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Physicochemical Properties and Economic Viability of Vermicompost Produced from Selected Noxious Weeds and Farm Waste Materials

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ABSTRACT

This study evaluated the physicochemical properties and economic viability of vermicompost produced from selected noxious weeds and farm waste materials. Specifically, it determined the physical and chemical properties of vermicompost, assessed the interaction effects and significant differences among treatment combinations, and evaluated the economic viability of vermicompost production through return on investment (ROI). The experiment was conducted at Barangay Tina-an Sur, Leon, Iloilo, from December 2021 to March 2022 using a 3 × 4 factorial arrangement in a Split-Plot Design under a Completely Randomized Design (CRD) with three replications. Three noxious weed species (*Lantana camara*, *Chromolaena odorata*, and *Imperata cylindrica*) served as the main plot treatments. In contrast, four farm waste materials (dried banana leaves, rice straw, corn stover, and fruit wastes), each combined with animal manure, served as subplot treatments. Data were analyzed using Analysis of Variance (ANOVA), Least Significant Difference (LSD) test, Pearson's correlation analysis, and the Statistical Tool for Agricultural Research (STAR). Results revealed significant interaction effects between noxious weed species and farm waste materials on the physical and chemical properties of vermicompost. The combination of *Lantana camara* and rice straw with animal manure consistently produced superior compost quality, recording the highest organic matter (29.13%), organic carbon (16.93%), total nitrogen (1.46%), and the highest yield of 20.3 kg. In contrast, *Imperata cylindrica* combined with fruit wastes and animal manure produced the highest total phosphorus (1.42%), whereas *Lantana camara* combined with dried banana leaves and animal manure, and *Chromolaena odorata* combined with corn stover and animal manure recorded the highest total potassium (0.91%). Cost and return analysis showed that *Lantana camara* combined with rice straw and animal manure generated the highest return on investment (85%), indicating its economic advantage over the other treatment combinations. The study concludes that the interaction between noxious weed species and farm waste materials significantly influences the quality and profitability of vermicompost. Among the treatments evaluated, *Lantana camara* combined with rice straw and animal manure proved to be the most suitable substrate combination for producing high-quality and economically viable vermicompost.

Keywords: *vermicompost, noxious weeds, farm waste materials, physicochemical properties, economic viability, return on investment*

INTRODUCTION

Sustainable agriculture requires effective strategies for managing organic wastes while maintaining soil fertility and environmental quality. Vermicomposting has emerged as an environmentally friendly technology that converts biodegradable organic materials into nutrient-rich organic fertilizer through the combined action of earthworms and microorganisms. Compared with conventional composting, vermicomposting accelerates the decomposition process and produces vermicompost with improved nutrient availability, microbial activity, water-holding capacity, and soil-conditioning properties, thereby enhancing soil fertility and supporting sustainable crop production (Balachandar et al., 2021; Enebe & Erasmus, 2023). Consequently, vermicomposting has gained increasing recognition as a practical approach for organic waste management and sustainable agricultural development.

Agricultural production generates large quantities of biodegradable residues, including cattle manure, rice straw, corn stover, dried leaves, and fruit wastes, many of which remain underutilized despite their potential as composting substrates. At the same time, invasive and noxious weeds such as *Chromolaena odorata*, *Lantana camara*, and *Imperata cylindrica* have become major threats to agricultural productivity and biodiversity because of their rapid growth, allelopathic properties, and ability to outcompete desirable vegetation. Conventional weed management practices often provide only temporary control and may contribute to environmental degradation. Transforming these invasive weeds and farm wastes into vermicompost offers an alternative strategy that simultaneously addresses weed management, waste recycling, and sustainable fertilizer production (Ganguly et al., 2022; Das & Tangjang, 2024).

Recent studies have demonstrated that combining invasive weed biomass with organic farm waste materials during vermicomposting improves compost maturity, enhances nutrient recovery, and reduces phytotoxic compounds. Earthworm activity accelerates organic matter decomposition, decreases the carbon-to-nitrogen ratio, and increases the availability of essential nutrients such as nitrogen, phosphorus, and potassium, resulting in high-quality vermicompost suitable for agricultural use (Balachandar et al., 2021; Enebe & Erasmus, 2023). The quality of vermicompost is commonly evaluated through its physicochemical properties, including bulk density, porosity, water-holding capacity, moisture content, color, pH, organic matter, organic carbon, and macronutrient content, all of which influence its effectiveness as an organic soil amendment (Singh et al., 2024).

Despite growing interest in vermicomposting technologies, limited studies have comprehensively evaluated the physicochemical properties of vermicompost produced from selected noxious weeds combined with different farm waste materials under Philippine conditions. Most existing studies have focused on single weed species or specific compost characteristics, with limited attention given to the interaction effects between different noxious weed species and farm waste substrates. Furthermore, few studies have incorporated economic analyses to determine whether vermicompost production using invasive weeds is financially viable for farmers and small-scale enterprises (Enebe & Erasmus, 2023; Ganguly et al., 2022).

Therefore, this study was conducted to evaluate the physicochemical properties and economic viability of vermicompost produced from selected noxious weeds and farm waste materials. Specifically, it assessed the physical and chemical properties of vermicompost produced from different substrate combinations, determined the interaction effects of noxious weed species and farm waste materials, identified significant differences among treatment combinations, and evaluated the cost and return of vermicompost production. The findings are expected to provide scientific evidence supporting the sustainable utilization of invasive weed biomass and agricultural wastes as alternative substrates for vermicomposting, thereby contributing to integrated weed management, resource recovery, soil fertility improvement, and sustainable agricultural production.

Objectives of the Study

The study was conducted to evaluate the physicochemical properties and economic viability of vermicompost produced from selected noxious weeds and farm waste materials.

Specifically, the study aimed to:

Evaluate the physical properties (bulk density, porosity, water holding capacity, moisture content, color) of vermicompost derived from noxious weeds combined with different farm waste materials.

Evaluate the chemical properties (pH, organic matter, organic carbon, Total Nitrogen, Total Phosphorus, Total Potassium) of vermicompost derived from noxious weeds combined with different farm waste materials.

Determine the interaction effect of different noxious weed species combined with different farm waste materials in terms of its physical and chemical properties.

Determine if there are significant differences among the different treatment combinations in terms of physical and chemical properties.

Assess the cost and return analysis of vermicompost derived from noxious weeds combined with different farm waste materials.

