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EVALUATION OF VERMICOMPOST FROM LOCAL SUBSTRATES: EFFECTS ON SOIL CONDITIONING, NUTRIENT DYNAMICS, AND ITS POTENTIAL AS A SUSTAINABLE ORGANIC FERTILIZER

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ABSTRACT

This study evaluated the potential of vermiculture in improving soil fertility through the production of vermicasts derived from different organic substrates. The research focused on analyzing the chemical properties of vermicasts, particularly nitrogen (N), phosphorus (P), potassium (K), and soil pH, which are critical in determining soil quality and crop productivity. The experiment took place at Isabela State University – San Mariano Campus, San Mariano, Isabela. A Randomized Complete Block Design (RCBD) was employed with six substrate treatments: cow manure + rice straw + taro, cow manure + corn stover + taro, cow manure + ipil-ipil + taro, cow manure + centrosema + taro, cow manure + taro, and cow manure + kakawate + taro. Substrates were prepared and placed in vermibeds, and vermiworms were introduced after 15 days to initiate decomposition. Moisture was carefully maintained to ensure optimal microbial and earthworm activity. Laboratory analysis revealed that nitrogen levels were highest in vermicasts from cow manure + centrosema + taro (1.75%), indicating the positive contribution of nitrogen-fixing legumes. Treatments with rice straw and ipil-ipil also produced relatively high nitrogen contents (1.52% and 1.50%, respectively), while the lowest level was observed in cow manure + taro (1.13%). Phosphorus enrichment was likewise most pronounced in treatments with centrosema, while potassium levels peaked in combinations containing kakawate, highlighting its potential in supporting plant health and yield. Soil pH across treatments ranged from 6.94 to 7.20, reflecting a slightly acidic to neutral balance favorable for both earthworm activity and crop production. Moisture content varied widely, from 13.5% to 55%, with the highest recorded in cow manure + corn stover + taro, which created conditions conducive to nutrient transformation. Overall, the findings confirm that vermiculture is an effective means of producing a sustainable and nutrient-rich organic fertilizer. The study demonstrates that substrate composition significantly influences the nutrient profile of vermicasts, with legumes and potassium-rich plants offering particular benefits. The results emphasize the value of vermiculture as an eco-friendly alternative that improves soil health, enhances crop productivity, and contributes to long-term sustainable agricultural systems.

Key words: Vermicomposting, Vermicast, Soil fertility, Nitrogen enrichment, Phosphorus dynamics, Potassium availability

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INTRODUCTION

Sustainable crop production has become increasingly important as farmers seek alternatives to costly synthetic fertilizers and declining soil fertility. In many agricultural communities, farmers primarily rely on traditional organic sources such as animal manure, compost, and crop residues, which are often applied without standardized rates or proper nutrient balancing. Although these inputs improve soil structure, their nutrient content is highly variable, leading to inconsistent crop performance and limited yield gains. In addition, the lack of optimized combinations of organic materials results in nutrient deficiencies or slow nutrient release, restricting the full potential of crop growth and fruit quality.

Despite the widespread use of these conventional organic fertilizers, farmers' current practices typically do not involve formulated or scientifically tested organic mixtures. Most applications rely on what is readily available on the farm rather than what is agronomically optimal. This practice creates a gap in ensuring that crops receive adequate and timely nutrients. As a result, there is growing interest in identifying more efficient organic fertilizer combinations that can enhance plant growth, improve fruit quality and increase overall productivity.

This experiment was conducted to evaluate specific organic fertilizer treatments formulated from locally available materials and to compare their performance with the fertilizers farmers commonly apply. By testing controlled mixtures and application rates, the study aims to demonstrate the potential value added over farmers' actual practice, particularly in improving soil fertility, enhancing crop vigor, and increasing yield and fruit quality. Establishing these benefits is essential to providing farmers with practical, science-based fertilizer options that can strengthen sustainable and cost-effective crop production systems.

In the Philippines, particularly in Region II or Cagayan Valley, socio-economic, environmental, health and waste management challenges have been exacerbated by the widespread use of inorganic farming practices. Region II, located in the northeastern part of Luzon, comprises the provinces of Batanes, Cagayan, Isabela, Nueva Vizcaya, and Quirino. The region is characterized by vast agricultural lands, fertile plains, and the Cagayan River Basin—the largest in the country—which serves as a primary source of livelihood for most residents through farming and fisheries. Despite its agricultural productivity, the region faces increasing soil degradation and declining fertility due to the excessive and prolonged use of synthetic fertilizers. About 80% of Philippine soils are already deteriorated as a result of the abusive use of inorganic or chemical fertilizers, leading to long-term productivity loss and environmental pollution [5].

