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Design and Performance Evaluation of a Mechanical Screw-Press Manure Processor for Small-Scale Farming

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Abstract

Livestock manure remains an underutilized agricultural resource in small-scale farming, often contributing to environmental pollution due to improper disposal and inefficient composting practices. This study presents the design and performance evaluation of a locally fabricated mechanical screw-press manure processor intended to improve manure management efficiency while producing nutrient-rich organic fertilizer. The system integrates mechanical compression, solid–liquid separation, and controlled aeration to reduce moisture content, enhance nutrient retention, and minimize processing time. Performance evaluation was conducted by analyzing operational parameters such as processing capacity, operating speed, and cycle time, as well as fertilizer quality indicators including nitrogen, phosphorus, and potassium (NPK) content. Agronomic effectiveness was assessed through plant growth trials using Brassica rapa (pechay). Results indicate that the developed manure processor significantly improved processing efficiency and produced organic fertilizer comparable to conventional composting methods in terms of nutrient content, with favorable effects on plant growth and soil fertility. The findings demonstrate that the proposed system offers a practical, energy-efficient, and locally adaptable solution for sustainable manure management in small-scale agricultural settings.

Keywords: *Screw-Press Manure Processor, Organic Fertilizer, Small-Scale Farming, Sustainable Agriculture, Manure Management.*

INTRODUCTION

Sustainable agriculture increasingly depends on efficient waste management strategies that convert agricultural byproducts into valuable resources. Livestock manure, when improperly handled, contributes to nutrient loss, greenhouse gas emissions, and environmental degradation. Conventional composting methods commonly employed by small-scale farmers are labor-intensive, weather-dependent, and characterized by long processing times and inconsistent fertilizer quality.

Recent studies have introduced various mechanical and automated systems designed to accelerate composting and improve fertilizer uniformity. Park et al. (2024) reported that automated composting systems significantly reduced processing time and odor emissions through controlled aeration and mixing. Similarly, Shahadan et al. (2022) developed a compost processor equipped with a grinder and conveyor system that shortened drying time from two days to just thirty minutes. These systems demonstrate that the integration of aeration and mechanical mixing enhances nutrient recovery, decomposition efficiency, and product consistency.

Mechanical manure processing technologies such as screw-press separators have been shown to enhance solid–liquid separation, improve aeration, and accelerate stabilization of organic matter. However, commercially available systems are often expensive, energy-intensive, and unsuitable for small farms due to their reliance on imported components and high maintenance requirements. Consequently, there remains a need for a simplified, low-cost, and locally manufacturable manure processing system tailored to small-scale agricultural operations.

This study addresses this gap by developing and evaluating a mechanical screw-press manure processor designed to convert raw livestock manure into usable organic fertilizer. Anchored on circular economy and ecological modernization

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principles, the study aims to assess the system's operational performance and fertilizer quality while examining its effects on soil nutrients and plant growth.

METHODOLOGY

Research Design and Locale

A comparative experimental research design was employed to evaluate the performance of the developed manure processor against conventional composting methods. The study was conducted in Barangay Butubut Sur, Balaoan, La Union, Philippines, a rural agricultural community with abundant livestock manure resources. These conditions make it a suitable location for organic fertilizer production and for testing a manure-processing machine, as the area has a substantial supply of livestock waste.The area is known for its clay-loam soils, which have been widely used to grow field crops and vegetables. Clay-loam soil is known for its fine texture, and its water-holding characteristics make it responsive to the application of organic fertilizer. Improved organic fertilizer application directly improves these soil characteristics, which makes the environment suitable for evaluating the potential effects of processed manure on agronomic results.

Machine Description

The fabricated system consists of a hopper, perforated barrel, screw press mechanism, electric motor (3 HP), filtration unit, and separate outlets for solid and liquid outputs. The screw press applies mechanical compression to facilitate dewatering and separation, producing solid-moist fertilizer and liquid organic fertilizer. The extraction process begins as manure is loaded into the screw press through a hopper positioned above the main chamber. Inside, a rotating screw conveys the material through a perforated barrel, gradually compressing it to separate the liquid and solid components. As compression increases, liquid is expelled through the barrel perforations and directed through a discharge tube into the lower drum. The press head creates the necessary resistance to enhance dewatering efficiency, while the extracted liquid undergoes fine filtration through an ultra-fine mesh to remove remaining impurities.

Experimental Procedure

Cow manure and a 50:50 mixture of cow manure and crop residues were processed using the developed machine. Operational parameters, including processing time, operating speed, and throughput capacity, were measured. Fertilizer quality was evaluated through NPK analysis, pH measurement, and moisture content determination.

Agronomic Evaluation

Processed fertilizers were applied to Brassica rapa (pechay) under controlled conditions. Plant growth indicators—plant height, leaf length, biomass yield, and SPAD chlorophyll readings—were recorded weekly. Soil samples were collected before planting and after harvest to assess changes in nutrient levels.

Data Analysis

Descriptive statistics were used to summarize performance data. One-way ANOVA and t-tests were conducted to determine statistically significant differences among treatments at a 95% confidence level ($p < 0.05$).

RESULTS AND DISCUSSION

Operational Performance of the Manure Processor

The screw-press manure processor operated stably across varying input capacities and operating speeds. Throughput increased with input capacity, indicating that the system can accommodate fluctuations in manure loading typical of small-scale farms. However, excessively high loading slightly reduced separation efficiency due to increased resistance within the screw chamber, suggesting an optimal operating range.

