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Community-driven engineering: Designing and constructing a mixing machine for organic fertilizer pellets from cricket dung

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Abstract Results demonstrated effective pellet formation with moisture content averaging 28.66-32.57% wb. Optimal performance was observed at a mixing speed of 75 rpm and a pelletizing speed of 350 rpm, achieving a production rate of 160.85±0.53 kg/hr. Production losses were minimal, with an average residual pellet percentage of 0.87±1.47% and an efficiency of 96.44±1.63%. The machine appears suitable for efficient community-level organic fertilizer production. Future research should focus on examining productivity factors, the long-term impacts of the process on sustainability and quality, and potential design improvements for enhanced transportability, such as tractor attachments, to better support farmers across various agricultural contexts.

Keywords: Organic fertilizer production, Cricket dung, Moisture content optimization, Fertilizer pelletization, Agricultural efficiency

Introduction

Assessing soil quality stands as a critical determinant of agricultural success. The imperative to enhance soil quality encompasses various strategies, notably the application of fertilizers, which may be either chemical or organic in

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nature. Currently, there is a prevalent deficiency of essential plant nutrients, particularly nitrogen, phosphorus, and potassium, across the majority of agricultural regions in northeastern Thailand, leading to diminished agricultural productivity. Consequently, farmers often resort to chemical fertilizers despite their associated drawbacks, including increased soil compaction, difficulty in plowing, and heightened susceptibility to diseases and pests. Furthermore, concerns persist regarding chemical residues in crops consumed by humans. To address these challenges, converting animal manure into organic fertilizer granules emerges as a viable solution to ameliorate soil-related issues, enhance soil fertility, mitigate disease and pest occurrences, and augment crop yields, all without the adverse ramifications associated with chemical fertilizers (Verma *et al.,* 2019).

Chemical fertilizers are commonly used in agricultural practices; however, concerns regarding their adverse effects on soil health and human health persist. Organic fertilizers derived from various organic materials, such as plant residues, animal manure, and microbial cells offer a sustainable alternative (Kurniawati *et al.,* 2023; Panday *et al.,* 2024; Doungpueng *et al.,* 2024). These materials undergo microbial decomposition, releasing nutrients gradually and improving soil structure. In northeastern Thailand, insect farming, particularly cricket farming, has emerged as a significant contributor to the local economy (Bongbut and Chaichuay, 2023; Krongdang *et al.,* 2023). Entities like the Ban Saen Tor Cricket Farm Community Enterprise Group and the Ban Hong Hi Cricket Farm Community Enterprise Group exemplify the success of this venture. Cricket farming is known for its space-efficient nature, simple management practices, and profitable returns. With an average income of 163,464 baht annually per breeding cycle, government support and positive market responses have strengthened the viability of cricket farming (Halloran *et al.,* 2017; Reverberi, 2020). However, cricket farming presents challenges, notably the substantial daily production of cricket dung. Each breeding pond accumulates approximately 30 tons of dung per cycle or an estimated 180,000 tons annually. This poses environmental concerns such as ammonia emissions, offensive odors, and the creation of breeding grounds for insects and disease vectors. To address these challenges, researchers propose the conversion of cricket dung into organic fertilizer pellets, offering a sustainable solution to manage waste and improve soil fertility (Tanangteerapong, 2017; Dikinya and Mufwanzala, 2010; Muangtim *et al.,* 2023).

In recent years, there has been heightened emphasis on finding sustainable solutions to environmental challenges, leading to innovative approaches aimed at addressing various ecological issues. One such promising avenue involves utilizing cricket droppings as a valuable resource for producing pelletized organic fertilizer. Research studies, as exemplified by Butnan and Duangpukdee (2021), are highlighted the significant positive impact of incorporating cricket frass into soil amendments on the growth dynamics of vegetable crops. Notably, the application of cricket frass has resulted in noticeable enhancements in the height and leaf proliferation of amaranth plants, with optimal effects observed at specific application rates. Cricket frass is rich in essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K), surpassing the prescribed thresholds for organic fertilizers, as suggested by Sindhu *et al.* (2020). Furthermore, research findings by Wang *et al.* (2020), and Herencia and Maqueda (2016), have elucidated the beneficial effects of organic fertilization on soil vitality, nutrient availability, and agricultural productivity, thereby affirming the viability of cricket droppings as an environmentally friendly and effective organic fertilizer resource. These empirical insights collectively advocate for the utilization of cricket droppings in fertilizer production as a promising strategy for addressing environmental concerns and promoting sustainable agricultural practices.

