

Development of a Goat Manure Shredding Machine as an Appropriate Technology for Organic Fertilizer Production

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Article Information	ABSTRACT
Article History Received : May 31, 2025 Revised : June 06, 2025 Published : July 04, 2025	This study aimed to develop and test an appropriate technology in the form of a goat manure shredding machine to enhance organic fertilizer production and improve waste management efficiency. The research adopted a 4-D development model comprising Define, Design, Develop, and Disseminate stages. Initial problem analysis was conducted through field observations and farmer interviews. Based on these findings, a prototype shredding machine was designed and fabricated using a 7 HP gasoline engine with adjustable rotation speeds. The machine was then tested in both workshop and field environments. Fifteen local farmers participated in the field implementation, which included technical training and composting trials. The performance test showed that the machine could process 10 kg of goat manure in 5.23 minutes at low speed and 2.12 minutes at high speed, resulting in a maximum shredding capacity of 283.02 kg/hour. The shredded manure accelerated the composting process, producing mature organic fertilizer within 21–28 days. The final compost exhibited optimal physical characteristics, including dark color, neutral odor, and balanced moisture content. Additionally, farmers reported increased skills, reduced labor burden, and growing interest in commercializing the compost product. In conclusion, the developed shredding machine proved effective in addressing manure waste challenges, enhancing composting efficiency, and supporting sustainable agricultural practices in rural areas. The technology has strong potential for replication and integration into broader circular agriculture systems.
Keywords: <i>Appropriate technology; Goat manure; Organic fertilizer; Shredding machine; Sustainable agriculture</i>	

INTRODUCTION

Wonokerso Village, located in Pakisaji District, Malang Regency, is an agricultural area endowed with abundant natural resources. Situated at an altitude of 300–500 meters above sea level and supported by natural irrigation systems from rivers and local springs, this village possesses a geographical condition that is ideal for agricultural and livestock development. Its fertile land and cool climate allow for the cultivation of various food and horticultural crops. According to the 2024 village government data, 2,705 out of the 4,769 total residents are in the productive age range (18–56 years), serving as a vital asset for economic development, including livestock waste processing initiatives.

One of the main commodities in Wonokerso's livestock sector is goat farming, with the most commonly raised breeds being Etawa, kacang, and gibas goats. Goat farming is practiced

traditionally by families or small groups, relying on naturally available forage such as local leaves and grasses like kabesak and elephant grass. This practice aligns with findings that many rural Indonesian farmers still rely on extensive and traditional husbandry methods (Achmad et al., 2023; Aisyah et al., 2022; Alimudin; et al., 2020). Research by Anam and Falasifah has shown that such forages contribute significantly to goat growth, while feed diversification plays a crucial role in improving livestock productivity (Anam & Regar, 2022; Falasifah & Setyowati, 2023). Nevertheless, limited knowledge of feed management and animal health remains a challenge for local farmers (Amalo et al., 2020; Dhanisa et al., 2022).

A pressing issue in Wonokerso Village is the suboptimal management of livestock waste, particularly goat manure. Most of the waste is disposed of around the pens, posing risks of soil and water pollution. In fact, goat manure holds significant potential as a raw material for organic fertilizer, containing essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K), as evidenced by Krisnawati et al. (2021) and Hasan et al. (2021). Organic fertilizers derived from goat manure can improve soil structure, increase water retention capacity, and support beneficial soil microorganism activity vital for plant growth (Rosniawaty, 2021; Pandaleke et al., 2023; Tanjung et al., 2022).

Organic fertilizer use also offers a strategic alternative to reduce dependency on chemical fertilizers, which are often costly and environmentally harmful. According to (Kadir et al., 2023), production costs in agriculture can be reduced through the use of environmentally friendly organic inputs. Further studies affirm that organic fertilizers enhance the water-holding capacity of soil (Arman et al., 2020; Farid, 2020) and mitigate soil degradation caused by prolonged chemical fertilizer use (Firdhausiyah & Prihatin, 2023; Ganestri et al., 2021). However, few farmers and livestock keepers in Wonokerso have implemented proper methods to process goat manure into usable organic fertilizers, due to technological limitations and insufficient technical knowledge.