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Consequently, there is a pressing need to advocate for the adoption of organic agriculture to address these challenges and build resilience against environmental and disaster risks. The Organic Agriculture Act of 2010 (Republic Act 10068) provides a robust framework for this transition, recognizing organic agriculture as a key component of national development [5]. The law promotes ecologically sound, socially acceptable, economically viable, and technically feasible farming systems that enhance food security, protect biodiversity and ensure environmental stewardship.

One of the most promising approaches under organic agriculture is vermicomposting—a biological process that uses earthworms to convert organic waste into nutrient-rich fertilizer known as vermicompost. Vermicompost plays a crucial role in conserving soil, sustaining crop quality, and safeguarding the environment. It has been recognized globally as an effective alternative to chemical fertilizers, with numerous studies underscoring its benefits in improving soil fertility, enhancing microbial activity, and boosting plant growth [1, 2, 3, 4]. Beyond providing organic carbon and essential macronutrients such as nitrogen (N), phosphorus (P) and potassium (K), vermicompost also contains growth-promoting enzymes, hormones and beneficial microorganisms that contribute to healthier and more resilient crops [6, 7, 8, 9].

Unlike chemical fertilizers, the effects of organic fertilizers such as vermicompost develop gradually through microbial decomposition, yet their benefits are long-lasting [10, 11, 12]. Vermicompost enhances soil texture, water-holding capacity, and pH balance, typically maintaining slightly acidic to near-neutral conditions favorable for crop growth [13, 14]. Although its Nitrogen (N), Phosphorus (P), and Potassium (K) concentration is lower than that of synthetic fertilizers, vermicompost provides additional micronutrients including calcium, magnesium, manganese, copper, iron and zinc [15]. Studies further highlight its consistent contribution to nitrogen enrichment, making it a reliable component for improving soil fertility [16, 17, 18].

Phosphorus dynamics in vermicompost also offer significant agricultural benefits. Research has shown that earthworm activity increases the bioavailability of phosphorus by breaking down organic matter into forms readily absorbed by plants [19, 20, 21, 22]. Stable or increased phosphorus content in vermicasts further validates its role in soil enrichment [23]. Similarly, potassium levels in vermicompost vary depending on the substrate composition and earthworm activity, transforming nutrients into more accessible forms for plant uptake [24, 25].

Given these advantages, this study was conducted to evaluate the nutrient content of vermicast produced from different substrate combinations. Specifically, it aimed to: (1) determine the nitrogen levels that best support soil health, (2) assess the pH

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conditions most favorable to plants and earthworms, (3) examine how varying substrates influence phosphorus and potassium content beneficial for crops, and (4) compare the nutrient composition of vermicast with commercial fertilizers to emphasize vermiculture's potential as a sustainable and eco-friendly farming alternative.

From a sustainability perspective, vermicomposting aligns with the principles of sustainable agriculture, aiming to minimize environmental impact while enhancing soil productivity and ecological balance [8, 9]. Its contribution to soil conditioning, nutrient enrichment, and waste recycling reinforces its importance as a viable strategy for promoting agricultural sustainability in Region II and beyond.

In light of these considerations, this study was undertaken to evaluate the nutrient content of vermicast produced from different substrate combinations. Specifically, it aimed to determine the nitrogen levels that best support soil health, assess the pH conditions most favorable to plants and earthworms, and examine how varying substrates influence the phosphorus and potassium content beneficial for crops. Finally, it sought to compare the nutrient composition of vermicast with commercial fertilizers to highlight vermiculture's potential as a sustainable farming alternative.

Objectives:

1. To measure the nitrogen levels in vermicasts from different substrate blends and find the best one for soil health, particularly in terms of soil fertility as indicated by total nitrogen content.
2. To investigate the pH of vermicasts and ascertain which substrates create the best environment for plant productivity and earthworm reproduction.
3. To explore how different substrates, affect the phosphorus and potassium content in vermicasts and their potential benefits in terms of crop nutrition and growth.

MATERIALS AND METHODS

The conceptual framework shown in Figure 1 served as a guide in the production of vermicast. It follows the input-process-output method.