After reviewing past research findings, it became evident that there are currently four types of fertilizer pellet machines in use. Firstly, screw-type pellet machines that utilize a spiral mechanism to push the fertilizer into compaction, with a perforated protection plate determining the pellet size at the end of the process. Secondly, vertical roller compactors that employ 2-5 vertical roller shafts attached to the upper part of the machine for compaction, with material passing through a rotating circular, perforated steel plate that moves vertically (Amiri *et al.,* 2017). Thirdly, horizontal roller compactors that function similarly to horizontal roller lines, with pressing rollers touching the side walls (Sun, 2023). Lastly, mixer machines equipped to compress organic fertilizer pellets that feature a propeller in the tank for mixing, where the mixed fertilizer flows through a spiral conveyor to reach the compression head (Daniyan *et al.,* 2017; Lawong *et al.,* 2011; Orisaleye *et al.,* 2009). Despite the capabilities of these machines, the fertilizer pellets produced still exhibit irregular sizes and shapes, are prone to breakage, and lack continuity in the production process. Consequently, they have a low production rate and are unsuitable for making fertilizer pellets from cricket droppings (Sritram *et al.,* 2016). These issues highlight significant limitations in the current designs of fertilizer pellet machines, underscoring the urgent need for innovative solutions to enhance efficiency and versatility in fertilizer pellet production (Doungpueng *et al.,* 2024).

This research aimed to develop technology for producing organic fertilizer pellets from cricket excrement, focusing on enhancing nutrient release, decomposition, and binder properties to ensure durability and ease of handling.

Materials and methods

The research project is divided into two distinctive phases. The initial segment encompasses the conceptualization, design, and construction of a pelletizing mixer tailored for organic fertilizer derived from cricket dung, constituting an engineering design endeavor. The subsequent phase entailed the empirical testing and evaluation of the designed pelletizing mixer concerning its performance in processing organic fertilizer sourced from cricket dung.

Design and construction of the mixer and pelletizer machine for organic fertilizer from cricket dung

The conceptualization and construction of the mixer and pelletizer required insights derived from sources such as Shigley and Mischke (1989) and Krutz *et al.* (1994), while concurrently addressing feasibility, challenges, and constraints associated with the amalgamation and pelletization processes in organic fertilizer production. This design phase was divided into two parts, namely, criteria establishment and primary component design.

Design criteria

The machine was designed to be a medium-sized unit, optimized for the communal production of organic fertilizer pellets from cricket dung. It must be inherently mobile to cater to the logistical needs of dung cricket farmers' collectives.

The mixer-pelletizer configuration was exhibited the capacity for continuous pelletization, smoothly transitioning from mixing to pelletizing. Operational throughput should facilitate the production of organic fertilizer pellets from cricket dung at a rate ranging between 150-200 kg/hr.

The operational mechanics of the machine was characterized by simplicity, ensuring facile reparability by operators.

Minimal maintenance requisites were paramount, with readily replaceable components to address potential malfunctions.

Operation hinged upon rotational and compressive forces, necessitating a propulsion system with an engine with a minimum output of 5.5 hp. Operational engagement during machine movement required 1-2 operators.

The main components of the mixer and pelletizer machine

The definition and structural details of the prototype had four fundamental constituents: 1. Machine Structure, 2. Fertilizer Mixing Unit 3. Fertilizer Pelletization Unit, and 4. Power Unit, as shown in Figure 1.