Literatur Review

Goat farming waste, particularly manure, poses a significant environmental challenge in rural agricultural systems of developing countries, especially when not managed properly. Improper disposal of goat manure contributes to land and water pollution, degrades local ecosystems, and poses serious public health risks (Fyka et al., 2021; Hasan et al., 2021). However, numerous studies have demonstrated that when adequately processed, this type of organic waste can be converted into high-value compost. Jadmiko et al. (2024) reported the success of compost production from goat manure in Jember, highlighting the potential for manure valorization within rural economies.

One of the primary obstacles to effective manure processing is the limited understanding of composting techniques and the economic potential of processed waste among rural farmers. Previous research by (Jadmiko et al., 2024; Krisnawati et al., 2021) indicates that a lack of technical knowledge significantly reduces the optimization of goat manure resources. Additionally, Jasman et al. (2023) emphasize that increasing financial literacy among small-scale farmers can influence better decision-making in manure resource allocation. From a health perspective, improperly managed manure can act as a medium for zoonotic disease transmission, requiring innovative and sustainable treatment strategies, including composting and biogas technology ((Nugraha & Desnanjaya, 2022; Indraloka et al., 2023).

Goat manure is notably rich in essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K), making it a valuable input for sustainable agriculture ((Kurniati Sari & Ahmad Hasan Al-Hafiz, 2024; Maula, 2023)). The Food and Agriculture Organization (FAO) classifies organic fertilizers including animal manure as critical for enhancing soil fertility and crop productivity. Compared to cow or poultry manure, goat manure provides a more balanced nutrient profile and better supports long-term soil health. Studies confirm that processed goat manure improves soil cation exchange capacity and boosts yields; strawberries grown with such compost, for instance, have shown yield increases of up to 20% compared to chemical fertilizers (Migusnawati et al., 2022; Pandaleke et al., 2023). Composting methods, including aerobic

fermentation and the application of effective microorganism (EM4) decomposers, have been shown to enhance nutrient bioavailability (Muzaka et al., 2021; Priyadi et al., 2021).

The integration of shredding technology in organic waste management introduces a significant advancement in improving compost production efficiency, particularly in manure-based systems. Shredding machines operate by fragmenting biomass into smaller particles, thereby increasing surface area and accelerating the decomposition process (Purnamasari et al., 2022). This method is especially effective for goat manure, which can be difficult to process in bulk due to its texture and density. Machine types vary in design and capacity ranging from 4.5–7.0 HP gasoline engines to 8–16 HP diesel units adapted according to volume and processing needs (Rosniawaty, 2021; Satriawan et al., 2023). (Pandaleke et al., 2023) found that the use of shredders increased daily compost output to 85–100 kg, enhancing microbial activity and producing compost with improved consistency. Moreover, evidence from controlled trials in various rural regions such as Banyuwangi indicates that such machines significantly elevate fertilizer quality while reducing waste accumulation (Muzaka et al., 2021; Wulandari, 2025).

Appropriate Technology (AT), when developed based on empirical evidence and adapted to local needs, serves as a catalyst for rural innovation and sustainability. Defined as cost-effective, context-relevant, and environmentally sound, AT can support agricultural modernization and resource efficiency (Saputra & Karcana, 2022; Satriawan et al., 2023). Within the framework of innovation diffusion theory (Rogers, 2003), the adoption of AT is influenced by its perceived advantages, compatibility with existing systems, and ease of use. Furthermore, AT implementations are more sustainable when accompanied by structured capacity-building programs, fostering user independence and technical competence ((Siti et al., 2021; Sujito et al., 2021). Practical examples, such as wind-powered hydroponic irrigation in West Java ((Wulandari et al., 2020)), validate how appropriate technology when supported by institutional collaboration can increase food production and local resilience.

In the context of this study, the development of a goat manure shredding machine represents a strategic response to the twin challenges of waste management and organic fertilizer production. Empirical findings from recent studies suggest that transforming livestock waste into valuable inputs not only reduces environmental burden but also supports rural economic empowerment (Nainggolan, 2022). Thus, the integration of functional, locally appropriate technologies such as shredding machines holds considerable promise for advancing circular agricultural systems in villages like Wonokerso.

