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Original Research Article

Preliminary Evaluation of The Performance of Micro Combine Harvesters in Rice Farming

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Abstract: Rice is the most widely used staple food, especially in Asia, accounting for about 90% of the world's rice production. In Malaysia, the cultivated area is as much as 730,016 hectares, and the show was about 3.3 million metric tons throughout the country in 2016. Currently, big combine harvesters are used in Malaysia to harvest rice, allowing for quicker harvesting. However, harvesting with a big combine harvester is impossible in areas with soft soil. As a result, employing a micro combine harvester is one of the options for harvesting in areas with soft soil problems. This study aims to evaluate the performance of a micro combine rice harvester. Performance evaluations were conducted at the MARDI Seberang Perai, Penang research plot. The pedestrian-type micro combines harvester with a triangular rubber crawler type was used in this study. The working width of the machine is 1 meter. The rate of harvesting losses is also evaluated as part of the study. The performance test results of the micro combine harvester show that the farm's efficiency is about 70 percent, with a work rate of 0.10 ha/hour. By keeping the harvester's speed at 1.5 km/h, this micro combine harvester's potential work rate is 0.15 hectares per hour. The losses during the harvesting operation were calculated to be 2.2 per cent. The study's results show that using micro combine harvesters can assist in carrying out rice harvesting work in areas where soft soil issues make it challenging to use the standard large combine harvesters. Farmers that grow rice on a small scale also benefit from using this micro combine harvester. The small percentage of losses demonstrated the effectiveness of this micro combine harvester.

Keywords: Evaluation; Performance; Micro Combine Harvesters; Work rate; Losses

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1. Introduction

The global population is expected to reach 9.61 billion by 2050 and 11.2 billion by 2100 (Nath *et al.*, 2022). By 2025, it is predicted that this growth will be accompanied by a 60 % increase in the food requirements of the present population (Arık & Korkut, 2022). To fulfil the rising demand for food, agricultural productivity needs to be raised to preserve vitality (Aküzüm *et al.*, 1999). With an increasing population, the consumption of rice-based foods will rise significantly, especially in developing nations (Godfray & Garnett, 2014). The harvesting operation is critical to sustaining rice yield and quality, requiring 150-200 hours of labour per hectare (Dalin *et al.*, 2019). To solve labour shortages in rice cultivation, harvesting operations in Malaysia have been carried out with a giant combine harvester (Wagiman *et al.*, 2018). The large combine harvesters play an essential role in harvesting operations because they provide timely harvesting while maintaining paddy quality (Alam *et al.*, 2021). Using a giant combine harvester can speed up the harvesting process. However, its use will cause damage to the hard layer of the soil and will then cause the harvesting process to be challenging to implement. Therefore, a smaller harvester must carry out harvesting operations in problematic areas. In addition, harvesting using this small harvester is more suitable for farmers who have smaller crop areas. A micro combine harvester is also suitable for areas with low soil bearing capacity below 0.2 Mpa. A large combine harvester requires a soil-bearing capacity of more than 0.3 Mpa (Shahrin *et al.*, 1989) to ensure that harvesting operations are unaffected. Using a micro combine harvester will help the nearly 8000 hectares of paddy fields affected by soft soil with a soil-bearing capacity reading of less than 0.3 Mpa at the Muda Agriculture Development Authority (MADA) (Isa *et al.*, 2023). If this is not resolved, the rice production will be affected. Many factors influence effective combine harvester operation, including land size, machine accessibility, field-to-field distance, crop characteristics, weather and soil type, combine harvester availability and management, and economic issues (Islam *et al.*, 2021). Most farmers, especially in Sarawak, have a relatively small paddy crop area of about 1 acre or smaller. As a result, a smaller combined harvester is preferable to a more significant combined harvester. Most farmers there also engage in manual harvesting, which increases harvesting time. Farmers will benefit from the introduction of this micro combine harvester. In addition, using a micro combine harvester with a width of 1 m is more suitable for small areas because it involves low operation and maintenance costs compared to using a giant combine harvester (Abdullahi, 2020).

The overall loss of grain during the harvesting operation and combine harvester efficiency are essential indications of combine harvester performance (Siebenmorgen, 1994).