Scope and Limitations

This study was conducted at Barangay Tina-an Sur, Leon, Iloilo, Philippines. It focused on evaluating the physicochemical properties and economic viability of vermicompost produced from selected noxious weeds and farm waste materials used as substrates. Specifically, the study utilized three noxious weed species Chromolaena odorata, Lantana camara, and Imperata cylindrica combined with four farm waste materials, namely dried leaves, rice straw, corn stover, and fruit wastes, each supplemented with cattle manure as the primary substrate for vermicomposting.

The experiment was conducted using a 3 × 4 factorial arrangement in a Split-Plot Design under a Completely Randomized Design (CRD) with three replications, resulting in a total of 36 experimental units. The study evaluated the physical properties of vermicompost, including bulk density, porosity, water-holding capacity, moisture content, and color, as well as its chemical properties, namely pH, organic matter, organic carbon, total nitrogen, total phosphorus, and total potassium. In addition, the study determined the interaction effects and significant differences among treatment combinations and assessed the economic viability of vermicompost production through cost and return analysis.

The study was limited to the selected noxious weed species, farm waste materials, and the African night crawler (Eudrilus eugeniae) as the decomposer organism. The findings were based on the physicochemical analyses conducted on vermicompost harvested under the experimental conditions of the study and did not include the evaluation of microbial populations, heavy metal content, maturity indices, greenhouse gas emissions, or the agronomic performance of the vermicompost under field conditions. Statistical analyses were performed using Analysis of Variance (ANOVA) to determine treatment effects, Pearson's correlation analysis to examine relationships among selected variables, and mean comparisons where appropriate using the Statistical Tool for Agricultural Research (STAR).

METHODS

Materials

The following materials were acquired prior to the start of the study; 8ft sakoline, Earthworms (E. eugeniae), meter stick, record book, plastic sheets, 0.3mm sieving net, weighing scale, noxious weeds (C. odorata, L. camara and I. cylindrica), cattle manure, rice straw, corn stover, fruit wastes and dried leaves.

Study site

The study was conducted at Brgy. Tina-an Sur, Leon, Iloilo, Philippines. The area is geographically located at coordinates 10°46’29”N, 122°22’27”E and an elevation of 607 m (Google Earth). The municipality is located in the south western part of the Province, about 28 kilometers from Iloilo City. It is bounded by the municipalities of Alimodian in the north, San Miguel in the East, Tigbauan and Tubungan in the south, and San Remigio, Antique, in the west.

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Research Design and Lay-out

The study was laid out in a 3 × 4 × 3 two factorial experiment using Split-Plot in Complete Randomize Design (CRD). It was done to assess the physicochemical characteristics of vermicompost derived from noxious weeds (Factor A) combined with different farm waste materials (Factor B). The study was composed of 12 treatment combinations. Randomization and lay-out were presented in Figure 1.

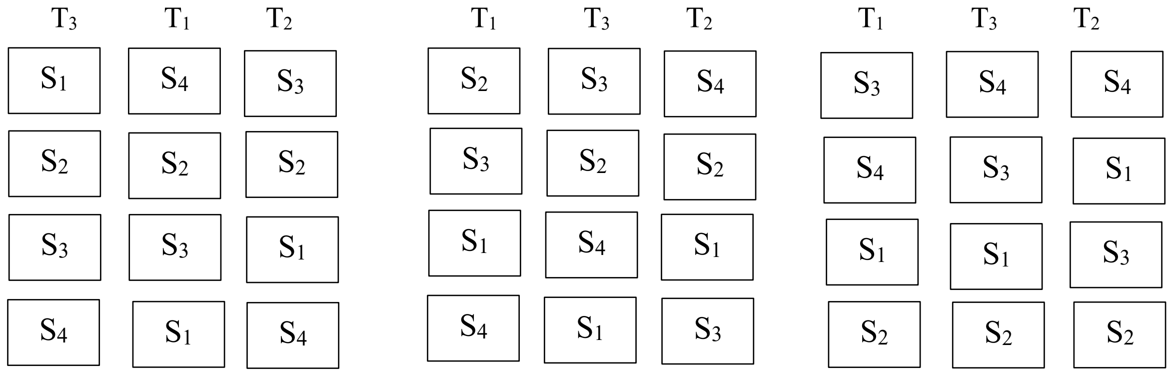

Figure 1. *Experimental lay-out of the study*

Legend:

Main Plot	Sub Plot
(Factor A - Noxious Weeds)	(Factor B - Farm Waste Materials)
T1 - 10 kgs L. camara	S1 - 6 kgs Dried leaves + 9 kgs cattle manure
T2 - 10 kgs C. odorata	S2 - 4 kgs Rice straw + 11 kgs cattle manure
T3 - 10 kgs I. cylindrica	S3 - 4 kgs Corn stover + 11 kgs cattle manure
	S4 - 8 kgs fruit wastes + 7 kgs cattle manure

Treatment Combinations

T1S1	10 kgs L. camara + 6 kgs Dried leaves + 9 kgs cattle manure
T1S2	10 kgs L. camara + 4 kgs Rice straw + 11 kgs cattle manure
T1S3	10 kgs L. camara + 4 kgs Corn stover + 11 kgs cattle manure
T1S4	10 kgs L. camara + 8 kgs Fruit wastes + 7 kgs cattle manure
T2S1	10 kgs C. odorata + 6 kgs Dried leaves + 9 kgs cattle manure
T2S2	10 kgs C. odorata + 4 kgs Rice straw + 11 kgs cattle manure
T2S3	10 kgs C. odorata + 4 kgs Corn stover + 11 kgs cattle manure
T2S4	10 kgs C. odorata + 8 kgs Fruit wastes + 7 kgs cattle manure
T3S1	10 kgs I. cylindrica + 6 kgs Dried leaves + 9 kgs cattle manure
T3S2	10 kgs I. cylindrica + 4 kgs Rice straw + 11 kgs cattle manure
T3S3	10 kgs I. cylindrica + 4 kgs Corn stover + 11 kgs cattle manure
T3S4	10 kgs I. cylindrica + 8 kgs Fruit wastes + 7 kgs cattle manure

Establishment and Set-up of Vermibin

Vermibox made of sakoline measuring 0.5 × 0.5 × 0.4 m was used in the study. Forty (40) holes were poked at the bottom to facilitate drainage and ensure proper moisture for earthworms. However, the holes made were covered with a fine mesh screen to prevent the worms from migrating to the bin. A shed was also constructed to prevent the vermiboxes from direct sunlight and heavy rains. Thirty-six (36) vermiboxes were constructed and labeled according to treatment combination and randomization.