RESEARCH METHODS

This study employed the 4-D development model (Define, Design, Develop, Disseminate) to produce a functional goat manure shredding machine as an appropriate technology for organic fertilizer production in Wonokerso Village, Malang Regency.

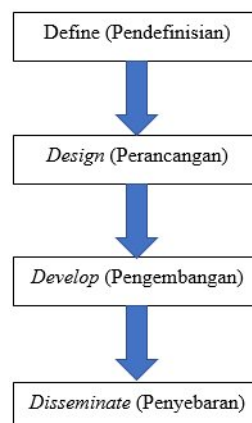


Figure 1. Development Models 4D
(Muqdamien dkk, 2021)

Each stage of the model was systematically implemented as follows:

1. Define (Pendefinisian)

At this initial stage, a needs analysis was conducted to identify existing problems related to goat manure management and the lack of proper waste processing technology in the village. Field observations, interviews with farmers, and environmental assessments revealed that unmanaged manure was contributing to local pollution. Additionally, the majority of farmers lacked the knowledge and tools necessary to process manure into organic fertilizer. These findings became the foundation for the development of a suitable technology-based solution.

2. Design (Perancangan)

Based on the data collected, the research team collaborated with mechanical engineering experts to design a shredding machine prototype tailored to the local context. The design specifications considered engine type (gasoline-powered), ease of use, portability, and compatibility with the typical characteristics of goat manure. Detailed engineering drawings were created, and the machine was built using materials readily available in the region. This phase also included planning for instructional materials and training modules to support machine use and composting processes.

3. Develop (Pengembangan)

In this phase, the machine was fabricated, tested, and improved through iterative trials. The prototype underwent workshop testing to ensure structural durability, cutting efficiency, and motor stability. Following successful lab validation, the machine was transported to the field for practical implementation with 15 selected farmers. These farmers participated in a series of structured activities including technical training, composting workshops, and machine operation practice. Performance tests of the machine were conducted at three engine speeds (low, medium, high) to measure processing speed (kg/hour), energy efficiency, and compost quality.

As part of the development phase, the fabrication process was carried out through several key stages including shaft machining, frame welding, and mechanical assembly as shown in Figures 2 to 4. The fabrication process consisted of several stages, including conceptual design, component selection, assembly, welding, and preliminary workshop testing. The cutting mechanism utilized a blade assembly mounted on a horizontal shaft and driven by a V-belt transmission system. After assembly, the machine was subjected to both static and dynamic tests to ensure structural stability, operational safety, and cutting effectiveness. Once validated, the unit was transported and installed at the field trial site in Wonokerso Village, where it was tested directly with the participating farmers.



Figure 2. Machining Process of Shaft Making & Welding Shreeding Machine



Figure 3. Welding Process for Making Shredding Machine Frame



Figure 4. Shredding Machine Assembly

4. Disseminate (Penyebaran)

After field trials showed effective results, the shredding machine and composting method were disseminated to the broader farming community. Dissemination included (1) demonstration sessions for surrounding villagers, (2) preparation of printed manuals and video tutorials, and (3) the proposal of machine replication in neighboring sub-villages. Farmers involved in the development became peer mentors for other community members. The long-term plan included collaboration with village government and agricultural extension services to integrate the use of shredders into local organic farming programs.

RESULTS AND DISCUSSION

Results

The development of a shredding machine as an appropriate technology for processing goat manure in Wonokerso Village was successfully carried out through a collaborative design and fabrication process. This machine was specifically designed to meet the needs of local goat farmers, who previously lacked adequate waste processing tools. The frame was constructed from lightweight yet durable steel, and the machine was equipped with rotating blades powered by a 7 HP gasoline engine, along with a hopper and discharge system that supported continuous and efficient operation.

During the field trial, the machine was tested using fresh goat manure sourced from local livestock pens. The testing evaluated several key parameters, including shredding capacity per hour, particle uniformity, engine stability, and user feedback.