Harvesting can be done effectively if the combined harvester is regularly adjusted (Abdullahi, 2020). A reduced loss rate is essential for increasing production. Thus, the evaluation of the efficiency of the micro combine harvester in the field is required to study the performance of the micro combine harvester and is necessary to ensure that the harvester can operate in optimal conditions. Therefore, this study aims to evaluate the performance of the micro combine harvesters, including field efficiency (FE), effective field capacity (EFC), and grain losses during the harvesting process.

2. Materials and Methods

2.1. Study Area

The research was conducted at MARDI Seberang Perai, located in Penang, Malaysia, during the harvest season 2022. The rice field was cultivated using the rice variety MR297, and planting was carried out using a transplanter.

2.2. Machine Description

As shown in Figure 1, the micro combine harvester is a 12.5 Hp @ 3600 rpm, air-cooled diesel pedestrian micro combine harvester for rice. This harvesting machine is small, lightweight, self-propelled, and weighs only 1000 kg. The measurements of this machine are 3500 mm x 1600 mm x 1500 mm (L x W x H). The micro combine harvester has an operating width of one metre.

Figure 1. Micro Combine harvester

The cutting height is adjustable from 180 to 700 millimetres. This machine can be operated by a single person who is in charge of controlling the harvesting machine. The motor, manipulating unit, header, threshing, separating, and washing unit are the primary components of the self-propelled mini combine harvester. Table 1 shows the technical details and specifications of the rubber-tracked self-propelled rice micro combine harvester.

Table 1. Technical specifications of the self-propelled mini combine harvester

Parameter	Specification
Working width	100 cm
Type	Full feeding, self-propelled
Engine power	12.5 Hp @ 3600 rpm, air-cooled diesel
Engine type	Air-cooled, 1, Diesel
Starting system	12-volt electric
Transmission type	Mechanical
Crawler type	Rubber, triangle
Ground contact area	2000 cm^2
Threshing system	Cylinder rotor
Cutting height	180 mm to 700 mm
Efficiency	0.05 to 0.1 ha/hr

2.3. Performance Evaluation

The machine's theoretical and practical field capacities, as well as field efficiency, were assessed. The testing was performed several times in the MARDI Seberang Perai study plot. The speed of operation (Omar *et al*., 2022) was evaluated by recording the time needed to cross the distance in the area during the process using Equation 1.

$$S = \frac{d}{t} \; x \; 3.6 \tag{1}$$

Where:
S= Speed of operation (km/h)
d = distance travelled (m)
t = time (s)

The theoretical field capacity (Omar *et al.*, 2022) was computed without accounting for the time losses that arise during operation (Equation 2).

$$TFC = \frac{\text{W x S}}{10} \tag{2}$$

Where:
TFC = Theoretical field capacity,
W = The width between-row spacing (m),
S = The average forward speed (km/hr).

Time losses during operation, such as turning at the end of rows, mishandling, and fixing implement failure, were considered when calculating the adequate field capacity (Equation 3). EFC (Omar *et al.*, 2022) is the machine's capacity to function in real-world conditions.

$$EFC = \frac{\boldsymbol{W \, x \, S}}{\boldsymbol{10}} \times FE = TFC \times FE \tag{3}$$

Where:
EFC = Effective field capacity, which is the work rate achieved over the whole plot considering the total time taken for the work done at the plot,
FE = the field efficiency of the implementation under actual conditions.

The FE (Omar *et al.*, 2022) can be determined by dividing the adequate field capacity, EFC, by the ideal field capacity, TFC (Equation 3). Field efficiency is usually stated as a percentage.

$$FE = \frac{EFC}{TFC} x\ 100 \qquad (4)$$

2.4. Grain Losses Computation

The percentage of grain loss during the harvesting operation is required to evaluate a harvester's efficiency. Smith *et al.* (1994) explain how to assess grain loss during harvesting with a micro combine harvester. To catch the straw, a plastic bag was attached to the rear of the harvester. A 1-metre broad by 10-metre-long experimental plot was created to perform this research. 1-metre breadth accounts for the entire width of the cut. The straw caught in the bag will then be processed, and the overall weight of the paddy will be calculated to determine the number of losses. The experiment was carried out three times to acquire an average number.