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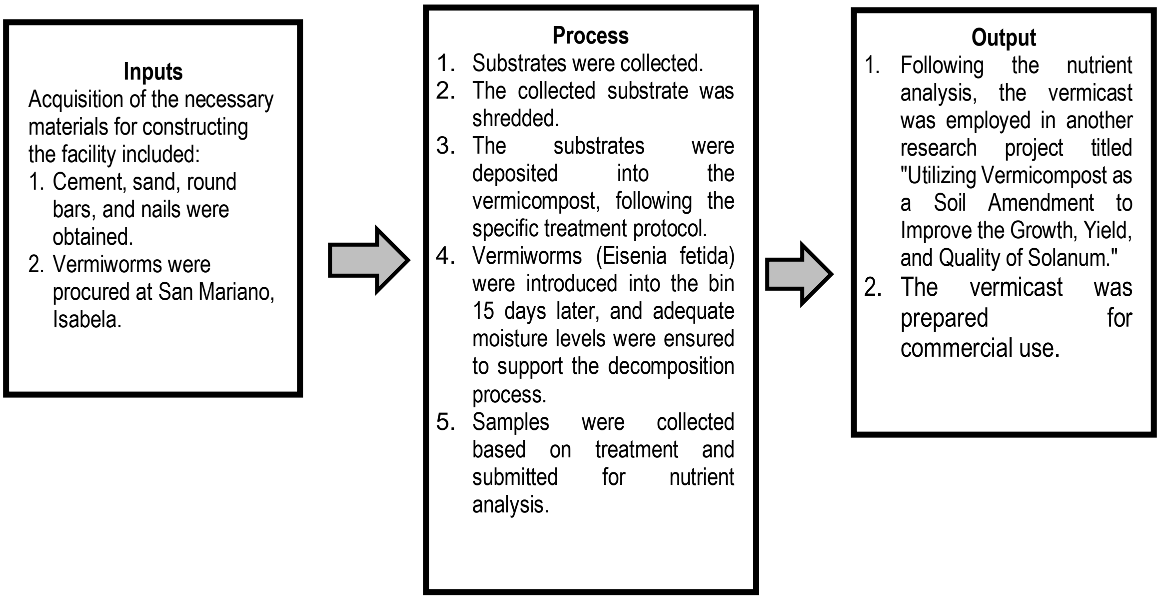

Figure 1: Conceptual Framework of the Study

Randomized Complete Block Design and environment control were utilized in data gathering and analysis. This was important to provide a valid measure of experimental error used in the different farm waste and composting derived from a mushroom.

The following farm waste was used as substrates in the production of vermicomposting.

1. Cow manure + Rice straw + Taro
2. Cow manure + Corn Stover + Taro
3. Cow manure + Ipil-Ipil + Taro
4. Cow manure + Centrocema + Taro
5. Cow manure + Taro
6. Cow manure + Kakawate + Taro

Experimental Procedure and Sample Collection

substrates were gathered, shredded and placed in vermibeds according to treatment. Vermiworms were introduced after 15 days, and moisture was maintained at levels suitable for decomposition and worm activity. After composting, samples were collected and submitted to the Department of Agriculture – Cagayan Valley Research Center (DA–CVRC) for laboratory analysis, which measured nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and pH. Moisture content was also monitored, ranging from 13.5% to 55%, with the highest values observed in the cow manure + corn stover + taro mix.

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The chemical analyses followed standard soil and fertilizer testing protocols of the Department of Agriculture – Cagayan Valley Research Center. Soil pH was determined using a 1:2.5 soil-to-water suspension measured with a calibrated pH meter. Total nitrogen (N) was analyzed using the Kjeldahl digestion method, available phosphorus (P) by the Olsen colorimetric method, and exchangeable potassium (K) using flame photometry. Calcium (Ca) and magnesium (Mg) were quantified through atomic absorption spectrophotometry (AAS). Moisture content was determined gravimetrically by oven-drying samples at 105°C until constant weight was achieved. These procedures ensured standardized and reliable measurement of key soil fertility parameters for all treatments.

Data Analysis

Data collected from the experiments were subjected to statistical analysis using Analysis of Variance (ANOVA), which was deemed appropriate for the Randomized Complete Block Design (RCBD) employed in the study. The ANOVA was used to determine whether significant differences existed among the treatment means. When significant differences were detected, post hoc comparisons were conducted using the Least Significant Difference (LSD) test at a 5% level of significance to further identify which treatments differed.