Collection of Materials

Raw materials such as C. odorata, L. camara, I. cylindrica, cattle manure, rice straw, corn, dried leaves, and fruit wastes were gathered before study started. The materials were manually chopped at 1-2.5 cm while cattle manure was air dried and pulverized to hasten the decomposition process (DA-NDA). The E. eugeniae species of earthworm was purchased from the local vermi raisers in Leon, Iloilo, Philippines.

Pre-decomposition of Substrates

A total of 50 kgs fresh substrate materials were pre-decomposed for 2 weeks. The materials were placed inside the garbage bag and sealed to allow the materials to decompose anaerobically. The pre-decomposed materials were transferred into each bin following a recommended C:N ratio of 25-35:1.

Stocking of African Night Crawler

Vermi were selected and stocked after two weeks of decomposition at 250 grams per 25 kgs of compost material. It was calculated following the recommended stocking ratio of 1 kg vermi to every 1 sq.m bed with a substrate of around 100-200 kgs (DA-NDA). Partially decomposed cattle manure (included in 25 kgs substrates) was used as starter for the earthworms to ensure the availability of food and served as their hideout for reproduction. A 1-kilogram starter was placed in the center of the bin enclosed with banana sheaths with small opening at the sides forming like a rectangular box.

Care and Maintenance

Watering was done in 4-5 days intervals when the soil moisture meter reading falls behind 60%. One vermi box in the middle part of the experiment served as the basis in determination of the moisture content to facilitate easier measurement. Around 36 - 42 L of water was applied into each vermi box using a 6 Liter sprinkler.
The set up was enclosed with nets to prevent the worms from predators.

Harvesting

The compost was harvested 7 weeks after stocking of African Night Crawler (DA-NDA). Harvesting was done on two consecutive days across treatments and replications regardless of the maturity. The harvested compost was sieved using a sieving net with a diameter of 0.3 mm to separate fully decomposed cast from partially decomposed one. The fully sieved vermicompost was air dried for 5 days.

Data Collection

Bulk density and porosity test. The bulk density and porosity test was conducted at Natural Science Laboratory in Iloilo Science and Technology University - Leon, Campus, Leon, Iloilo, Philippines. The following laboratory materials were used in the conduct of the activity; graduated cylinder, beaker and digital weighing scale. For the bulk density test, an empty graduated cylinder was weighed. After weighing, a dry compost sample was poured into the cylinder and weighed again to determine its final weight. For the porosity test, a specific volume of water was measured in another graduated cylinder. The measured water was then added into the soil and was stirred until water completely penetrated the soil. The volume of the soil and water mixture was measured and recorded. The bulk density and porosity were obtained using the following equations:

Bulk density = Mass of the soil / Volume of the soil (g/cm3 or g/ml)
Where:
Mass of the soil = Mass of cylinder and soil - Mass of cylinder alone (g)

Porocity= Pore space Volume/Volume of soil x100
Where:
Pore space volume = Volume of soil + Volume of water - volume of soil and water (cm3 or ml)

The test was conducted following the methods and formula stated in the Soil Testing Manual, Roots of Peace, (2008).

Water holding capacity (%). The water holding capacity test was conducted at Natural Science Laboratory in Iloilo Science and Technology University - Leon, Campus, Leon, Iloilo, Philippines. The following laboratory materials were used in the conduct of the test; 6 small pots with 56 small holes in the bottom (modified Gooch crucible), digital weighing scale, small dishes and graduated cylinders. Water holding capacity was determined by weighing the crucible using digital weighing scale. After weighing, the crucible was filled up to 3/4 of the sample and then weighed and placed into a small dish half filled with water. The pot with sample was left for 20 minutes and then weighed to determine the total weight. The water holding capacity was calculated using the following formula:

Water holding capacity by mass = (Weight of water / Weight of the wet soil) x 100 (%)
Where:
Weight of the dry soil = Weight of dry soil and pot - Weight of the pot (g)
Weight of wet soil = Weight of wet soil and pot - Weight of the pot (g)
Weight of water = Weight of wet soil - Weight of dry soil

The test was conducted following the methods and formulas stated in the Soil Testing Manual, Roots of Peace, (2008).

Moisture content. Soil moisture content was analysed at the Regional Organic Soils Laboratory in Hamungaya, Buntatala, Jaro, Iloilo City, Philippines through gravimetric method.

Color. The color of the compost was determined through the guide of Munsell Color Chart. A small sample was taken and placed beside the color indexes in the chart and assessed based on chroma, value and hue. The data was recorded qualitatively.

Chemical Analysis

A 0.5 kg sample of harvested compost for analysis was obtained through coning and quartering method of sampling. The thoroughly sieved compost was air-dried before subjecting to analysis. Total K, pH and OC were analyzed at Regional Organic Soils Laboratory in Hamungaya, Buntatala, Jaro, Iloilo City, Philippines, while Total P was analyzed in Sugar Regulatory Authority - Negros, Occidental, Philippines.

The following are the methods used in determining the chemical properties of the vermicompost:

pH. The pH was determined using Potentiometric Method.

Organic matter. Organic matter was derived using the following formula: OM = Percent Organic Carbon x 1.72, assuming that organic matter is composed of 58% carbon (Rameshwar and Argaw, 2016).

Organic carbon. Organic carbon was determined through Walkley-Black Method.

Total N. Total N was obtained through the following equation as cited in Cagasan et al., (2020): Total N (%) = % OM x 0.05. This was done because Kjeldahl digestion which is used in determining the nitrogen content of organic matter is not available in the region.

Total P. The Total P was analyzed using Volumetric and Titration method.

Total K. The Total K was determined using Flame Atomic Emission Method.

Data Analysis

All data was tabulated and analyzed using Analysis of Variance (ANOVA) for split-plot design at 5% and 1% probability levels through Statistical Tool for Agricultural Research (STAR). Correlation analysis was also done to test the relationship between the two variables. Further, the Least Significant Difference (LSD) Test was used to test the significant differences among treatment means. Qualitative data are described descriptively and were presented using charts and graphs.

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RESULTS AND DISCUSSION

Bulk density

The average bulk density of vermicompost produced from selected noxious weeds combined with different farm waste materials is expressed in g mL^{-1} and presented in Table 1.

