Design and Performance Test of a Portable Rice Collector Machine Based on a Screw Conveyor Mechanism

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ABSTRACT

The process of collecting grain after drying is still largely done manually, thus requiring a relatively long time and potentially increasing yield losses. This study aims to design and test the performance of a portable, screw conveyor-based grain collector to improve the efficiency of the grain collection process during the post-harvest stage. The study was conducted through the stages of design, fabrication, and testing of the tool's performance by comparing the manual method and the use of the tool based on parameters of working time, collection capacity, and grain loss. The machine was designed using a galvanized pipe frame, grain collection components, a screw conveyor system, sack supports, and a two-stroke engine drive. The test results showed that the use of the tool produced a working capacity of 2550 kg/hour, higher than the manual method of 1965.5 kg/hour. In addition, the use of the tool was able to reduce grain loss from 14.7% to 12.1% and increase the total efficiency of working time by up to 25.3%. Thus, the developed portable grain collector machine has the potential to be applied as an appropriate technology to support the efficiency of post-harvest handling of rice on a small to medium scale. The relatively low standard deviation values for all test parameters indicate a relatively consistent performance of the machine across all replicates. These results can be used as a basis for further development, particularly to evaluate the effects of variations in screw conveyor rotational speed, grain moisture content, and operating scale on machine performance. Therefore, the machine can be implemented as an appropriate technology to support efficient post-harvest rice handling on small to medium-scale farms, as well as increase the effectiveness and flexibility of its use in the field.

Keywords: *agricultural mechanization, paddy collecting machine, post-harvest rice, screw conveyor, work efficiency*

I. INTRODUCTION

Rice is a strategic food commodity that plays an important role in global and national food security as the main source of energy consumption for the community, especially in developing countries including Indonesia, as well as supporting the national agricultural sector (Paman, *et al*., 2023; Yusuf, *et al*., 2024). The success of rice production is not only determined by cultivation in the field, but also by the effectiveness of harvest and post-harvest handling in maintaining the quality and quantity of the results before distribution (Andriani, *et al*., 2025). Post-harvest stages such as harvesting, threshing, collecting, drying and storing rice are important parts of rice production because they directly affect yield losses and rice quality (Ndindeng, et al., 2021). However, yield losses at the harvest and post-harvest stages are still a major problem in many developing countries due to technological limitations and low adoption of agricultural mechanization, especially among small-scale farmers (Paman, *et al*., 2023; Castelein, *et al*., 2022). Therefore, the application of agricultural mechanization at the production and post-harvest stages is an important strategy to increase work efficiency, reduce yield losses, and support increased productivity and sustainability of modern rice production systems.

Manual grain collection using push boards or simple tools is still commonly carried out by small farmers in developing countries due to limited access to post-harvest mechanization (Castelein, *et al*., 2022; Madzivanzira, *et al*., 2024). This method requires intensive labor and has the potential to cause loss of grain due to scattering, thus reducing the efficiency of post-harvest handling compared to using mechanical tools (Castelein *et al*., 2022; Nath *et al*., 2025). Labor limitations due to urbanization and the shift of rural labor to the non-agricultural sector encourage the development of simple mechanization in the post-harvest stage (Min, *et al*., 2021; Yangchen, *et al*., 2025). The use of appropriate mechanical tools for small-scale farmers can increase labor and resource efficiency, speed up work processes, and reduce crop losses (Yangchen, *et al*., 2025). Therefore, the development of a portable grain collecting machine is an appropriate technological solution to increase post-harvest handling efficiency, reduce yield losses, and support farmer productivity (Castelein, *et al*., 2022; Nath, *et al*., 2025).

The development of mechanization of grain handling shows that screw conveyors are widely used in granular material transportation and collection systems because they are able to move materials continuously and stably and are easy to integrate with agricultural machinery (Karthikeyan, *et al*., 2025; Zhao, *et al*., 2025). Screw conveyor performance is influenced by rotational speed, inclination angle, and screw configuration which determine the transfer efficiency, flow capacity, and energy consumption of the system (Pezo, *et al*., 2025; Mei, *et al*., 2025; Zhang, *et al*., 2026). Experimental studies and simulations based on the Discrete Element Method (DEM) are widely used to analyze grain flow in conveyor systems to improve operational efficiency and reduce grain damage (Ge, *et al*., 2025; Guo, *et al*., 2025; Mei, *et al*., 2025). The development of grain collecting equipment leads to the integration of picking and screw conveyor systems to improve material flow continuity, collection efficiency, and transfer capacity compared to manual methods (Zhao, *et al*., 2025; Bulgakov, *et al*., 2025).