All statistical computations were carried out using International Business Machines – Statistical Package for the Social Sciences (IBM SPSS) Statistics version 26. Descriptive statistics were expressed as mean ± standard deviation (SD) to summarize data variability and central tendency. Data visualization, including the preparation of graphs and tables, was accomplished using Microsoft Excel 365, ensuring that all figures were presented with properly labeled axes, units of measurement, and appropriate statistical indicators for clarity and interpretability.

RESULTS AND DISCUSSION

Laboratory Analysis of the Nutrient Content of Vermicasts Produced

Table 1 presents the soil laboratory analysis of nitrogen content in vermicasts produced from different vermicompost mixtures. The analysis revealed notable differences in nitrogen levels among the treatments. Treatment 1, which included cow manure, taro, and rice straw, recorded a nitrogen content of 1.52%, indicating that rice straw contributes effectively to nitrogen enrichment when combined with organic substrates. Treatment 2, consisting of cow manure, taro, and corn stover, yielded a nitrogen content of 1.39%, reflecting a moderate contribution to soil nitrogen. Treatment 3, which incorporated ipil-ipil, showed a slightly higher nitrogen content of 1.50%, suggesting the positive influence of leguminous plant material. The highest nitrogen content was observed in Treatment 4 (20% cow manure + 15% centrosema + 15% taro) at 1.75%, highlighting the significant role of centrosema as a nitrogen-fixing legume in enhancing vermicompost quality and soil fertility. In

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contrast, Treatment 5, which contained only cow manure and taro without additional plant materials, exhibited the lowest nitrogen content at 1.13%, indicating that the absence of nutrient-rich or nitrogen-fixing substrates limits nitrogen enrichment. Lastly, Treatment 6, which included kakawate, recorded a nitrogen level of 1.40%, demonstrating a fair contribution to nitrogen content. Overall, these findings emphasize the importance of substrate selection in vermicomposting, with leguminous materials—particularly centrosema—showing strong potential for improving soil nitrogen levels and supporting sustainable agricultural practices.

Chemical Characteristics of Vermicasts: Soil pH

In this study, vermicomposts produced from a blend of cow manure (20%), corn stover (15%), and taro (15%) exhibited the highest pH level, reaching 7.20. This shows a slightly alkaline nature compared to other substrates. Interestingly, all the vermicasts across different substrates showed a consistent pH range from 6.94 to 7.20, which falls within the ideal pH range for earthworm health. This indicates that all the treatments provided conditions suitable for earthworm survival and productivity.

Among the various substrates, Treatment 1 (cow manure, rice straw, and taro) stood out with the highest pH levels, moving toward neutrality. This makes it an exceptional choice for fostering a soil environment conducive to agricultural growth.

On the other hand, the vermicast produced by the Eisenia fetida (EE) earthworm species showed a slightly lower pH. This could be due to lower concentrations of calcium and magnesium in the vermicast. The vermicomposting process, involving microbial activity, generates organic acids as complex organic materials like rice straw break down into simpler forms [27, 28]. Additionally, the presence of humic acids in the Earthworm Efficiency (EE) vermicast may contribute to the lower pH. These humic acids are acidic due to their high carboxylic and phenolic group content, as described by Tan [29]. Research also suggests that humic acids often contain higher levels of nitrogen, possibly derived from amino acids or proteins, which further connects nitrogen with the pH changes observed in the vermicast.

Maintaining the right soil pH is essential for the health of earthworms and the quality of the resulting vermicompost. Hamilton [26] noted that composting worms thrive best at a neutral pH (pH = 7), with extreme pH levels (below 5 or above 9) being harmful to their survival. The pH levels of the vermicasts in this study indicate that the vermicomposting process, along with substrate composition, plays a significant role in regulating soil pH and creating optimal conditions for earthworm health, thus enhancing the potential benefits of vermicomposting for sustainable agriculture.