Bulk density values of vermicompost derived from noxious weeds ranged from 0.69 to 0.80 g mL^{-1}, with *L. camara* producing the highest bulk density (0.80 g mL^{-1}), followed by *C. odorata* (0.71 g mL^{-1}) and *I. cylindrica* (0.69 g mL^{-1}). Among the farm waste materials, bulk density ranged from 0.68 to 0.77 g mL^{-1}. Vermicompost produced from dried banana leaves + animal manure recorded the highest bulk density (0.77 g mL^{-1}), followed by fruit wastes + animal manure (0.75 g mL^{-1}), corn stover + animal manure (0.72 g mL^{-1}), while rice straw + animal manure produced the lowest bulk density (0.68 g mL^{-1}).

Analysis of Variance (ANOVA) revealed a highly significant ($p < 0.01$) interaction effect between noxious weed species and farm waste materials, indicating that the combination of these substrates significantly influenced the bulk density of the resulting vermicompost. The Lowest Significant Difference (LSD) test showed that *L. camara* generally produced vermicompost with higher bulk density, whereas *I. cylindrica* combined with fruit waste and animal manure produced the lowest bulk density. Likewise, significant differences were observed among the farm waste materials, with dried banana leaves producing higher bulk density than the other substrates, while corn stover produced significantly lower values.

Lower bulk density is generally considered desirable because it improves soil structure, enhances aeration, facilitates root penetration, and increases water infiltration and drainage. The relatively lower bulk density observed in vermicompost derived from *I. cylindrica* may be attributed to the porous and fibrous nature of its biomass, which decomposes into lighter organic particles during vermicomposting. Similarly, the lower bulk density obtained from rice straw + animal manure may be associated with the high lignocellulosic content and loose fiber structure of rice straw, which promotes greater pore space within the finished vermicompost. In contrast, dried banana leaves produced denser compost because of their compact leaf tissues and relatively slower decomposition rate, resulting in finer and more compact organic particles.

These findings agree with recent studies demonstrating that the physical properties of vermicompost are largely influenced by the type and composition of organic substrates used during composting. Enebe and Erasmus (2023) reported that substrate composition significantly affects bulk density, porosity, and water-holding capacity because different organic materials undergo varying rates of decomposition and humification. Likewise, Balachandar et al. (2021) observed that vermicompost produced from invasive weed biomass exhibited favorable physical characteristics, including reduced bulk density and improved soil-conditioning properties, making it suitable for sustainable crop production. Furthermore, Singh et al. (2024) emphasized that vermicompost with lower bulk density promotes better soil aggregation, root development, and moisture retention, thereby enhancing overall soil productivity.

Table 1. *Bulk density of vermicompost produced from noxious weeds and farm waste material as substrates harvested at 7 weeks after vermicomposting*

Main Plot and Subplot		Bulk density (g/ml)
Main Plot – Noxious weeds		
T_1	*L. camara*	0. 79^a
T_2	*C. odorata*	0. 73^b
T_3	*I. cylindrica*	0. 69^b
Subplot - Farm waste materials		
S_1	Dried banana leaves + animal manure	0. 77^a
S_2	Rice straw + animal manure	0. 68^c
S_3	Corn stover + animal manure	0. 75^b

S_4	Fruit wastes + animal manure	0. 73^{b}
	TREATMENTS' INTERACTION EFFECT	
$T_1 S_1$	*L. camara* + Dried banana leaves + animal manure	0. 75^{b}
$T_1 S_2$	*L. camara* + Rice straw + animal manure	0. 70^{c}
$T_1 S_3$	*L. camara* + Corn stover + animal manure	0. 84^{a}
$T_1 S_4$	*L. camara* + Fruit wastes + animal manure	0. 86^{a}
$T_2 S_1$	*C. odorata* + Dried banana leaves + animal manure	0. 76^{a}
$T_2 S_2$	*C. odorata* + Rice straw + animal manure	0. 73^{a}
$T_2 S_3$	*C. odorata* + Corn stover + animal manure	0. 68^{b}
$T_2 S_4$	*C. odorata* + Fruit wastes + animal manure	0. 73^{a}
$T_3 S_1$	*I. cylindrica* + Dried wastes + animal manure	0. 79^{a}
$T_3 S_2$	*I. cylindrica* + Rice straw + animal manure	0. 62^{c}
$T_3 S_3$	*I. cylindrica* + Corn stover + animal manure	0. 74^{b}
$T_3 S_4$	*I. cylindrica* + Fruit wastes + animal manure	0. 61^{c}

p – value (a)	0 . 002**
p – value (b)	0. 000**
p – value (axb)	0. 000**
cv (a)	5.38 %
cv (b)	2. 74 %

[abcd] treatment means with the same letter superscript are not significantly different at 1% of probability
** Significant at 1% level of probability

Porosity (%)

The mean percent porosity of vermicompost produced from noxious weed species and farm waste materials is shown in Table 2.

The porosity values ranged from 62.50% - 68.04% for vermicompost produced from noxious weeds. The highest porosity value of 68.04% was found in *I. cylindrica* vermicompost, followed by *C. odorata* with 64.25% and the lowest was found in *L. camara* with 62.50% porosity. For different farm waste materials, rice + animal manure obtained the highest percent porosity (66.67%) followed by fruit wastes + animal manure (66.56%), corn stover + animal manure (64%) and dried banana leaves + animal manure (62.50%) as the lowest.

The Analysis of Variance (ANOVA) revealed significant (p>0.01ɑ) interaction effect. Least Significant Difference (LSD) Test revealed that vermicompost obtained from *C. odorata* combined with fruit wastes + animal manure obtained the highest porosity. However, no significant differences (p>0.05ɑ) were observed among noxious weeds and farm waste materials.