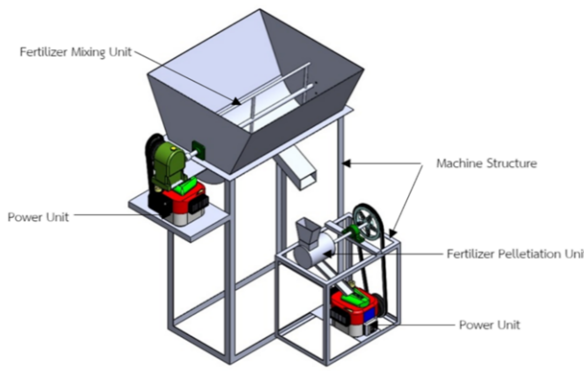


Figure 1. The engineering prototype of a mixer and pelletizer machine

Testing and evaluating the mixer and the pelletizer machine

Preliminary testing carried out in this phase, prior to the process of pelletizing cricket dung-integrated organic fertilizer, encompassed the composting procedure (Figure 2). Composting, a widely adopted technique for nitrogen (N), phosphorus (P), and potassium (K) level modulation, involved mixing five raw materials: cricket dung (1 sack), rice bran (1 sack), Rice Husk Charcoal (1 sack), Molasses (1 liter), bio-extract (1 liter), and water (15 liters). The composting duration lasted for 14 days.

Figure 2. The process of organic fertilizer composting using Cricket dung as the primary substrate

Determination of suitable moisture content in organic fertilizer derived from cricket dung for pelletizing

The moisture content in organic fertilizer derived from cricket dung was assessed in order to determine its suitability for the pelletization process. Post-composting, 15-kilogram samples were systematically chosen for the evaluation. The approach involved gradually adding water, in 1-liter portions, until reaching a maximum of 5 liters, aiming to find the best water-to-fertilizer ratio for pelletization. The resultant composite mixture was subsequently introduced into a pelletizer, from which random pellet samples were obtained.

For further analysis, three replicates of 200 g each and were selected and dried in a hot air oven at 105 degrees Celsius for 24 hours. Following the drying process, the pertinent data were meticulously recorded. The calculation of moisture content was executed utilizing Equation 1, in accordance with the testing and computation protocols delineated in the Association of Official Analytical Chemists standards of 1984 (1984).

$$MC(\%wb)=[\frac{w-d}{w}]\times 100 \tag{1}$$

Where:

MC denotes the moisture content ratio, expressed as %wb

w signifies the initial weight of the material before undergoing the baking process, measured in g.

d denotes the dry weight of the material after baking, also measured in g.

Evaluation of suitable fertilizer quantity and mixing speed in fertilizer mixer unit

Both the suitable quantity of fertilizer and the mixing speed required for efficient pellet formation in the fertilizer mixer unit were determined in this section. This information is crucial for understanding the initial operational parameters of the machine. The variables being investigated included five different quantities of the fertilizer (15, 25, 35, 45, and 50 kg), the speed of mixing at four levels (55, 75, 95, and 105 rpm), and the speed of pelletizing at four levels (300, 400, 500, and 600 rpm). Each level was evaluated in triplicate. Subsequently, the acquired data was recorded and subjected to systematic analysis.

Evaluation of performance of the mixer and the pelletizer machine

Following the comprehensive examination of factors influencing the operation of the organic fertilizer pelletizing mixer, the mixer's performance, specifically with cricket dung-derived organic fertilizer, was assessed. The parameters under investigation included mixing speed at four gradations (55, 75, 95, and 105 rpm) and pelletizing speed at four levels (250, 350, 450, and 550 rpm). Each level was evaluated in triplicate using samples of 20 kg. The recorded data was subsequently processed for detailed calculations and analysis. Key performance indicators encompassed fertilizer pellet production rate, post-production loss, and the efficiency of fertilizer pellet production, all derived using Equations 2, 3, and 4, respectively.

$$c_p=\frac{m_1}{t}\times 60 \tag{2}$$

Where:

Cp denotes the working capacity of fertilizer pellets, expressed in kg/hr.

m1 represents the quantity of fertilizer pellets, measured in kg.

t stands for the total operating time of the machine, denominated in minutes.

The computation of post-production loss for fertilizer pellets, as outlined by Lomchangkum *et al.* (2022a), involves the systematic assessment of losses incurred subsequent to the pelletization process.

$$L_s=\frac{m_2}{m_1+m_2}\times 100 \tag{3}$$

Where:

Ls designates the production losses for fertilizer pellets, expressed as a percentage.

m1 signifies the quantity of fertilizer pellets, measured in kg.

m2 represents the quantity of the remaining fertilizer pellets, quantified in kg.

The determination of efficiency in the production of fertilizer pellets, as elucidated by Lomchangkum *et al.* (2022b), entails the systematic evaluation of the effectiveness and productivity of the pelletization process.

$$\eta=\frac{m_2}{m_1}\times 100 \tag{4}$$

Where:

η denotes the efficiency in the production of fertilizer pellets, expressed as a percentage.

m1 signifies the quantity of fertilizer pellets, measured in kg.

m2 represents the quantity of the remaining fertilizer pellets, quantified in kg.