Although screw conveyor systems have been extensively researched for the transportation and handling of granular materials, most research focuses on industrial applications, design parameter optimization, and numerical simulations using Computational Fluid Dynamics (CFD) and Discrete Element Method (DEM) approaches (Pezo, *et al*., 2025; Mei, *et al*., 2025; Ge, *et al*., 2025). In the agricultural sector, screw conveyors are generally used as material transfer components in harvesting machines, dryers, and agricultural product storage systems (Guo, *et al*., 2025; Zhao, *et al*., 2025). However, research on the development of portable grain collectors specifically designed to support post-harvest activities at the small-scale farmer level is still very limited. Available mechanization technologies are generally relatively large in size, high investment costs, and low mobility, making them less suitable for application in small-scale farming systems (Madzivanzira, *et al*., 2024; Yangchen, *et al*., 2025).

Therefore, this study developed a portable grain collector that integrates a grain pickup unit with a screw conveyor mechanism driven by a modified two-stroke engine. Unlike previous studies that focused more on optimizing screw conveyors and industrial-scale material transfer systems, the machine developed in this study was designed with portability, ease of operation, and suitability for

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small-scale farmers' post-harvest conditions in mind. The novelty of this study lies in the integration of the grain collector and screw conveyor systems into one compact and portable machine to increase grain collection efficiency while reducing yield losses during the post-harvest process. In addition, this study also presents an evaluation of the machine's performance based on field testing through parameters of work capacity, grain loss, work time efficiency, and machine performance efficiency as a basis for developing practical, simple, and affordable post-harvest mechanization technology for farmers.

II. MATERIALS AND METHOD

This research was conducted through several main stages arranged systematically (Figure 1), starting with the identification of problems in the post-harvest grain collection process which is still done manually, followed by a literature study as the basis for tool design. The next stage was the design and fabrication of a portable, screw conveyor-based grain collection machine according to operational needs in the field. After the tool was completed, performance testing was conducted by comparing the manual method and the use of the tool based on the parameters of collection time, work capacity, and grain loss. The test data were then analyzed to evaluate the effectiveness of the tool, which was then used as the basis for drawing conclusions and developing recommendations for tool development.

2.1 Tools and Materials

The equipment used includes a welding machine, grinder, electric drill, and measuring instruments such as tape measures and stopwatches. The materials used include:

a. Galvanized pipe
Galvanized pipe (Figure 2) is used as the primary material for the tool frame, particularly for the handle and support structure. This material was chosen for its good mechanical strength and corrosion resistance, making it suitable for outdoor use, such as rice drying areas. The pipe sizes used are 1.5 inches and 2 inches, providing a balance between structural strength and weight, ensuring ease of operation.

b. Wheels
Ten-inch-diameter wheels (Figure 3) are used as mobility components, allowing the machine to be easily moved around the work area. These wheels reduce the operator's burden on moving the machine and improve work efficiency in the field. The relatively large wheel diameter also helps the machine remain stable on uneven drying surfaces.