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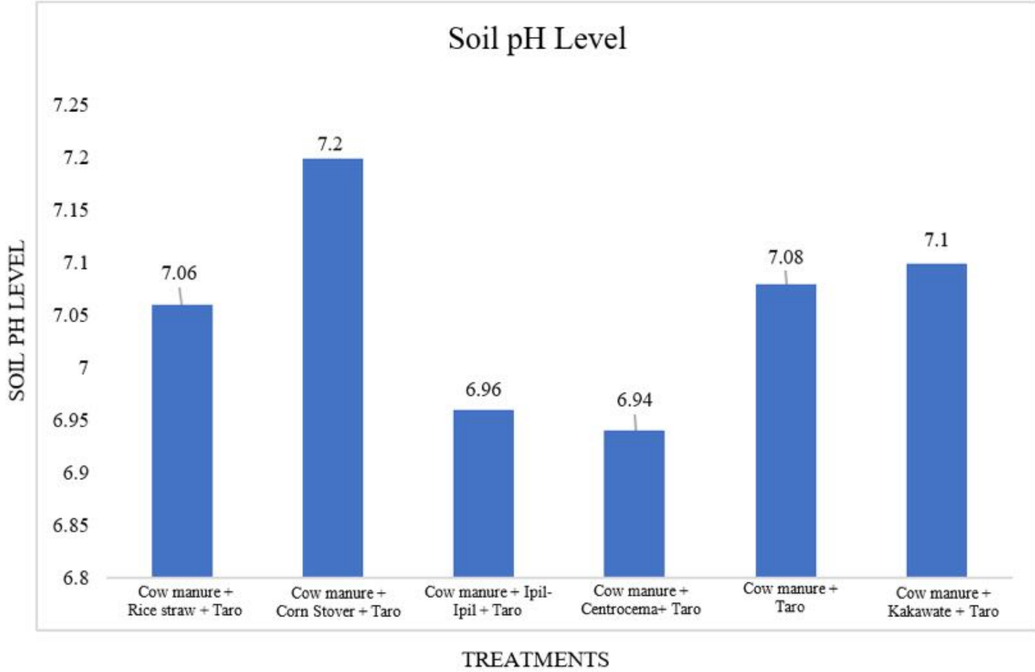

Figure 1: Soil pH level of Vermicasts

Moisture Content of Vermicasts

The moisture content within the vermicasts produced exhibited a notable range spanning from 13.5% to 55%, contributing significantly to the heightened microbial activity in the soil. Remarkably, the highest moisture content was recorded in vermibeds nourished with a specific blend of substrates, specifically cow manure, corn stover, and taro, peaking at an impressive 55%. This aligns with the findings of Singh and Kalamdhad [30], who emphasized that the digestive tracts of earthworms play host to beneficial microorganisms capable of transforming otherwise insoluble essential elements such as nitrogen (N), available phosphorus (P), exchangeable potassium (K), calcium (Ca), and magnesium (Mg) into soluble forms that are readily accessible for plant uptake. The presence of abundant moisture content serves to expedite the decomposition process of substrates, harmonizing seamlessly with the feeding habits of the African nightcrawler.

The discernible variance in moisture content among the diverse vermibeds underscores the pivotal role of substrate composition in determining the water-holding capacity of the vermicomposting system. The elevated moisture levels observed in the vermibed enriched with cow manure, corn stover, and taro unequivocally signal that this specific amalgamation of organic materials fosters an environment conducive to robust microbial activity and efficient earthworm digestion. Consequently, this creates a favorable milieu for the conversion of essential nutrients into readily available forms for plants, thus conferring tangible benefits to soil fertility and plant growth. The interconnected relationship between substrate

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composition, moisture content, and nutrient transformation not only reinforces the understanding of vermicomposting processes but also supports the effectiveness of tailored vermibed formulations in enhancing soil health and promoting plant growth.