Data analysis

The present investigation adopted a rigorous experimental framework characterized by a 4x4 Factorial in Randomized Complete Block Design (RCBD). Statistical analysis of the obtained test results was conducted employing the principles of Analysis of Variance (ANOVA) to elucidate variance values. To facilitate the comparison of means, the Duncan method, set at a 95% confidence level, was employed. This methodological approach was undertaken with the specific objective of discerning the interplay between mixing speed and pelletizing speed.

Results

Designing and constructing the mixer and pelletizer machine for organic fertilizer from cricket dung

The determination of design criteria and requisite information for the design process resulted to the development of various components within the prototype mixer and pelletizer for organic fertilizer derived from cricket dung, as illustrated in Figure 4. These components were classified into four main categories. The detailed specifications for each component are outlined below.

Machine structure

The machine's structural integrity is paramount as it functions as the foundational support for all equipment and parts. Consequently, the machine structure necessitates meticulous design and construction to ensure robustness and the capability to withstand varying loads and forces. In this investigation, the machine structure was meticulously designed using angle steel with dimensions (width x length x height) of 48 x 88 x 126 cm, respectively. Assembly of the machine structure was accomplished through electrical welding.

Fertilizer mixing unit

This unit is employed to mix fertilizers before the compaction process. It comprises a mixing tank with dimensions (width x length x depth) of 81 x 88 x 44 cm, respectively, and is equipped with ten mixing blades, which facilitates thorough blending. The bottom of the mixing tank features a drainage channel, and a valve (size: 18 x 37 cm) that regulates the flow, allowing the fertilizer to exit through the outlet channel and be directed towards the fertilizer pelletizing unit.

Fertilizer pelletizing unit

This unit is responsible for compacting the fertilized mixture into pellets subsequent to the mixing phase. Designed as a horizontal roller with dimensions (width x length x height) of 40 x 60 x 52 cm, respectively, it incorporates a flange with a diameter of 16 cm, containing a total of 400 holes. Key elements include a compression cylinder and a horizontal roller, pellet mill flat die and cutting blade, as depicted in Figure 3.

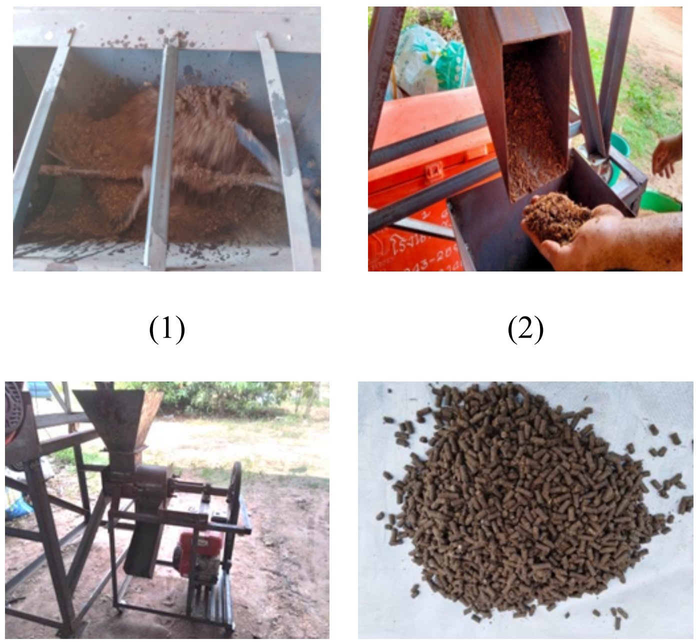
Figure 3. The horizontal roller and pellet mill flat die

Power unit

To achieve optimal efficiency in mixing and pelletizing organic fertilizers, a small engine with a minimum power output of 7 hp was carefully selected. This engine, operating at a speed of 1,420 rpm, serves as the primary power source for both the mixing and pelletizing units, with one unit allocated to each apparatus.