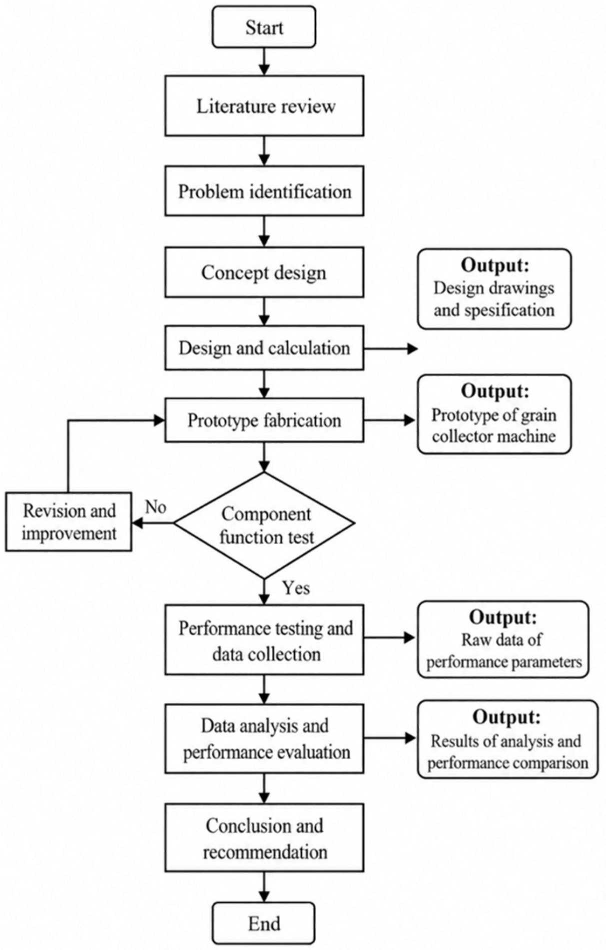

Figure 1. Research Flowchart


Figure 2. Galvanized Pipe


Figure 3. Wheels

c. Iron plate
Iron plates (Figure 4) are used to support grain or hold sacks during the collection process. This material was chosen because it has sufficient strength to support a certain amount of grain without deforming. The iron plate's dimensions, approximately 70 cm, provide sufficient surface area to support the sacks stably during the filling process.

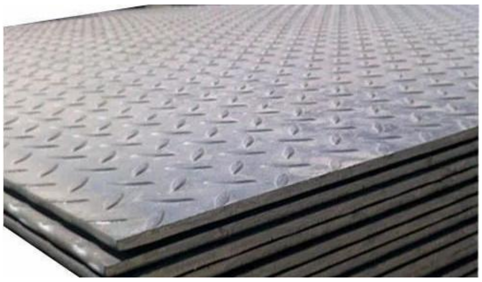
Figure 4. Iron Plates

d. Axle/Shaft
The axle (Figure 5) serves as the main axis that supports and connects the wheel to the tool frame. This component, approximately 1 inch in diameter and 50 cm long, is designed to provide strength and stability as the wheel rotates. The axle also plays a role in evenly distributing the tool's load, ensuring more balanced movement.


Figure 5. Axle

e. Pillow blocks
Pillow blocks (Figure 6) are used as bearing supports to support the shaft, ensuring stable rotation with minimal friction. These bearings are crucial for maintaining the performance of rotating systems, particularly screw conveyors, thereby reducing component wear and increasing tool efficiency. The bearing size used is 25 mm.


Figure 6. Pillow Block

f. Electrodes
The RD-E6013 electrode (Figure 7) is used as a welding material in the tool fabrication process. This electrode is used to connect various metal components such as galvanized pipes and sheet metal. This electrode was selected based on its ability to produce strong and stable joints, as well as its ease of use in light to medium construction welding processes.

Figure 7. Electrodes

g. Grinding wheels
A 4-inch grinding wheel (Figure 8) is used as an aid in the cutting and shaping process during fabrication. This component allows for precise cutting of pipes, plates, and other metal components, thus supporting the tool assembly process according to the planned design.


Figure 8. Grinding Wheel

h. Lawn mower
A two-stroke lawn mower engine (Figure 9) is used as the primary power source for the machine. This engine is modified to generate rotational power that is transmitted to a screw conveyor system, enabling the mechanical collection and transfer of grain. This engine was selected based on its availability in the field, ease of use, and its ability to generate sufficient rotational power to support the machine's performance.

Figure 9. Lawn Mover

2.2 Machine Design

The grain collector machine is designed with functionality, mobility, and ease of operation at the farmer level in mind. The main components of the machine include the frame, drive system, screw conveyor, grain collector, and wheels. The machine works by collecting grain from the drying floor using the pick-up section and then transferring it through a screw mechanism to the collector. The drive system uses a two-stroke engine connected to a screw shaft via a transmission system. The machine is designed to be portable for easy transportation and field use.

2.3 Fabrication Process

Machine fabrication includes cutting materials, assembling the frame, installing mechanical components, and installing the drive system. The main frame is fabricated by welding galvanized pipe according to the design. Next, the shaft and threads for the grain transfer system are installed, followed by the installation of the drive motor and transmission system. After all components are installed, a functional check is performed to ensure proper operation of the machine before testing.

