grain preservation.

The power source used to drive the threshing machine also affects its performance and applicability in rural areas. Gasoline engines in the range of 5–6.5 HP are widely preferred due to their availability, portability, and sufficient power output for small- to medium-capacity threshing machines. Studies have shown that properly matched engine power and cylinder speed can result in threshing efficiencies exceeding 95% with grain losses below acceptable limits.

The Ciherang rice variety, as a nationally recognized superior variety in Indonesia, has been frequently used in experimental studies due to its uniform grain size, stable moisture content, and favorable panicle structure. Its morphological characteristics make it suitable for toothed-cylinder threshing systems, enabling consistent performance evaluation and reliable comparison with previous studies (Wamalwa, 2022).

Based on the reviewed literature, it is evident that the optimization of cylinder rotational speed is a key factor in improving the performance of rice threshing machines. However, specific performance data for a 100 kg/h rice threshing machine powered by a 6 HP gasoline engine using the Ciherang variety remain limited. Therefore, this study aims to address this gap by experimentally analyzing the relationship between shaft rotational speed, threshing efficiency, and grain loss.

METHODS

Equipment and Materials

This study employed several main devices and supporting instruments to obtain performance data of the rice threshing machine. The specifications of the equipment and materials used are described as follows:

1. Rice Threshing Machine (Threshing Unit)

The rice threshing machine used in this study was a straight spike-tooth cylinder type thresher with the following specifications:

- Cylinder diameter: 400 mm
- Cylinder length: 600 mm
- Number of threshing teeth: 40 teeth
- Cylinder–concave clearance: 15–20 mm
- Separation system: blower and vibrating sieve

2. Driving Engine

The driving unit was a four-stroke gasoline engine with the following specifications:

- Maximum power: 6 HP (4.4 kW)
- Maximum torque: 10.5 N·m at 2500 rpm
- Engine displacement: 196 cc
- Average fuel consumption: 0.8–1.0 L/hour

3. Test Material: Ciherang Rice Variety

Ciherang rice was used as the test material with the following characteristics:

- Grain moisture content: 14% (wet basis)

- 1000-grain weight: ±27 g
- Panicle structure: medium, easy to thresh

4. Supporting Instruments

To ensure accurate and reliable testing, the following auxiliary instruments were used:

- Digital tachometer: to measure shaft rotational speed (rpm)
- Digital balance (±0.01 g accuracy): to weigh threshed and unthreshed grains
- Stopwatch: to record machine operating time
- Fuel measuring cylinder (±1 ml accuracy): to measure gasoline consumption
- Sample bags and manual sieves: to separate impurities and broken grains
- Moisture meter: to verify grain moisture content prior to testing

Testing Procedure

The testing was conducted systematically to determine the effect of shaft rotational speed on threshing efficiency, grain loss, working capacity, and fuel consumption. The rice threshing machine evaluated in this study is clearly illustrated in Figure 1.

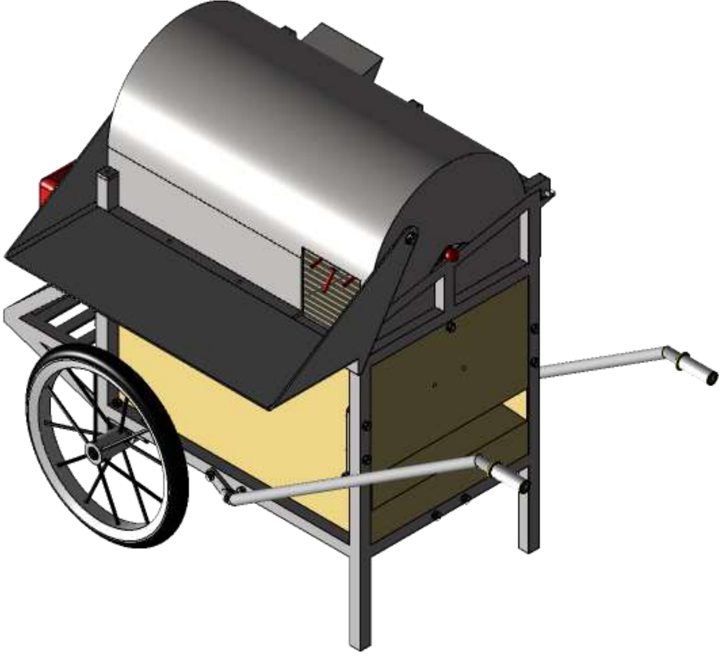

Figure 1. Rice threshing machine used for testing

The testing procedure was carried out through the following steps:

1. Preparation of Materials and Equipment
   - Harvested dry paddy of the Ciherang variety was weighed at 5–10 kg for each trial.
   - Grain moisture content was measured using a moisture meter.
   - The threshing machine components were inspected to ensure there were no blockages or mechanical damage.

2. Adjustment of Rotational Speed
   - The driving engine was started and allowed to run at idle for 2 minutes.
   - The shaft rotational speed was set at 600, 800, 1000, 1200, and 1400 rpm.
   - Each speed variation was tested three times (triplicate).

3. Threshing Process
   - Paddy was fed evenly through the input hopper at approximately 1 kg every 20–30 seconds.
   - The machine was operated until all panicles were completely processed.
   - Threshed grains (clean grains, filled grains, and empty grains) were collected in a separate container.
   - Unthreshed grains remaining attached to the panicles were collected to determine grain loss.

4. Fuel Consumption Measurement
   - The volume of gasoline was measured using a graduated cylinder at the beginning and end of each 30-minute operation period.
   - Fuel consumption was calculated in units of mL/hour.

5. Quality Assessment of Threshed Grains
   - The threshed grains were sieved to separate impurities, straw residues, and broken grains.
   - A representative grain sample was analyzed to determine the percentage of whole grains and damaged grains.

All data were recorded on observation sheets and used for the calculation of the machine performance parameters.

Calculated Parameters

Several parameters were used to evaluate the performance of the rice threshing machine, including threshing efficiency, grain loss, working capacity, fuel consumption, and grain quality.

1. Threshing Efficiency (%)

Threshing efficiency indicates the machine's ability to separate grains from the panicles and is expressed as a percentage of successfully threshed grains relative to the total grains processed. It is calculated using the following equation

$$Threshing\ Efficiency\ (\%) = \frac{W_t}{W_t+W_u} \times 10 \dots\dots\dots (1)$$

where:

W_t= weight of threshed grains (kg)

W_u= weight of unthreshed grains remaining on the panicles (kg)

A higher efficiency value indicates better performance in separating the grains from the panicles (Lu et al., 2023).

2. Grain Loss (%)

Grain loss represents the proportion of grains that remain unthreshed or are lost during the threshing process. It is expressed as a percentage of the total grains processed and is calculated using the following equation:

$$Grain\ Loss\ (\%) = \frac{W_u}{W_t + W_u} \times 100 \quad (2)$$

W_u= weight of unthreshed grains remaining on the panicles (kg)
W_t= weight of threshed grains (kg).

3. Working Capacity (kg/hour)

$$C = (W / t) \times 60 \quad (3)$$

Where:
C = working capacity of the machine (kg/hour)
W = weight of threshed paddy per batch (kg)
t = operating time per batch (minutes)

Working capacity indicates the ability of the machine to complete work per unit of time.

RESULTS AND DISCUSSION

The results of the performance testing of the rice threshing machine are presented in Table 1.

Table 1. Results of Rice Threshing Machine Performance Testing

Shaft Speed (rpm)	**Capacity (kg/hour)**	**Efficiency (%)**	**Grain Loss (%)**	**Fuel Consumption (L/hour)**
600	68	70	30	0.42
800	82	78	22	0.47
1000	96	85	15	0.52
1200	100	88	12	0.58
1400	103	83	17	0.65

The working capacity increased from 68 kg/hour at 600 rpm and reached a maximum of 103 kg/hour at 1400 rpm. This trend is consistent with the findings of M. Saleh et al. (2019), who reported that the increase in capacity is attributed to the higher impact energy at elevated rotational speeds, which accelerates the separation of grains from the panicles [6]. However, the rate of capacity increase began to decline beyond 1200 rpm, with only a 3 kg/hour increase up to 1400 rpm, indicating the occurrence of a diminishing return. This phenomenon is believed to result from air turbulence and unstable material distribution at excessively high rotational speeds.