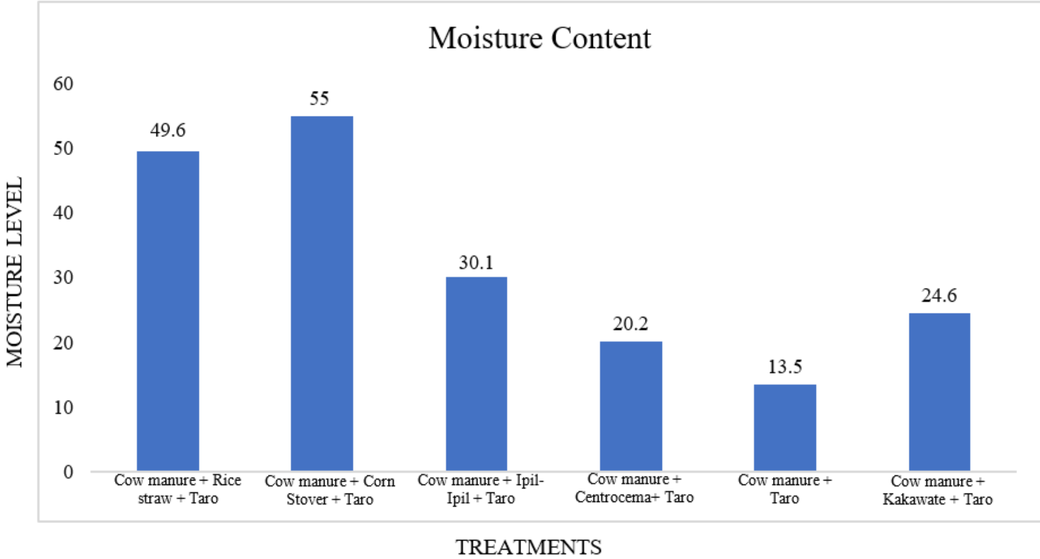

Figure 2: Moisture Content of Vermicasts Produced as affected by varying substrates

Total Nitrogen Content (%) in Vermicasts from Various Substrates

Figure 3 presents the nitrogen content in vermicasts produced from different substrate combinations, based on soil analysis by the DA-Cagayan Valley Research Center (DA-CVRC). The highest nitrogen level, 1.75%, was found in Treatment 4 (20% cow manure + 15% centrosema + 15% taro), highlighting the value of leguminous plants like centrosema in boosting nitrogen content. Treatment 1 (with rice straw) followed closely at 1.52%, while other treatments ranged from 1.39% to 1.50%. The lowest nitrogen level, 1.13%, was recorded in Treatment 5 (30% cow manure + 20% taro).

Although the differences were not statistically significant, the trend suggests that including legumes improves vermicast quality. Statistical analysis was performed using Analysis of Variance (ANOVA) under a Randomized Complete Block Design (RCBD). These findings support previous research by Dulaurent *et al.* [31] and Medina-Sauza *et al.* [32], which noted that earthworms help release nitrogen—mainly in nitrate form—benefiting both soil and worm growth. Overall, the study shows how vermicomposting with the right materials can naturally enrich soil and support better crop yields.

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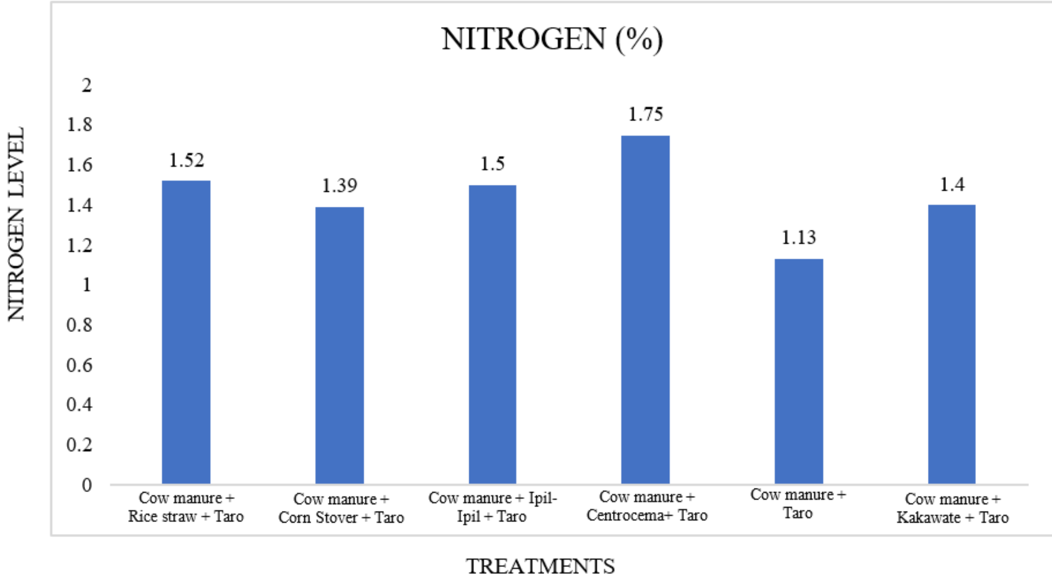

Figure 3: Nitrogen (%) Analysis of Vermicasts

Total Phosphorus (%) in Vermicasts

Figure 4 shows the phosphorus content in vermicasts, with Treatment 4 (20% cow manure + 15% centrosema + 15% taro) leading in phosphorus levels, followed by Treatments 6, 2, 1, and 5 in that order. Treatment 3 had the lowest phosphorus content.