Figure 4. The mixer and pelletizer machine for organic fertilizer from cricket dung

The operational principles of the mixer and pelletizer machine for organic fertilizer from cricket dung are as follows: Upon activation, the blades attached to the shaft within the mixing tank initiate rotation, facilitating the blending of fertilizer components (Figure 5-1). Once homogeneous, the gate at the bottom of the mixing tank is opened, allowing the fertilizer to flow seamlessly into the pelletizing machine (Figure 5-2), which houses a rotating roller within a perforated pressing head. As the fertilizer enters the pressing head, the roller compresses it through the perforations in the pelletizing die, while wires at the forefront of the head ensure precise cutting, resulting in uniformly sized pellets. These pellets are then discharged through the machine's outlet (Figure 5-3) and undergo sun-drying (Figure 5-4). to remove moisture from the final product.



(1) (2)

(3) (4)

Figure 5. Operational principles of the mixer and pelletizer machine for organic fertilizer from cricket dung

Testing and evaluating the mixer and the pelletizer machine

Determining the suitable moisture content in organic fertilizer derived from cricket dung for pelletizing

The outcomes of tests conducted to ascertain the suitable moisture content in organic fertilizer derived from cricket dung, intended for pelletization (Table

1). The findings revealed that employing a mixing ratio of 1-2 liters of water per 15 kg of fertilizer resulted in dry coagulation, preventing pellet formation. The average moisture content was within the range of 14.44-17.37% wb. Alternatively, by elevating the mixing ratio to 3-4 liters of water per 15 kg of fertilizer, the fertilizer pellets exhibited favorable cohesion with a moisture content ranging from 28.66-32.57 %wb. Further increasing the mixing ratio to 5 liters of water per 15 kg of fertilizer or beyond led to liquid coagulation, impeding pellet compression, and yielding a moisture content of 40.13 % wb. Consequently, the optimal water-to-fertilizer ratio conducive for pelletizing was determined to be 3-4 liters of water per 15 kg of fertilizer, maintaining a moisture value within the range of 28.66-32.57 %wb. This was consistent with earlier research by Sritram *et al.* (2016), which explored the essential ingredients for manure pelletization. Furthermore, it was observed that optimal pellet coalescence occurred within a moisture range of 26.66-33.33 %wb relative to the wet standard.

Table 1. Determination of suitable moisture content in organic fertilizer derived from cricket dung for pelletizing

Fertilizer weight (kg)	**Water quantity (l)**	**Weight of fertilizer used for drying**		**Moisture content (%wb.)**	**Physical characteristics of fertilizer pellets**
		Before Drying (g)	After Drying (g)		
15.00	1.00	200.00	171.12	14.44	Dry, not pelletized.
15.00	2.00	200.00	165.25	17.37	Dry, not pelletized.
15.00	3.00	200.00	142.67	28.66	Well-compact pelletized.
15.00	4.00	200.00	134.85	32.57	Well-compact pelletized.
15.00	5.00	200.00	121.73	40.13	Liquid, not pelletized.

Evaluation of suitable fertilizer quantity and mixing speed in a fertilizer mixer unit

The correlation between fertilizer capacity and rotational speed of the mixing unit, with regards to machine performance was evaluated. Fertilizer capacity was categorized into five tiers: 15, 25, 35, 45, and 50 kg, while mixing speed was delineated into four levels: 55, 75, 95, and 105 rpm, as outlined in Table 2. Analysis of the findings elucidated that the optimal mixer speed was105 rpm, with the equipment reaching its maximum operational threshold at a capacity of 50 kg. Beyond this capacity, operational efficacy diminished due to increased load on the primary engine, leading to operational halts after prolonged use. Subsequent experimentation demonstrated that by reducing mixer speeds to 95, 75, and 55 rpm, the equipment could effectively handle capacities of 45, 35, and 25 kg, respectively. Attempts to exceed these capacities—46, 36, and 26 kg, respectively—proved unfeasible due to inadequate engine power. Therefore, it is evident that the operational capacity of the machine is contingent upon both the rotational speed of the mixer and the power output of the engine. It was determined that operating the mixer at a speed of 104 rpm resulted in effective compost blending, yielding a friable texture, and facilitating easy removal from the tank.