Table 1. Operational Parameters of the Screw-Press Manure Processor at Varying Input Capacities

Parameters	Trial 1	Trial 2	Trial 3
Input Mass (kg)	5	7.5	10
Initial Moisture (%)	80	80	80
Speed (rpm)	20	20	20
Temp (°C)	70	70	70
Time (min)	30	30	30
Energy (kWh)	0.40	0.40	0.40
Solid Out (kg)	4.1	5.32	6.15
Solid Moisture (%)	50	50	50
Yield (%)	39.2	39.8	40.1
Liquid Out (L)	6	7	9
Dewatering Rate (kg/h)	8	10	12

Table 2. Operational Parameters of the Screw-Press Manure Processor at Varying Processing Times

Parameters	Trial 1	Trial 2	Trial 3
Input Mass (kg)	5	5	5
Initial Moisture (%)	80	80	80
Speed (rpm)	20	20	20
Time (min)	30	45	60
Solid Out (kg)	4.2	3.5	3.0
Solid Moisture (%)	50	45	40
Yield (%)	40	35	30
Liquid Out (L)	6.0	6.5	7.0
Dewatering Rate (kg/h)	8.0	4.7	3.0

Processing time significantly influenced separation efficiency. As shown in Table 2, longer processing times improved moisture reduction, but further increases resulted in minimal efficiency gains while increasing energy consumption. This indicates the need to operate the system at an optimum processing duration. Similarly, increasing screw rotational speed enhanced throughput up to a critical level, beyond which separation efficiency declined due to reduced residence time.

Table 3. Operational Parameters of the Screw-Press Manure Processor at Varying Operating Speeds

Parameters	Trial 1	Trial 2	Trial 3
Input Mass (kg)	5	5	5
Initial Moisture (%)	80	80	80
Speed (rpm)	15	20	25
Time (min)	30	30	30
Solid Out (kg)	3.0	4.0	4.5
Solid Moisture (%)	33	50	55
Yield (%)	30	40	45
Liquid Out (L)	7.0	6.0	5.5
Dewatering Rate (kg/h)	6.0	8.0	9.0

Fertilizer Quality and Nutrient Content

The nutrient composition of the processed manure was evaluated based on nitrogen, phosphorus, and potassium contents.

Table 4. Nutrient Content of Processed, Conventionally Composted, and Mixed Processed Manure

Nutrient	Treatment	Mean (%)	Std. Dev.
Total N	Processed (100% Manure)	1.403	0.032
	Conventional Composting Method	1.224	0.036
	50/50 Mix Processed (50% Manure, 50% Crop Residues)	1.667	0.017
Total P	Processed (100% Manure)	0.694	0.016
	Conventional Composting Method	0.709	0.018
	50/50 Mix Processed (50% Manure, 50% Crop Residues)	0.756	0.035
Total K	Processed (100% Manure)	1.5	0.048
	Conventional Composting Method	1.636	0.036
	50/50 Mix Processed (50% Manure, 50% Crop Residues)	1.717	0.017

Table 5. ANOVA Results for Content Among Treatments (3 Replications per Treatment)

Nutrient	F-statistic	p-value	Significance
Total N	2.722	0.150	Not Significant (NS)
Total P	2.214	0.176	Not Significant (NS)
Total K	1.364	0.296	Not Significant (NS)

Results in Table 4 show that fertilizers produced using the screw-press system exhibited NPK levels comparable to those obtained through conventional composting. One-way ANOVAconfirmed that differences among treatments were not statistically significant ($p > 0.05$), indicating effective nutrient retention despite reduced processing time. Mechanical dewatering also improved compost quality by reducing moisture content, resulting in better handling characteristics and improved stability during storage and application.

Plant Growth and Soil Fertility Response

Plant growth trials using Brassica rapa demonstrated that machine-processed manure supported comparable or slightly improved growth performance compared to conventional compost. As shown in Table 6, increases in biomass yield and chlorophyll content suggest improved nutrient availability and uptake.

Table 6. Plant Growth Metrics

Treatment	Yield	Height	SPAD
Processed (100% Manure)	42.0 ± 1.0	32	36.5 ± 0.5
Conventional Composting Method	39.0 ± 1.0	30	34.5 ± 0.5
50/50 Mix Processed (50% Manure, 50% Crop Residues)	41.0 ± 1.0	35	35.5 ± 0.5

Soil analysis after harvest (Table 7) indicated increased NPK levels, confirming effective nutrient retention and improved soil fertility. These results highlight the suitability of the processed manure for sustainable crop production.

Table 7. Plant growth metrics for Pechay under different fertilizer treatments.

Sample Type	Nitrogen (mg/kg)	N Temp (°C)	Phosphorus (mg/kg)	P Temp (°C)	Potassium (mg/kg)	K Temp (°C)
Processed Manure)	7	28	9	28	17	29
Conventional Composting Method	11	25	12	25	28	25
50/50 Mix Processed	6	28	7	28	15	29

Overall Performance Implications

Overall, the developed screw-press manure processor demonstrated effective operational performance, reduced processing time, and produced fertilizer with agronomic effectiveness comparable to conventional composting. Its low-cost and locally adaptable design makes it a practical solution for sustainable manure management in small-scale farming systems.

CONCLUSION

This study demonstrated that the developed mechanical screw-press manure processor is an effective and sustainable solution for small-scale manure management. The system efficiently converts livestock manure into nutrient-rich organic fertilizer with favorable agronomic performance comparable to conventional composting. Its locally adaptable design, reduced labor demand, and compliance with Philippine agricultural standards highlight its potential to support sustainable and circular farming practices. Further studies are recommended to evaluate long-term durability, energy optimization, and scalability for broader agricultural applications.

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