Table 2. *Porosity (%) of vermicompost produced from noxious weeds and farm waste materials as substrates harvested at 7 weeks after vermicomposting*

	Main Plot and Subplot	Porosity (%)
Main plot –	Noxious weeds	
T_1	*L. camara*	62. 50
T_2	*C. odorata*	64. 25
T_3	*I. cylindrica*	68. 04
Subplot –	Farm waste materials	
S_1	Dried banana leaves + animal manure	62. 50
S_2	Rice straw + animal manure	66. 67
S_3	Corn stover + animal manure	64. 00

S_4	Fruit wastes + animal manure	66. 56
TREATMENTS' INTERACTION EFFECT		
$T_1 S_1$	*L. camara* + Dried banana leaves + animal manure	66^{a}
$T_1 S_2$	*L. camara* + Rice straw + animal manure	61^{a}
$T_1 S^3$	*L. camara* + Corn stover + animal manure	63^{a}
$T_1 S_4$	*L. camara* + Fruit wastes + animal manure	60^{a}
$T_2 S_1$	*C. odorata* + Dried banana leaves + animal manure	58^{b}
$T_2 S_2$	*C. odorata* + Rice straw + animal manure	69^{a}
$T_2 S_3$	*C. odorata* + Corn stover + animal manure	58^{h}
$T_2 S_4$	*C. odorata* + Fruit waste + animal manure	72^{a}
$T_3 S_1$	*I. cylindrica* + Dried banana leaves + animal manure	64^{b}
$T_3 S_2$	*I. cylindrica* + Rice straw + animal manure	70^{a}
$T_3 S_3$	*I. cylindrica* + Corn stover + animal manure	71^{a}
$T_3 S_4$	*I. cylindrica* + Fruit waste + animal manure	68^{ab}
p- value (a)		0.0746^{ns}
p- value (b)		0.0795^{ns}
p- value (axb)		0. 0010**
cv (a)		6.55%
cv (b)		5.77%

[ab] treatment means with the same letter superscript are not significantly different at 1% level of probability
[ns] not significant at 5% level of probability
** significant at 1% level of probability

Relationship of Bulk density and Porosity

The relationship between bulk density and porosity of vermicompost produced from selected noxious weeds and different farm waste materials is presented in Table 1 and 2. The porosity of vermicompost derived from noxious weeds decreased from 68.04% to 62.50% as bulk density increased from 0.69 to 0.80 g mL^{-1}. Although the correlation analysis indicated that the relationship between bulk density and porosity was not statistically significant ($p > 0.05$), an inverse trend was consistently observed among the treatment combinations. Similarly, vermicompost produced from the different farm waste materials exhibited the same pattern, with porosity ranging from 66.67% to 62.50% while bulk density increased from 0.68 to 0.77 g mL^{-1}.

The inverse relationship between bulk density and porosity is expected because these physical properties are structurally interdependent. Vermicompost with lower bulk density generally contains greater pore spaces, resulting in higher porosity, improved aeration, enhanced water infiltration, and better root penetration. Conversely, higher bulk density indicates a more compact material with fewer pore spaces, leading to reduced porosity. Although the present study did not detect a statistically significant correlation, the observed trend agrees with the physical principles governing soil and compost structure and suggests that substrate composition influenced the arrangement of organic particles during the vermicomposting process (Enebe & Erasmus, 2023).

The lower bulk density and higher porosity observed in vermicompost produced from *Imperata cylindrica* may be attributed to the fibrous and porous nature of grass biomass, which creates greater interparticle spaces during decomposition. Likewise, rice straw-based substrates produced vermicompost with relatively higher porosity because rice straw contains coarse lignocellulosic fibers that resist excessive compaction and maintain a loose compost structure. In contrast, dried banana leaves produced vermicompost with relatively higher bulk density and lower porosity, possibly because the finer particles generated during decomposition occupied pore spaces and resulted in a denser compost matrix.

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Recent studies have similarly reported that substrate characteristics strongly influence the physical properties of vermicompost. Enebe and Erasmus (2023) emphasized that feedstock composition determines bulk density, porosity, and water-holding capacity because different organic materials undergo varying rates of decomposition and humification. Likewise, Lim et al. (2023) reported that vermicompost produced from fibrous agricultural residues generally exhibits lower bulk density and higher porosity than compost produced from more compact organic materials. These physical characteristics are important indicators of compost quality because highly porous vermicompost promotes soil aggregation, root development, water movement, and microbial activity, thereby improving overall soil productivity (Singh et al., 2024).

Water holding Capacity (%)

The mean water holding capacity of vermicompost produced from noxious weed species and farm waste materials is shown in Table 3.

The water holding capacity values for vermicompost produced from noxious weed species ranged from 20.99 – 34.96% *C. odorata* obtained the highest water holding capacity (34.96%), followed by *L. camara* (23.12%) and *I. cylindrica* with the lowest value (20.99%). For farm waste materials, the values ranged from 23.57 – 31.41%. The highest water holding capacity was found with vermicompost derived from dried banana leaves + animal manure (31.41%), followed by corn stover + animal manure (26.83%), fruit waste + animal manure (23.61%) and the lowest was found in the rice straw + animal manure (23.57%).

Significant ($p<0.01$ 0.α) interaction effect was observed between noxious weeds and farm waste materials. The Least Significance Difference (LSD) Test revealed that vermicompost obtained from *C. odorata* in combination with dried banana leaves + animal manure obtained significantly higher water holding capacity. Significant difference ($p<0.01$α) among noxious weeds and farm waste materials were also found. Least Significant Difference (LSD) Test revealed that vermicompost derived from *C. odorata* obtained the highest water holding capacity compared to *L. camara* but comparable to that of *I. cylindrica.* On the other hand, dried banana leaves + animal manure obtained the highest water holding capacity and are comparable to the rest of the treatments.

Table 3. *Water holding capacity (%) of vermicompost produced from noxious weeds and farm waste materials as substrates harvested at 7 weeks after vermicomposting*

Main Plot and Subplot		Water holding capacity (%)
Main plot –	Noxious weeds	
T_1	*L. camara*	23.12^{b}
T_2	*C. odorata*	34.96^{a}
T_3	*I. cylindrica*	20.99^{abc}
Subplot –	Farm waste material	
S_1	Dried banana leaves + animal manure	31.41^{a}
S_2	Rice straw + animal manure	23.57^{ab}
S_3	Corn stover + animal manure	26.83^{ab}
S_4	Fruit waste + animal manure	23.61^{ab}
TREATMENTS' INTERACTION EFFECT		
$T_1 S_1$	*L. camara* + Dried banana leaves + animal manure	29.65^{a}
$T_1 S_2$	*L. camara* + Rice straw + animal manure	23.24^{ab}
$T_1 S_3$	*L. camara* + Corn stover + animal manure	18.29^{b}
$T_1 S_4$	*L. camara* + Fruit waste + animal manure	21.29^{b}
$T_2 S_1$	*C. odorata* + Dried banana leaves +animal manure	38.98^{a}
$T_2 S_2$	*C. odorata* + Rice straw + animal manure	35.97^{ab}