Meanwhile, fuel consumption exhibited a linear increasing trend, rising from 0.42 L/hour at 600 rpm to 0.65 L/hour at 1400 rpm. This increase is a direct consequence of the engine operating under higher load and rotational speed, which requires greater energy input to be sustained.

As shown in Figure 2, threshing efficiency and grain loss exhibit opposing and interrelated trends, which are critical in determining the overall operational quality of the machine. Threshing efficiency follows an optimum curve pattern (increasing and then decreasing). The efficiency increased significantly from 70% at 600 rpm and reached its peak value of 88% at 1200 rpm. Within this range, the combined effects of impact energy and friction acted optimally. However, the efficiency decreased to 83% at 1400 rpm. This decline is attributed to excessively high rotational speeds creating unfavorable conditions, including increased grain breakage and the ejection of grains before proper separation, as well as excessive airflow and turbulence that carry grains out together with straw.

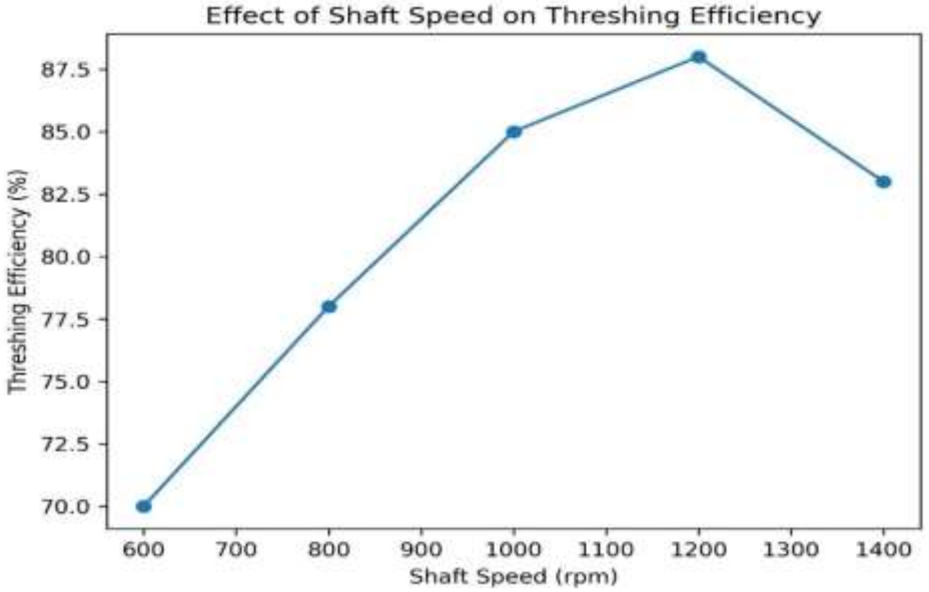

Figure 2. Threshing Efficiency as a Function of Shaft Speed (RPM)

Next, the grain loss is analyzed, as shown in Figure 2, which exhibits a trend inversely proportional to threshing efficiency. As the rotational speed increased from 600 to 1200 rpm, grain loss decreased because the material received sufficient impact energy to separate the grains without excessive scattering. Within this range, material flow was more stable, allowing adequate contact time between the grains and the threshing teeth.

However, at 1400 rpm, grain loss increased again. This occurred because the grains moved too rapidly, causing some grains to be ejected before optimal interaction with the threshing teeth. In addition, part of the grains was carried away by airflow and discharged together with straw (carry-over effect), resulting in reduced residence time and less effective mechanical contact.