Table 1. Performance Test Results of the Shredding Machine

Trial	Low Speed (minutes)	Medium Speed (minutes)	High Speed (minutes)
I	5.15	3.28	2.12
II	5.3	3.3	2.14
III	5.25	3.32	2.1
Total	15.7	9.9	6.36
Average	5.23	3.3	2.12

Based on Table 1, the performance test of the shredding machine was conducted using three different engine speeds to shred 10 kg of goat manure. At a low engine speed of approximately 1200 RPM, the machine took an average of 5.23 minutes to complete the shredding process. At a medium speed of around 2400 RPM, the required time decreased to 3.30 minutes, while at a high speed of approximately 3600 RPM, the machine only required 2.12 minutes. These results clearly demonstrate the effect of engine speed on processing time, with higher speeds resulting in significantly faster shredding performance.

The average shredding capacity per hour was calculated based on the time taken to process 10 kg of goat manure at each speed level. At low speed, the machine could shred approximately 115.72 kg per hour. At medium speed, the capacity increased to 181.82 kg per hour. The highest performance was recorded at high speed, where the machine reached a capacity of 283.02 kg per hour. These findings confirm that higher rotational speeds substantially enhance the machine's efficiency in processing organic waste. The results of these trials are visually presented in Figure 4.

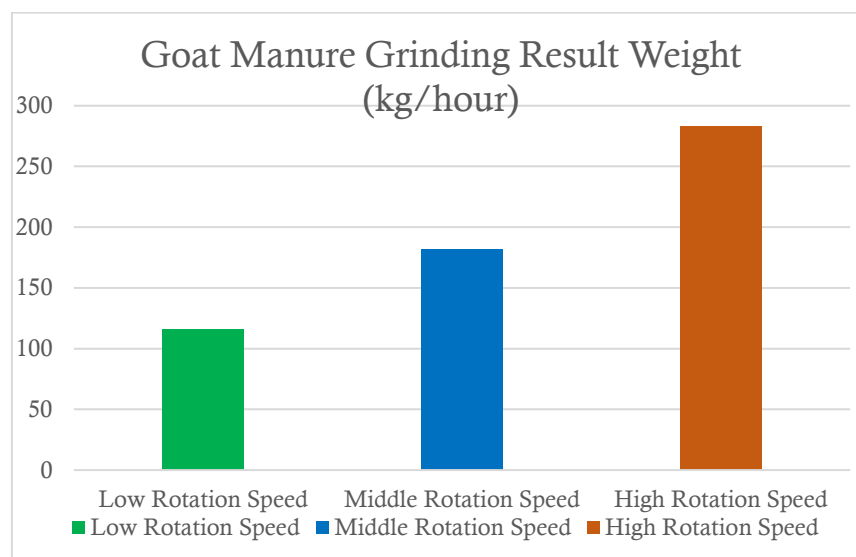


Figure 5. Performance Graph of the Shredding Machine Based on Engine RPM

Following shredding, the goat manure was mixed with dry organic matter and decomposer agents (EM4), and left to ferment for 21–28 days. The resulting compost exhibited excellent characteristics: neutral odor, dark color, and balanced moisture, indicating a successful decomposition process. This outcome not only demonstrates the technical effectiveness of the machine, but also highlights its potential to shift local farmers' behavior in livestock waste management. Thus, the implementation of this program produced two major outcomes: (1) the

creation of a functional, locally appropriate technological tool, and (2) improved efficiency and quality of the organic fertilizer produced. These findings suggest that the goat manure shredding machine has strong potential for replication in other rural communities with similar livestock and environmental conditions.



Figure 6. Disseminate of Shredding Machine

Discussion

The implementation of appropriate technology in the form of a goat manure shredding machine has demonstrated high effectiveness in optimizing livestock waste management processes, especially in rural agricultural settings. Compared to conventional manual methods, the application of this mechanical solution significantly reduced time and labor burdens. Performance tests revealed that at a low engine speed of approximately 1200 RPM, the machine processed 10 kg of goat manure in an average of 5.23 minutes. When operated at high speed (around 3600 RPM), the same volume was processed in just 2.12 minutes, resulting in a maximum processing capacity of 283.02 kg per hour.

These results confirm the shredding machine's operational efficiency, aligning with findings by Migusnawati et al. (2022) whose shredding prototype achieved 100 kg/day in compost production capacity. In comparison, the current study's machine demonstrates significantly higher throughput, suggesting an advancement in design optimization and energy transfer. Furthermore, the performance closely approaches that of larger-scale units described by Siti et al. (2021), which employ diesel engines and achieve capacities of up to 300 kg/hour. This affirms that small-engine shredders (7 HP gasoline-powered) can deliver comparable effectiveness when adapted with appropriate blade configurations and shaft speed calibrations.