$T_2 S_3$	*C. odorata* + Corn stover + animal manure	30. 36[b]
$T_2 S_4$	*C. odorata* + Fruit wastes + animal manure	34. 53[ab]
$T_3 S_1$	*I. cylindrica* + Dried banana leaves + animal manure	25. 60[a]
$T_3 S_2$	*I. cylindrica* + Rice straw + animal manure	11. 52[b]
$T_3 S_3$	*I. cylindrica* + Corn stover + animal manure	31. 85[a]
$T_3 S_4$	*I. cylindrica* + Fruit wastes + animal manure	15. 00[b]
p- value (a)		0. 000**
p- value (b)		0. 005**
p- value (axb)		0. 001**
cv (a)		11.59 %
cv (b)		17.05 %

[abcd] treatment means with the same letter superscript are not significantly different at 1% level of probability
** significant level of probability

Moisture Content

The mean moisture content of vermicompost produced from noxious weed species and farm waste materials was shown in Table 4.

The highest moisture content was obtained by the vermicompost produced from *C. odorata* (41.25%), followed by *L. camara* (36.09%) and *I. cylindrica* (32.82%). For farm waste materials, rice straw + animal manure obtained the highest moisture content (37.33%) followed by Corn stover + animal manure (36.70%) and fruit wastes + animal manure (35.64%).

Analysis of Variance (ANOVA) revealed a significant ($p<0.01\alpha$) interaction effect between noxious weeds and farm waste materials, suggesting that the combination of noxious weeds and farm waste materials contributed to the moisture content of the vermicompost produced. The Least Significant Difference (LSD) Test revealed that vermicompost produced from *C. odorata* combined with dried banana leaves + animal manure obtained the highest moisture content. Significant differences ($p<0.01\alpha$) among noxious weeds and farm waste materials were also found. The Least Significant Difference (LSD) Test revealed that vermicompost derived from *C. odorata* obtained significantly higher moisture content but is comparable to the rest of the treatments. On the other hand, rice straw + animal manure obtaines the highest water holding capacity and is comparable to dried banana leaves + animal manure and fruit wastes + animal manure. On the other hand, corn stover + animal manure was found to a have significantly different moisture content than dried banana leaves + animal manure.

Table 4. *Moisture content (%) of vermicompost produced from noxious weeds and farm waste materials as substrates harvested at 7 weeks after vermicomposting*

Main Plot and Subplot		MoisturContent (%)
Main plot –	Noxious weeds	
T_1	*L. camara*	36. 09[b]
T_2	*C. odorata*	41. 25[a]
T_3	*I. cylindrica*	32. 82[c]
Subplot –	Farm waste materials	
S_1	Dried banana leaves + animal manure	36. 70[b]
S_2	Rice straw + animal manure	37. 33[a]
S_3	Corn Stover + animal manure	37. 21[a]
S_4	Fruit waste + animal manure	35. 64[c]

TREATMENTS' INTERACTION EFFECT		
$T_1 S_1$	*L. camara* + Dried banana leaves + animal manure	41. 67[a]
$T_1 S_2$	*L. camara* + Rice straw + animal manure	29. 61[d]
$T_1 S_3$	*L. camara* + Corn stover + animal manure	37. 45[b]
$T_1 S_4$	*L. camara* + Fruit waste + animal manure	35. 64[c]
$T_2 S_1$	*C. odorata* + Dried banana leaves + animal manure	46. 25[a]
$T_2 S_2$	*C. odorata* + Rice straw + animal manure	44. 32[b]
$T_2 S_3$	*C. odorata* + Corn stover + animal manure	39. 78[c]
$T_2 S_4$	*C. odorata* + Fruit waste + animal manure	35. 30[d]
$T_3 S_1$	*I. cylindrica* + Dried banana leaves + animal manure	22. 82[d]
$T_3 S_2$	*I. cylindrica* + Rice straw + animal manure	38. 07[a]
$T_3 S_3$	*I. cylindrica* + Corn stover + animal manure	34. 31[c]
$T_3 S_4$	*I. cylindrica* + Fruit waste + animal manure	35. 98[b]
p- value (a)		0. 000**
p- value (b)		0. 000**
p- value (axb)		0.000**
cv (a)		0. 4074%
cv (b)		0. 5189%

[abcd] treatment means with the same letter superscript are not significantly different at 1% level of probability
** significant at 1% level of probability

Color

The color of the vermicompost produced from each treatment combination is presented in Table 5. Vermicompost color was determined through visual observation using the Munsell Soil Color Chart and described qualitatively. The dominant color observed among the vermicomposts was brownish black, particularly in treatments containing *Lantana camara* and *Chromolaena odorata*, except for those combined with rice straw and animal manure, which exhibited a brownish gray color. In contrast, vermicompost produced from *Imperata cylindrica* was predominantly brownish gray, except for the treatment combined with corn stover and animal manure.

The dark brown to black coloration observed in most treatments is generally considered an indicator of advanced organic matter decomposition and compost maturity. During vermicomposting, earthworms and microorganisms transform fresh organic residues into stabilized humified materials rich in humic and fulvic substances, resulting in a darker color. Dark-colored vermicompost is commonly associated with increased humification, improved organic matter stabilization, and enhanced nutrient availability, making it a desirable characteristic of mature compost (Enebe & Erasmus, 2023; Lim et al., 2023).

The lighter brownish-gray color observed in vermicompost containing *Imperata cylindrica* and rice straw may be attributed to the high lignocellulosic composition of these grass-based substrates. Grasses generally contain higher concentrations of cellulose, hemicellulose, silica, and lignin than broadleaf plant materials, resulting in slower decomposition and humification. Consequently, these substrates may produce compost with lighter coloration because of the lower accumulation of dark humic substances during the vermicomposting process (Balachandar et al., 2021; Das & Tangjang, 2024). The relatively slower degradation of fibrous grass materials may also explain the persistence of lighter-colored organic particles in the finished vermicompost.

Although few studies have specifically examined the influence of substrate type on vermicompost color, recent research consistently recognizes compost color as a practical indicator of decomposition, stabilization, and maturity. Enebe and Erasmus (2023) reported that darker vermicompost generally reflects greater humification and higher organic matter stabilization, while variations in color are influenced by the chemical composition of the feedstock and the extent of microbial decomposition. Likewise, Das and Tangjang (2024) observed that differences in substrate composition significantly affected the physicochemical characteristics of vermicompost, including maturity-related attributes associated with the decomposition of lignocellulosic materials. Therefore, the variation in color observed among the treatment combinations in the present study may be attributed to differences in the chemical composition and decomposition rates of the noxious weeds and farm waste materials used as vermicomposting substrates.