3. Results

3.1. Performance Evaluation

Preliminary testing of this harvester has been carried out at MARDI Seberang Perai Penang (Figure 2). The harvesting process went very well, as expected. The theoretical field capacity of the machines was calculated by measuring the forward movement speed of the machines during harvesting work while excluding all unproductive jobs. The equivalent mean work rate for the micro combine harvester was calculated to be 0.14 ha/h based on the data in Table 2. A micro combine harvester has an adequate field capacity of 0.11 ha/hr, which was found after allowing for time wasted on useless work such as turning at the headland, moving from one harvesting row to another, and loading the yield. The time it took to harvest the complete plot and the time wasted on unproductive work were documented. The findings indicate that the micro combine harvester has a field efficiency of 78.5% and a Labour requirement of 9.1 men. Hr/ha.

Figure 2. Performance testing evaluation

Table 2. Performance Evaluation

	Speed (km/h)	**Theoretical Field Capacity (TFC) (ha/h)**	**Effective Field Capacity (EFC) (ha/h)**	**Field efficiency (FE) (%)**	**Labour requirement Man-h/ha**
Micro combine harvester	1.43	0.14	0.11	78.5	9.1

3.2. Grain Losses

Post-harvest loss data during the harvesting process using the micro combine harvester is displayed in Table 3. The recorded grain loss data is at a rate of 1.95%. The recorded loss data is low compared to the study conducted by Ramappa *et al.* (2019), in which the total grain losses recorded is 5.44%. With a low rate, farmers' income can be further increased by maintaining a low rate of losses, which will also ensure that the country's rice production increases.

Total grain loss can be decreased by ensuring the harvester is correctly set according to the manufacturer's recommendations. A reasonable adjustment is also necessary to guarantee that the harvester's efficiency works optimally. Aside from that, the harvester operator must carry out the harvesting operation according to the proper process to ensure that the operation runs as smoothly as feasible.

Table 3. Grain loss estimation

Test	Yield (gram)	Area (m^2)	Losses (gram)	Percent Losses
1	451.4	10	8.5	1.88
2	235.4	10	5.1	2.17
3	298.9	10	5.6	1.87
Average	**328.57**	**10.00**	**6.40**	**1.95**

4. Discussions

In this study, the TFC was 0.14 ha/hr, the EFC was 0.11 ha/hr, and the FE rate was 78.5 per cent. Overall, this harvester performs admirably, and the manufacturer's specs say that the work rate is 0.1 ha/hr. To increase the EFC, the machine operator must organise the harvesting process by deciding the harvesting machine's route in advance. Furthermore, the machine must be classified according to the correct procedure before beginning harvesting work. After the harvesting process has been completed, the machine must be cleaned to guarantee that the machine's state is always maintained.

High grain losses will risk the country's food security. To guarantee that harvesting losses are minimized, effective and suitable post-harvest handling of rice can reduce losses and thus increase the country's rice and rice production. Appropriate adjustment work must be performed following the procedure to guarantee reduced losses. In this study, the reported loss percentage is minimal, i.e., less than 2%. This is due to the equipment being correctly set before harvesting. Studies conducted by Amponsah *et al.* (2017) found that the micro combine harvester offered field capacities from 0.10 ha h to 0.39 ha/h, and low losses were recorded at around 1.43% to 3.43%. So, the performance of the micro combine harvester is good, and it can be used by small farmers and in soft soil areas.

5. Conclusions

Overall, the performance of the evaluated micro combine harvester was satisfactory. This micro combine harvester is ideal for producers with less than a hectare of land. Furthermore, this micro combine harvester is helpful in regions with ground contact pressure below 0.3 Mpa. With a ground contact area of 0.025 Mpa, the micro combine harvester can manage to operate the harvesting process in a soft soil area where a giant combine harvester cannot be used. Correct adjustment following the set process is required to ensure that the harvester's performance remains at its peak. Additionally, the procedure-based modification will ensure that the rate of loss may be reduced.

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Conflicts of Interest: The authors declare no conflict of interest

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