2.4 Machine Performance Testing Method

Testing was conducted to evaluate the machine's performance in the grain collection process by comparing manual methods with the use of tools. The test was carried out on a 50 m2 grain drying area with uniform surface conditions. The parameters observed included collection time (seconds), work capacity (kg/hour), grain loss (%), time efficiency (%), and machine performance efficiency (%). The testing procedure was carried out by operating the tool until all the grain was collected, then recording the time required and weighing the amount of grain that was successfully collected and that was lost.

2.5 Engine Performance Parameters

The performance of the screw conveyor-based rice collecting machine is determined based on the following parameters.

a. Machine working capacity
   The working capacity of the machine is calculated based on equation 1:

$$C = \frac{m}{t} \tag{1}$$

   where C, m, and t are respectively the working capacity of the tool (kg/hour), the weight of the collected rice (kg), and the time required to collect the rice (hours).

b. Loss of grain
   Grain loss is defined as the percentage of grain scattered during the first collection, either manually or using a machine calculated based on equation 2 (Sikome, *et al.*, 2023):

$$L\ (\%) = \frac{m_l}{m_t} x100\% \tag{2}$$

   where L, m_l, and m_t are respectively the percentage of grain loss during collection (%), weight of scattered grain (kg), and total grain weight (kg).

c. Efficiency of work time
   Working time efficiency is calculated based on the comparison of manual method time and tool usage as expressed in equation 3:

$$E_t = \frac{t_t - t_m}{t_t} x\ 100\% \tag{3}$$

   where E_t, t_t, and t_m are respectively the time efficiency (%), manual rice collection time (hours), and rice collection time using a machine (hours).

d. Performance efficiency
   The performance efficiency of the machine is determined based on the ratio of the weight of the collected grain to the total weight of the grain, and is expressed in equation 4 (Purnomo & Fadli, 2023):

$$\eta = \frac{m}{m_t} x\ 100\% \tag{4}$$

where η, m, and m_t are respectively the working efficiency of the tool (%), the weight of collected grain (kg), and the total weight of grain (kg).

2.6 Data Analysis

Test data was analyzed quantitatively and descriptively by comparing performance parameters between manual and machine methods. The analysis focused on increased work capacity, reduced collection time, and reduced grain loss to assess the effectiveness of the developed machine.

III. RESULTS AND DISCUSSION

3.1 Machine Design and Fabrication Results

The portable grain collector machine that has been designed consists of several main components that are integrated with each other, namely the drive system, screw conveyor, grain collection component, and sack support as a container for the collected results. Overall, the tool has dimensions of approximately 1 m high and 50 cm wide (Figure 10), with a portable design so it is easy to use in areas where grain is dried. The drive system uses a modified grass trimmer engine to generate rotation on the screw shaft, thus allowing the process of grain removal to be carried out mechanically and continuously.

Figure 10. Rice Harvesting Machine

3.1.1 Screw Conveyor

The grain conveyor screw is the main component in the material transfer system, functioning to flow grain from the drying floor surface to the collection container. The screw is designed with a length of approximately 1 m and is installed parallel to the direction of grain flow (Figure 11). The screw's working principle utilizes the rotational motion of the shaft to generate axial thrust that can move the grain continuously. This screw design allows for a more stable grain transfer process than manual methods, because the material flow is uninterrupted and does not depend on operator movement. Furthermore, the relatively long screw provides adequate working range for the grain collection process in the field.

Figure 11. Screw Conveyor

3.1.2 Sack Holder

The sack holder functions as a storage place for the grain transferred from the screw. This component is designed with dimensions of approximately 40 cm x 40 cm and is able to support the sacks stably during the collection process (Figure 12). The support design is made to be integrated with the tool frame so that it can move together with the tool when operated in the field. The existence of this sack holder allows the grain collection process to be more efficient because the grain that has been moved by the screw is directly accommodated in the sack without requiring an additional transfer process. Additionally, the stable design also helps reduce grain loss due to spills during the collection process.

Figure 12. Sack Holder

3.1.3 Grain Collector Component

The grain collector component serves as the initial component that comes into direct contact with the grain on the drying floor. This component is designed with dimensions of approximately 70 cm x

30 cm and functions to direct the grain into the screw system (Figure 13). The collector component is designed wide enough to cover a wider collection area in a single pass, thereby increasing the machine's efficiency. Furthermore, the shape and position of this component are designed to allow the grain to enter the screw optimally without much spillage, thus supporting the overall performance of the machine in reducing yield losses during the collection process.