Table 5. *Vermicompost color derived from noxious weeds and farm waste materials as substrates harvested at 7 weeks after vermicomposting*

	Color
Farm waste Materials	
Lantana camara	
Dried banana leaves + animal manure	Brownish black
Rice straw + animal manure	Brownish gray
Corn stover + animal manure	Brownish black
Fruit wastes + animal manure	Brownish black
Chromolaena odorata	
Dried banana leaves + animal manure	Brownish black
Rice straw + animal manure	Brownish gray
Corn stover + animal manure	brownish black
Imperata cylindrica	
Dried banana leaves + animal manure	Brownish gray
Rice straw + animal manure	Brownish gray
Corn stover + animal manure	Brownish black
Fruit wastes + animal manure	Brownish gray

Vermicompost pH

The mean pH values of vermicompost produced from selected noxious weeds and different farm waste materials are presented in Table 6.

The pH of vermicompost derived from the noxious weed species ranged from 7.66 to 8.32, with *Lantana camara* recording the highest mean pH (8.32), followed by *Chromolaena odorata* (8.15) and *Imperata cylindrica* (7.66). Among the farm waste materials, pH values ranged from 7.81 to 8.30, wherein dried banana leaves combined with animal manure produced the highest pH (8.30), followed by fruit wastes + animal manure (8.10), corn stover + animal manure (7.96), and rice straw + animal manure (7.81).

Analysis of Variance (ANOVA) revealed a highly significant interaction effect ($p < 0.01$) between noxious weed species and farm waste materials, indicating that the combination of substrates significantly influenced the pH of the resulting vermicompost. The Least Significant Difference (LSD) test further showed that the combination of *L. camara* with fruit wastes and animal manure produced the highest pH (8.53). Significant differences were likewise observed among the main effects of noxious weed species and farm waste materials. Vermicompost derived from *L. camara* exhibited significantly higher pH than that produced from *I. cylindrica*, although it was statistically comparable with *C. odorata*. Likewise, dried banana leaves combined with animal manure produced significantly higher pH than rice straw and corn stover, but were comparable with fruit wastes combined with animal manure.

The moderately alkaline pH (7.66–8.32) observed in this study indicates that the vermicompost had reached an advanced stage of decomposition and stabilization. During vermicomposting, organic acids produced during the initial decomposition phase are gradually metabolized by microorganisms, while earthworm activity accelerates the mineralization of nitrogenous compounds. The release of ammonium ions, calcium, magnesium, and other basic cations, together with the formation of stable humic substances, contributes to the buffering capacity of vermicompost and results in a neutral to slightly alkaline pH (Enebe & Erasmus, 2023; Lim et al., 2023).

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The relatively higher pH observed in vermicompost derived from *L. camara* may be attributed to differences in the chemical composition of the substrate and the enhanced mineralization of organic matter during decomposition. Feedstocks rich in calcium, potassium, and other alkaline minerals generally produce vermicompost with slightly higher pH values because these elements neutralize organic acids generated during microbial degradation (Balachandar et al., 2021). Similar findings have been reported by Das and Tangjang (2024), who observed that vermicomposts prepared from invasive weed biomass exhibited neutral to moderately alkaline pH, indicating satisfactory compost maturity and stabilization.

The pH values obtained in the present study fall within the acceptable range for mature vermicompost and are considered suitable for agricultural application. Mature vermicompost generally exhibits a pH ranging from neutral to moderately alkaline, which favors nutrient availability, microbial activity, and improved soil fertility. Although slightly acidic to neutral pH is considered optimal for the availability of most plant nutrients, moderately alkaline vermicompost remains beneficial when incorporated into acidic soils because it helps improve soil buffering capacity and supports sustainable crop production (Enebe & Erasmus, 2023; Singh et al., 2024).

Table 6. *Vermicompost pH produced from noxious weeds and farm waste materials as substrates harvested at 7 weeks after vermicomposting*

	Main Plot and Subplot	pH
Main plot –	Noxious Weeds	
T_1	*L. camara*	8. 32[a]
T_2	*C. odorata*	8. 15[a]
T_3	*I. cylindrica*	7. 66[b]
Subplot –	Farm waste materials	
S_1	Dried banana leaves + animal manure	8. 30[a]
S_2	Rice straw + animal manure	7. 81[c]
S_3	Corn stover + animal manure	7. 96[b]
S_4	Fruit wastes + animal manure	8. 10[b]
	TREATMENTS' INTERACTION EFFECT	
$T_1 S_1$	*L. camara* + Dried banana leaves + animal manure	8. 51[a]
$T_1 S_2$	*L. camara* + Rice straw + animal manure	7. 97[c]
$T_1 S_3$	*L. camara* + Corn stover + animal manure	8. 26[b]
$T_1 S_4$	*L. camara* + Fruit wastes + animal manure	8. 53[b]
$T_2 S_1$	*C. odorata* + Dried banana leaves + animal manure	8. 38[a]
$T_2 S_2$	*C. odorata* + Rice straw + animal manure	7. 96[c]
$T_2 S_3$	*C. odorata* + Corn stover + animal manure	8. 08[bc]
$T_2 S_4$	*C. odorata* + Fruit wastes + animal manure	8. 18[b]
$T_3 S_1$	*I. cylindrica* + Dried banana leaves + animal manure	8. 02[a]
$T_3 S_2$	*I. cylindrica* + Rice straw + animal manure	7. 50[c]
$T_3 S_3$	*I. cylindrica* + Corn stover + animal manure	7. 68[b]
$T_3 S_4$	*I. cylindrica* + Fruit wastes + animal manure	7. 59[bc]
p- value (a)		0. 000**
p- value (b)		0. 000**
p- value (axb)		0. 011**
cv (a)		1. 45%
cv (b)		1. 25%

[abc] treatment means with same letter superscript are not significantly different at 1% level of probability
** significant at 1% level of probability

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Table 7. *Soil pH range and reaction rating*

pH Range	Soil Rating
<4. 6	Extremely acidic
4.6 – 5.5	Strongly acidic
5.6 – 6.5	Moderately acidic
6.6 – 6.9	Slightly acidic
7.0	Neutral
7.1 – 8.5	Moderately alkaline
>8.5	Strongly alkalaine

Source: L.A Alban and K. Mildred

Organic Matter (OM)

The mean organic matter content of vermicompost produced from noxious weeds and various farm waste materials as substrates are presented in Table 8.