Table 2. The results of evaluation of suitable fertilizer quantity and mixing speed in a fertilizer mixer unit

Mixing speed (RPM)	Fertilizer capacity (kg)
55	15, 25
75	15, 25, 35
95	15, 25, 35, 45
105	15, 25, 35, 45, 50

The results of evaluation of performance of the mixer and the pelletizer machine

The experimentation utilized organic fertilizer derived from cricket dung, with a standardized weight of 25 kg, representing the machine's operational threshold across all speed parameters. Test variables comprised four levels of mixing speed (55, 75, 95, and 105 rpm) and four levels of pelletizing speed (250, 350, 450, and 550 rpm). Results revealed statistically significant differences between the rotational speeds of the mixing and pelletizing units, with a confidence level of 95 percent (Table 3). Optimal functionality of the mixer for pelletizing organic fertilizer from cricket dung was observed at a mixing speed of 75 rpm and a pelletizing speed of 350 rpm, yielding 24.45±1.78 kg of fertilizer pellets. However, adjustments to lower mixing speed (55 rpm) and pelletizing speed (250 rpm) led to a decline in pellet production due to reduced force exerted during rotation. Conversely, elevating mixing (95-105 rpm) and pelletizing speeds (450-550 rpm) resulted in reduced pellet output attributed to excessive rotational velocities causing cricket dung to dislodge prematurely during the mixing and pelletizing stages. Additionally, blockage issues arose when prolonged pressure was applied during pellet formation. Consequently, the optimal operational parameters for the machine entailed a mixing speed of 75 rpm and a pelletizing speed of 350 rpm, ensuring efficient fertilizer pellet production at an average rate of 160.85±0.53 kg/hr, with negligible residual waste (0.87±1.47 kg) and an average production efficiency of 96.44±1.63%.

Table 3. Evaluation of performance of the mixer and the pelletizer machine

Mixing speed (rpm)	**Pelletizing speed (rpm)**	**Fertilizer weight testing (kg)**	**Quantity of fertilizer pellets (kg)**	**Quantity of remaining fertilizer pellets (kg)**	**Total operating time (min)**	**Production capacity (kg/hr)**	**Production losses (%)**	**Efficiency (%)**
55	250	25	20.15^{d}±1.25	1.16^{d}±0.23	10.51^{d}±1.13	115.03^{d}±2.43	5.44^{d}±2.13	94.24^{d}±2.45
75	350	25	24.45^{c}±0.01	0.87^{c}±1.47	9.12^{c}±0.25	160.85^{c}±0.53	1.66^{c}±1.14	96.44^{c}±1.63
95	450	25	21.23^{b}±2.21	1.56^{b}±2.01	8.36^{b}±1.23	152.36^{b}±1.53	6.84^{c}±0.83	92.65^{b}±0.43
105	550	25	19.87^{a}±1.23	1.87^{a}±1.11	7.96^{a}±1.17	149.77^{a}±1.73	8.60^{a}±1.36	90.58^{a}±1.93

Means sharing the same superscript within a column were not statistically significant at $P < 0.05$. The numbers represented mean values, with ± indicating the standard deviation.

Discussion

Optimization of fertilizer pelletization through controlled moisture content: Implications for agricultural efficiency

The study investigated the influence of various water quantities on the moisture content and physical characteristics of fertilizer pellets post-drying. Notably, it observed a critical moisture content range, between 28.66% and 32.57%, where well-compacted pelletization occurred. These findings were significant implications for optimizing fertilizer production processes and improving product quality.

Result found a direct correlation between water quantity and moisture content in the fertilizer pellets. As water quantity increased, so did the moisture content. Specifically, results showed moisture content ranging from 14.44% to 40.13% on a wet basis across different samples. This is aligned with basic principles of moisture absorption by porous materials, highlighting the importance of water availability in determining moisture content (Kader *et al.,* 2019; Nielsen, 2007; Ungureanu *et al.,* 2018).

Moreover, moisture content played a pivotal role in shaping the physical characteristics of the fertilizer pellets. Samples with lower moisture content remained dry and exhibited poor pelletization, while those within the critical range of 28.66% to 32.57% showed optimal pellet formation. This underscores the necessity of moisture control in pelletization processes, emphasizing the importance of achieving the right moisture content for desirable pellet quality (Bordoloi *et al.,* 2019; Gageanu *et al.,* 2021).

The findings are offered practical insights for the fertilizer production industry. By carefully managing water quantity during manufacturing, producers can adjust the moisture content of fertilizer pellets to fall within the critical range for optimal pelletization. This not only ensures uniform pelletization but also enhances product stability and handling.