The higher phosphorus content in Treatment 4 can be attributed to the presence of centrosema and cow manure, both known to have high phosphorus concentrations. Studies by Mao *et al*. [33] and Stuart [34] highlight the phosphorus-rich nature of these materials. After vermicomposting, Treatment 3 saw a decrease in organic phosphorus, while the other treatments, especially Treatment 4, showed significant increases. This supports findings by Sande *et al.* [23] and Yuan *et al.* [35] that vermicomposting can reduce organic phosphorus availability.

The results emphasize how substrate composition influences phosphorus enrichment in vermicomposting. The earthworms' role in breaking down organic matter and releasing phosphorus is crucial, as they enhance phosphorus mineralization through their bacterial and fecal phosphatase activity, as noted by Liu *et al.* [36] and Joseph [37]. This process not only enriches the soil with phosphorus but also helps improve agricultural productivity by boosting nutrient availability for plants.

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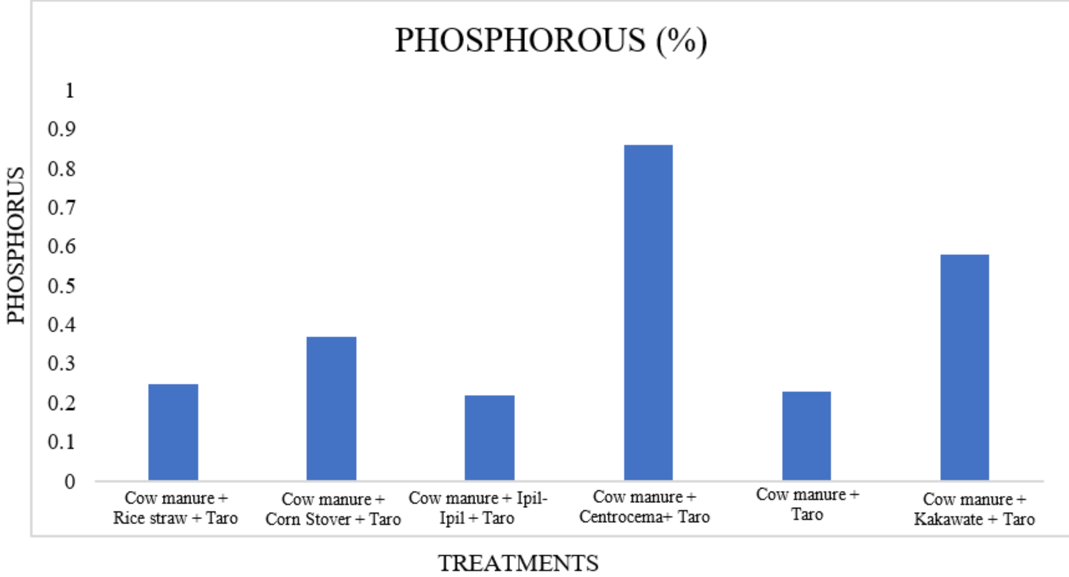

Figure 4: Phosphorous (%) Analysis of Vermicasts

Total Potassium Content (%) in Vermicasts

Figure 5 shows the total potassium content in the vermicasts. The highest potassium levels were found in vermibeds with kakawate, partially decomposed manure, and taro, while Treatments 1, 2, 3, 4 and 5 had potassium contents ranging from 0.24% to 0.40%.

These results highlight the significant variation in potassium content across the different treatments. The mix of kakawate and partially decomposed manure stands out for its particularly high potassium levels, making it a promising option for organic fertilizer production. Potassium is crucial for plant growth, regulating water balance, activating enzymes, and supporting photosynthesis, which makes these potassium-rich vermicasts valuable for improving crop health and yields [38,39,40].

The consistent potassium levels across the other treatments demonstrate the effectiveness of vermicomposting in providing a reliable source of this essential nutrient. These potassium-enriched vermicasts offer a strong potential for enhancing agricultural productivity by supporting plant growth and ensuring a steady supply of potassium for crops.