Figure 13. Grain Collector Component

3.2 Test Results and Calculations

The results of the grain collection tool test are presented in Table 1. The test results show that the use of a screw conveyor-based grain collecting machine can increase the efficiency of the grain collection process compared to the manual method. The average grain collection time (T1) decreased from 906.7 seconds using the manual method to 720 seconds using the machine, while the total collection time (Tt) decreased from 1446.7 seconds to 1080 seconds. This performance improvement resulted in an increase in work capacity from 1965.5 kg/hour to 2550.0 kg/hour, an increase of approximately 29.7%. In addition, work time efficiency reached an average of 20.6% based on the main collection time and 25.3% based on the total collection time.

In terms of yield loss, the use of the machine increased the amount of grain collected from an average of 495 kg to 510 kg and reduced the amount of scattered grain from 85 kg to 70 kg. Consequently, the percentage of grain loss decreased from 14.7% with the manual method to 12.1% with the machine. This reduction in yield loss contributed to an increase in performance efficiency from 85.3% to 87.9%. These results indicate that the integration of the grain collection component with the screw conveyor mechanism can accelerate the work process while increasing the effectiveness of grain collection in post-harvest activities.

Table 1. Manual Testing

N	T1 (s)	T2 (s)	Tt (s)	W1 (kg)	W2 (kg)	Wt (kg)	C (kg/h)	L (%)	η (%)
1	905.0	540.0	1445.0	494.0	86.0	580.0	1965.1	14.8	85.2
2	920.0	540.0	1460.0	501.0	79.0	580.0	1960.4	13.6	86.4
3	895.0	540.0	1435.0	490.0	90.0	580.0	1970.9	15.5	84.5
$\bar{X}$	906.7	540.0	1446.7	495.0	85.0	580.0	1965.5	14.7	85.3

Table 2. Testing with a Collection Machine

N	T1 (s)	T2 (s)	Tt (s)	W1 (kg)	W2 (kg)	Wt (kg)	C (kg/h)	L (%)	η (%)
1	730.0	360.0	1090.0	517.0	63.0	580.0	2549.6	10.9	89.1
2	710.0	360.0	1070.0	502.0	78.0	580.0	2545.4	13.4	86.6
3	720.0	360.0	1080.0	511.0	69.0	580.0	2555.0	11.9	88.1
$\bar{X}$	720.0	360.0	1080.0	510.0	70.0	580.0	2550.0	12.1	87.9

Table 3. Efficiency of Work Time

N	EffT1	EffTt
1	19.3	24.6
2	22.8	26.7
3	19.6	24.7
$\bar{X}$	20.6	25.3

where:
N = number of tests
T1 = ime used for one rice collection
T2 = the time used for one collection of scattered grain
Tt = total time spent collecting grain
W1 = weight of grain collected at time T1
W2 = weight of scattered grain at collection time T2
Wt = total weight of grain
C = work capacity
L = percentage of scattered grain
η = performance efficiency
EffT1 = efficiency of working time for collecting rice at T1
EffTt = efficiency of working time for collecting rice at Tt

3.3 Discussion

Test results show that the use of a portable grain collector machine can speed up the grain collection process compared to the manual method. The average collection time using the tool was 720 seconds, while the manual method took approximately 906.7 seconds. Furthermore, the total working time after taking into account the collection of scattered grain was also lower when using the tool, namely 1080 seconds compared to the manual method, which was 1446.7 seconds. This condition indicates that the use of simple mechanization in the post-harvest stage can increase work efficiency and reduce grain handling time in the field. The results of this study are in line with Nath et al. (2025) and Madzivanzira et al. (2024) who stated that the application of post-harvest mechanization can increase work productivity and reduce dependence on manual labor in small-scale rice production systems.