Furthermore, understanding the impact of water quantity on fertilizer pelletization can lead to process optimization and cost reduction. By identifying the critical moisture range for well-compacted pelletization, manufacturers can streamline resource usage and improve production efficiency. For example, our study found that moisture content between 28.66% and 32.57% yielded the best pelletization outcomes, providing a specific target range for industrial applications.

However, it is important to acknowledge the study's limitations. Our experimental design focused solely on manipulating water quantity, overlooking other variables like temperature, pressure, and formulation composition, which could also influence pellet quality. Future research should explore the interaction between these factors for a more comprehensive understanding of pelletization processes.

Optimization of mixing and pelletizing speeds to enhance efficiency and productivity in fertilizer pellet production

This study delved into the critical aspect of optimizing mixing and pelletizing speeds in fertilizer pellet production processes, offering valuable insights into enhancing production capacity, reducing losses, and improving efficiency.

Analysis of the data revealed that both mixing and pelletizing speeds initially boosted production capacity. However, there was a slight capacity decline when the speeds were beyond 95 rpm for mixing and 450 rpm for pelletizing. Through experimentation with various configurations, it was determined that a mixing speed of 75 rpm combined with a pelletizing speed of

350 rpm yielded the most promising outcomes, achieving a peak production capacity of 160.85 kg/hr. Optimizing mixing and pelletizing speeds enhances efficiency, quality control, and cost-effectiveness. Implementing these optimal speed settings provides a competitive advantage, improving overall production efficiency and competitiveness (Chikwado, 2013).

Furthermore, the selected configuration exhibited remarkably low production losses, recorded at 1.66%. This underscores the importance of fine-tuning operational parameters to minimize resource wastage and improve overall process efficiency. By adopting this optimized setting, manufacturers can achieve cost savings and mitigate environmental impacts associated with production activities (Li *et al.,* 2022a; Li *et al.,* 2022b; Przywara *et al.,* 2021).

Moreover, the efficiency of the fertilizer pellet production process was notably high for the identified optimal configuration, reaching 96.44%. This highlights the effectiveness of the chosen parameters in converting raw materials and energy inputs into usable outputs. Such high efficiency is indicative of improved resource utilization and operational effectiveness, essential for maintaining competitiveness in the agricultural industry (Alemi *et al.,* 2010; Barłóg, 2023; Srison *et al.,* 2023; Kliopova *et al.,* 2016).

This study is emphasized the significance of data-driven approaches and performance metrics in optimizing fertilizer pellet production processes. By systematically evaluating and adjusting operational parameters, manufacturers can enhance their production outcomes, contributing to the sustainable advancement of the agricultural sector. Future research endeavors could explore additional factors influencing production performance and delve into the long-term implications of different process configurations on product quality and sustainability.

In conclusion, this study successfully designed and tested a mixer and pellet machine for producing organic fertilizer from cricket dung. Through careful experimentation, valuable insights were gained into optimizing various factors crucial for efficient fertilizer pellet production. The focus on design criteria and construction details highlighted the importance of ensuring the structural integrity of the equipment for its durability and functionality. Additionally, optimizing moisture content within the critical range of 28.66 to 32.57%wb proved essential for achieving optimal pelletization, emphasizing the need for precise water control to enhance both product quality and process efficiency. Furthermore, the evaluation of mixing and pelletizing speeds provided valuable information on how operational parameters affect production capacity. Through systematic testing, optimal configuration speeds of 75 rpm for mixing and 350 rpm for pelletizing were identified, leading to maximum production capacity and minimal losses. These findings emphasize the importance of fine-tuning operational parameters to improve efficiency and minimize resource wastage in fertilizer pellet production. Overall, this research provides practical insights for the fertilizer manufacturing industry, offering a new approach to optimizing moisture content and processing speed to increase productivity and competitiveness. By implementing these findings, manufacturers can improve production processes, enhance product quality, and reduce environmental impact, contributing to sustainable agricultural practices. Future research should explore additional factors influencing productivity and examine the long-term effects of different process configurations on sustainability and product quality. Additionally, consideration should be given to design aspects that facilitate easy equipment transportation, such as attachment to tractors, to enhance usability for farmers in diverse agricultural settings.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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