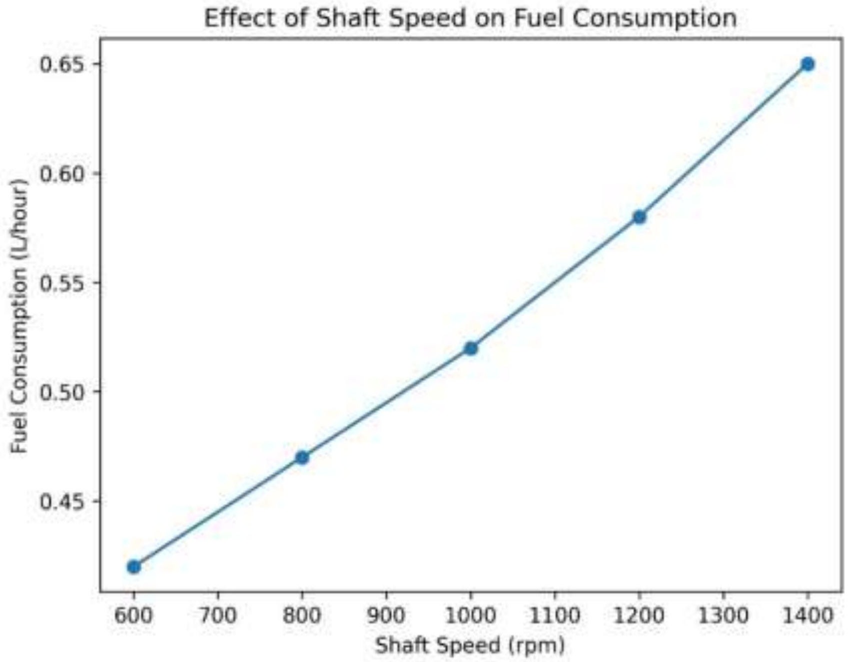

Figure 3. Fuel Consumption as a Function of Shaft Speed

From an energy perspective, at 1400 rpm fuel consumption increased but did not result in a significant improvement in either capacity or efficiency, leading to a reduction in energy efficiency, as illustrated in Figure 3. In contrast, at 1200 rpm, the energy input produced the best output per unit of fuel.

These findings also have important implications for machine design. The number and spacing of threshing teeth were found to operate optimally within the 1000–1200 rpm range, the 400 mm cylinder diameter generated the most favorable centrifugal force at 1200 rpm, and the blower setting should be adjusted carefully to avoid increased grain loss at higher rotational speeds.

CONCLUSIONS AND RECOMMENDATIONS

Based on the experimental performance evaluation of the rice threshing machine powered by a 6 HP gasoline engine, several conclusions can be drawn. Shaft rotational speed was found to have a significant influence on working capacity, threshing efficiency, grain loss, and fuel consumption. The working capacity increased with increasing rotational speed, reaching a maximum value of 100 kg/hour at 1400 rpm. However, threshing efficiency did not increase continuously with speed.

The results indicate that the optimum operating speed of the machine is 1200 rpm, at which the machine achieved a balanced performance with a working capacity of 100 kg/hour, the highest threshing efficiency of 88%, the lowest grain loss of 12%, and moderate fuel consumption of 0.58 L/hour. Operating the machine beyond this speed resulted in increased fuel consumption and grain loss without a proportional improvement in capacity or efficiency, leading to reduced energy efficiency.

Based on these findings, it is recommended that the machine be operated at approximately 1200 rpm to achieve optimal performance and energy efficiency.

Proper adjustment of the blower airflow and regular maintenance of the threshing teeth are also recommended to minimize grain loss and maintain consistent performance. These results can serve as practical guidelines for farmers and small-scale agricultural machinery operators to improve post-harvest efficiency..

FURTHER STUDY

This study was conducted under controlled experimental conditions using a single rice variety (Ciherang) with a fixed grain moisture content of 14%. Therefore, the results may not fully represent performance variations under different field conditions. Future studies are recommended to investigate the effects of different rice varieties, varying moisture contents, and feed rates on threshing performance.

In addition, further research could focus on optimizing blower design, tooth geometry, and concave clearance to reduce grain loss at higher rotational speeds. Comparative studies using alternative power sources, such as electric motors or diesel engines, may also provide valuable insights into improving energy efficiency and operational sustainability.

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