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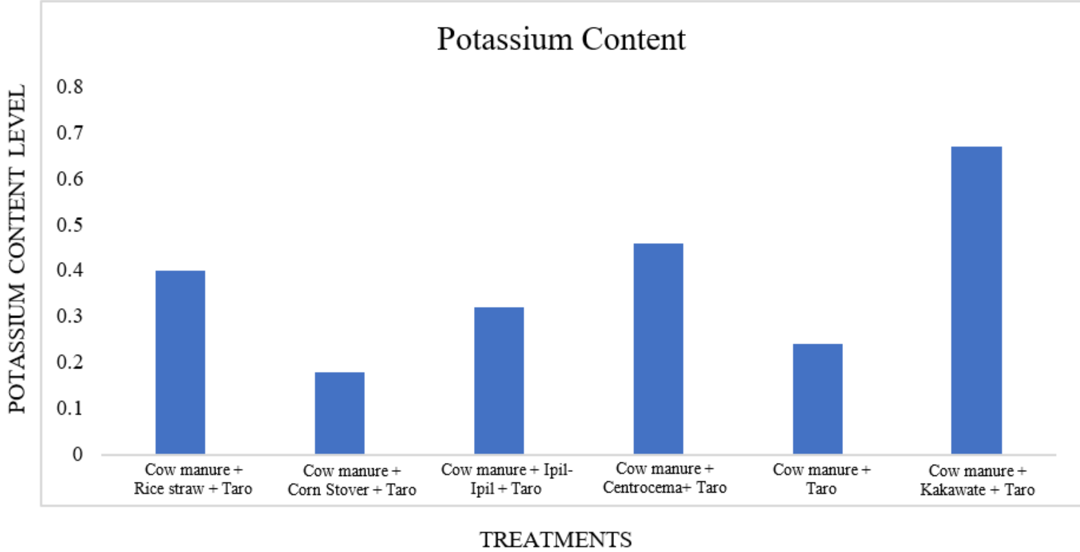

Figure 5: Postassium Content of Vermicast

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

This study shows that vermiculture, using different organic substrates, can greatly improve the quality of vermicasts by boosting their nutrient content and maintaining a healthy soil pH. The highest nitrogen levels were found in vermicasts made from a mix of cow manure, corn stover, and taro, while the most neutral pH, ideal for both plant growth and earthworm health, was seen in vermicasts from cow manure, rice straw, and taro. The pH remained within a slightly acidic to neutral range, suggesting that vermiculture helps create a soil environment supportive of sustainable farming. The presence of organic and humic acids, especially in vermicasts from *Eisenia fetida*, further highlights the role of earthworms in nutrient release. Overall, vermiculture proves to be a practical, eco-friendly alternative to chemical fertilizers, capable of improving soil health, enhancing productivity, and supporting the Philippine National Standards for Organic Agriculture (PNS for OA). Future studies should focus on testing substrate combinations that optimize nitrogen and potassium enrichment, tailoring mixes to specific crop requirements, and further exploring vermiculture's potential as a sustainable alternative to synthetic fertilizers.

To create richer vermicasts, it is important to mix the right materials. Using a combination of cow manure and leguminous plants, such as centrosema, can help improve nitrogen levels in the soil, resulting in healthier crops. Including potassium-rich ingredients in the vermicomposting mix, such as kakawate and partially decomposed manure, can further enhance soil fertility. Potassium is essential for strong plant growth and contributes to better crop yields.

Adopting vermicomposting also supports sustainable farming practices. As an eco-friendly alternative to chemical fertilizers, it naturally enriches the soil while reducing environmental impact.

Finally, selecting substrates that align with the nutrient requirements of specific crops ensures that vermicomposting efforts are maximized. Choosing the appropriate substrates can lead to improved productivity and more efficient use of resources over time.

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Conflict of Interest

The author declares that there is no conflict of interest.

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Table 1: Soil Laboratory Analysis Content of Vermicasts Produced

	NUTRIENTS ANALYSIS OF SOIL (%)		
TREATMENT	**NITROGEN**	**PHOSPHORUS**	**POTASSIUM**
Treatment 1-20% Cow manure + 15% rice straw + 15% taro	1.52	0.25	0.40
Treatment 2-20% Cow manure + 15% corn stover+15% taro	1.39	0.37	0.18
Treatment 3-20% cow manure+ 15% Ipil ipil+15% Taro	1.50	0.22	0.32
Treatment 4-20% cow manure+15% centrocema+15% Taro	1.75	0.86	0.46
Treatment 5-30% Cow manure+20% taro	1.13	0.23	0.24
Treatment 6-20% Cow manure+15% kakawate +15% taro	1.40	0.58	0.67

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