The enhanced processing speed directly contributes to reducing environmental pollution from unmanaged livestock waste. By breaking down manure into finer particles, the machine improves aeration and decomposition rates, thereby accelerating the composting cycle and producing mature fertilizer in 21–28 days. These characteristics align with Muzaka et al. (2021), who emphasized that reduced particle size improves microbial accessibility and nutrient bioavailability during composting.

Beyond its technical merits, the application of the shredding machine supports long-term economic sustainability. Farmers now have access to an alternative organic fertilizer source that reduces dependency on synthetic inputs, which are often cost-prohibitive and environmentally degrading. As highlighted by Syafitri & Sari (2023) appropriate technology plays a critical role in enhancing rural profitability by converting waste into productive assets. The reduced cost of agricultural inputs achieved through self-produced fertilizer represents a measurable economic benefit.

Importantly, this research also observed significant behavioral and cognitive shifts among users. Prior to implementation, most farmers had limited understanding of composting principles. After repeated machine operation, hands-on training, and successful compost output, farmers demonstrated increased confidence and motivation to utilize organic fertilizer independently. This aligns with Ganestri et al. (2021), who noted that experiential learning accelerates technology adoption and fosters sustainable practice change.

While the machine's primary value lies in its technical function, its broader socio-economic implications are equally notable. Farmers began to recognize the economic potential of processed goat manure and explored possibilities for packaging and commercial distribution of the organic fertilizer. The transformation of livestock waste into marketable commodities reflects the integration of environmental management with rural entrepreneurship a notion supported by Hasan et al. (2021), who observed that zero-waste training programs stimulate awareness and innovation in waste valorization.

In terms of agronomic impact, the organic fertilizer produced from the shredded manure exhibited favorable qualities neutral odor, granular texture, and balanced moisture indicating compost maturity and usability. The nutrient-rich profile of the compost contributed to improved soil structure and crop performance. These observations reinforce the study by Jadmiko et al. (2024), who reported yield increases of up to 20% in strawberries using goat-manure-based fertilizer, confirming the product's agricultural efficacy.

Finally, the success of this development initiative highlights the importance of multi-stakeholder collaboration in advancing technological innovation in agriculture. Synergies between universities, engineering experts, and local farming groups enabled effective knowledge transfer, capacity building, and contextual adaptation of the technology. These elements are essential for ensuring the long-term sustainability and replicability of the innovation in other rural areas with similar environmental and livestock profiles.

CONCLUSION

This study aimed to address the problem of unmanaged goat manure waste in Wonokerso Village by developing an appropriate technology solution in the form of a shredding machine. The results confirmed that the development and implementation of this machine significantly improved the efficiency of manure processing into organic fertilizer, both in terms of speed and compost quality. The shredding machine successfully reduced manure particle size, accelerated decomposition, and demonstrated a maximum processing capacity of 283.02 kg/hour, which is considered high for a 7 HP gasoline-powered unit. The strengths of the research lie in the machine's practicality, ease of use, and adaptability to rural conditions. It contributed to reducing environmental pollution, lowering fertilizer costs, and increasing farmers' awareness and skills in sustainable agricultural practices. Furthermore, the processed fertilizer showed favorable agronomic characteristics, supporting its viability for crop production enhancement.

However, the study also identified several limitations. First, machine performance varied depending on moisture content and fiber composition of the manure, indicating a need for pre-drying or material pre-sorting in certain cases. Second, although farmers demonstrated positive behavioral changes, continuous mentoring and follow-up are required to ensure long-term adoption and maintenance of the equipment. Additionally, the economic feasibility of mass production and distribution of the shredding machine was not fully explored within this study's scope. Despite these limitations, the research provides evidence that the application of appropriate

technology when systematically developed and locally contextualized can offer a sustainable solution for livestock waste management while fostering rural entrepreneurship. Future research is recommended to optimize machine design for scalability, evaluate long-term soil and crop impacts, and explore integration with other circular agriculture innovations.

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