The use of a grain collector machine produces a working capacity of 2550 kg/hour, higher than the manual method of 1980 kg/hour. This increase in working capacity is influenced by the screw conveyor mechanism that is able to move grain continuously and stably to the collection container, so that the collection process takes place faster and more efficiently than the manual method that relies on operator movement. In addition to increasing work capacity, the use of the tool is also able to reduce grain loss from 14.7% in the manual method to 12.1%. This reduction in yield loss indicates that the integration of the collection component with the screw conveyor system is able to direct the flow of grain in a more controlled manner and minimize grain loss during the collection process. The results of this study are in line with Zhang et al. (2026), Pezo et al. (2025), and Mei et al. (2025) who stated that screw conveyors are able to move granular material continuously and efficiently through a stable material flow. In addition to increasing work capacity and productivity of agricultural product handling (Bulgakov, et al., 2025; Ge, et al., 2025), the application of post-harvest mechanization is also reported to be able to increase the efficiency of grain handling and reduce yield losses on a small-scale farmer (Madzivanzira, et al., 2024; Nath, et al., 2025).

The efficiency of grain collection time, excluding additional time for recollecting scattered grain, reached 20.6%, while the total work time efficiency reached 25.3%. Furthermore, the machine's efficiency reached 87.9%, higher than the manual method at 85.3%. This increase in efficiency indicates that integrating the grain collection system with a screw conveyor mechanism can accelerate the collection process while reducing additional time due to scattered grain. The conveyor-based material transfer system allows for a more continuous and controlled grain flow, resulting in more effective operational performance than manual methods. These results are also supported by research on the development of an Internet of Things-based grain collection mechanism, which reported that the integration of a mechanical collection system with a control system can help the grain collection process become more efficient and reduce dependence on manual labor (Purnomo & Fadli, 2023). Furthermore, the integration of the material collection system and conveyor can improve transportation efficiency, work capacity, and the stability of granular material flow in agricultural

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product handling systems (Bulgakov, et al., 2025; Ge, et al., 2025).

Based on the description, the research results indicate that the developed portable rice collector has the potential to be applied as an appropriate technology in the rice post-harvest process at the farmer level. The simple and portable design of the device makes it easier to operate and move than larger machines. In addition to increasing work capacity and time efficiency, the use of the device can also reduce yield losses during the rice collection process. Therefore, the developed device has the potential to support increased productivity and efficiency of post-harvest rice handling, particularly in small- to medium-scale farming systems.

Table 4 presents a summary of the performance testing results of the manual and screw conveyor-based grain collection machines. Data are presented as average values and standard deviations from three repeated tests for collection time, working capacity, grain loss, and machine performance efficiency. Based on Table 1, the use of a screw conveyor-based grain collecting machine provided better performance than the manual method in all observed parameters. The grain collection time (T1) decreased from 906.7 ± 12.6 seconds to 720.0 ± 10.0 seconds, while the total collection time (Tt) decreased from 1446.7 ± 12.6 seconds to 1080.0 ± 10.0 seconds. This reduction in working time contributed to an increase in working capacity from 1965.5 ± 5.3 kg/hour in the manual method to 2550.0 ± 4.8 kg/hour using the machine. These results indicate that the screw conveyor mechanism is able to move grain more quickly and continuously than manual collection.

Table 4. Summary of Test Results

Parameter	Manual (Mean ± SD)	Mesin (Mean ± SD)
T1 (s)	906.7 ± 12.6	720.0 ± 10.0
Tt (s)	1446.7 ± 12.6	1080.0 ± 10.0
C (kg/h)	1965.5 ± 5.3	2550.0 ± 4.8
L (%)	14.7 ± 0.95	12.1 ± 1.25
η (%)	85.3 ± 0.95	87.9 ± 1.25

In addition to increasing work capacity, the use of the machine can also reduce grain loss during the collection process. The percentage of grain loss (L) decreased from 14.7 ± 0.95% to 12.1 ± 1.25%, while performance efficiency (η) increased from 85.3 ± 0.95% to 87.9 ± 1.25%. The relatively small standard deviation values for all parameters indicate that the test results are quite consistent across the three replications. Overall, these results indicate that the developed grain collecting machine can increase the efficiency and effectiveness of post-harvest grain handling compared to manual collection methods.

IV. CONCLUSION

The developed portable screw conveyor-based rice collector machine is capable of increasing the effectiveness of rice collection compared to manual methods, with a working capacity of 2550 kg/hour and a working time efficiency of up to 25%. The use of the tool can also reduce grain loss from 14.7% to 12.1%, thus making the collection process more efficient and controlled. In addition to its simple and portable design, this tool has the potential to be applied to post-harvest rice handling at the small-scale farmer level. Further research is recommended to examine the effect of variations in screw rotation speed and grain condition on machine performance.

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