The mean OM values found on vermicompost produced from noxious weeds ranged from 20.29 – 27.51, in which the highest value was found on *C. odorata* and the lowest was found in *I. cylindrica.* The mean OM values for different farm waste materials ranged from 18.27 – 33.20, with the highest found in rice straw + animal manure and the lowest in fruit wastes + animal manure.

Analysis of Variance (ANOVA) revealed a significant ($p>0.01\alpha$) interaction effect between noxious weeds and different farm waste materials. Thus, it can be implied that incorporating noxious weeds into farm waste materials will significantly affect its organic matter content. The Least Significant Difference (LSD) Test revealed that *L. camara* combined with rice straw + animal manure obtained the highest organic matter content of 29.13%. Significant ($p>0.01\alpha$) differences in the means of organic matter content found in noxious weeds and different farm waste materials. The Least Significant Difference (LSD) Test revealed that *C. odorata* compost has higher organic matter content but is also comparable with *L. camara* and *I. cylindrica.* Rice straw + animal manure was observed to have higher organic matter content for farm waste materials but is also comparable to the vermicompost obtained from corn stover + animal manure and fruit waste + animal manure. A significantly different result was obtained by vermicompost derived from banana leaves + animal manure.

Table 8. *Organic Matter of vermicompost produced from noxious weeds and farm waste materials as substrates harvested at 7 weeks after vermicomposting*

Main plot and Subplot		Organic Matter (%)
Main plot –	Noxious weeds	
T_1	*L. camara*	22.18^{b}
T_2	*C. odorata*	27.51^{a}
T_3	*I. cylindrica*	20.29^{c}
Subplot –	Farm waste materials	
S_1	Dried banana leaves + animal manure	19.60^{c}
S_2	Rice straw + animal manure	33.20^{a}
S_3	Corn Stover + animal manure	22.24^{b}
S_4	Fruit wastes + animal manure	18.27^{d}

TREATMENTS' INTERACTION EFFECT		
$T_1 S_1$	*L. camara* + Dried banana leaves + animal manure	22. 32[a]
$T_1 S_2$	*L. camara* + Rice stover + animal manure	29. 13[a]
$T_1 S_3$	*L. camara* + Corn stover + animal manure	23. 13[a]
$T_1 s_4$	*L. camara* + Fruit wastes + animal manure	14. 15[c]
$T_2 S_1$	*C. odorata* + Dried banana leaves + animal manure	16. 61[c]
$T_2 S_2$	*C. odorata* + Rice straw + animal manure	16. 48[c]
$T_2 S_3$	*C. odorata* + Corn stover + animal manure	22. 93[b]
$T_2 S_4$	*C. odorata* + Fruit wastes + animal manure	21. 06[a]
$T_3 S_1$	*I. cylindrica* + Dried banana leaves + animal manure	19. 88[b]
$T_3 S_2$	*I. cylindrica* + Rice straw + animal manure	21. 04[b]
$T_3 S_3$	*I. cylindrica* + Corn stover + animal manure	20. 66[c]
$T_3 S_4$	*I. cylindrica* + Fruit wastes + animal manure	19. 59[b]
p- value (a)		0. 000**
p- value (b)		0. 000**
p- value (axb)		0. 011**
cv (a)		0. 22%
cv (b)		0. 26%

[abcd] treatment means with the same letter superscript are not significantly different at 1% level of probability
** Significant at 1% level of probability

Percent Organic Carbon (OC)

The mean organic carbon (OC) content of vermicompost produced from selected noxious weeds and different farm waste materials is presented in Table 9.

The organic carbon content of vermicompost derived from the noxious weed species ranged from 11.20% to 12.90%. Vermicompost produced from *Lantana camara* recorded the highest mean organic carbon content (12.90%), whereas *Chromolaena odorata* produced the lowest (11.20%). Among the farm waste materials, organic carbon values ranged from 10.62% to 12.93%, with corn stover + animal manure recording the highest value (12.93%), followed by rice straw + animal manure, while fruit wastes + animal manure had the lowest organic carbon content (10.62%). Analysis of Variance (ANOVA) revealed a highly significant interaction effect ($p < 0.01$) between noxious weed species and farm waste materials, indicating that the organic carbon content of vermicompost was significantly influenced by the interaction of the two substrate components. The Least Significant Difference (LSD) test showed that the combination of *L. camara* with rice straw and animal manure produced the highest organic carbon content (16.93%). Likewise, significant differences were observed among the main effects of the treatments. Vermicompost produced from *L. camara* contained higher organic carbon than that produced from *C. odorata*, although it was statistically comparable with the latter. Among the farm waste materials, corn stover combined with animal manure produced the highest organic carbon content and was comparable with rice straw and fruit wastes, whereas dried banana leaves combined with animal manure differed significantly from the other treatments. Organic carbon is an important indicator of compost quality because it reflects the amount of stabilized organic matter available for improving soil fertility, aggregation, water-holding capacity, and microbial activity. The relatively higher organic carbon observed in vermicompost derived from *L. camara* may be attributed to its greater lignocellulosic biomass, which contributes to the formation of stable humic substances during decomposition. Likewise, corn stover and rice straw are rich in structural carbohydrates, including cellulose and lignin, which contribute to the retention of organic carbon throughout the vermicomposting process (Enebe & Erasmus, 2023; Lim et al., 2023).

The lower organic carbon content observed in vermicompost produced from *C. odorata* and fruit wastes may be explained by the more rapid decomposition of readily biodegradable organic compounds. During

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vermicomposting, microorganisms and earthworms mineralize organic carbon, releasing carbon dioxide through respiration while converting the remaining organic residues into stabilized humic substances. Consequently, substrates that decompose more rapidly often exhibit lower residual organic carbon in the finished vermicompost because a greater proportion of carbon has been mineralized (Balachandar et al., 2021). Similar findings were reported by Das and Tangjang (2024), who observed that differences in feedstock composition significantly influenced carbon transformation and compost quality during vermicomposting.

The organic carbon values obtained in this study indicate that the vermicomposts contained sufficient stabilized organic matter to improve soil physical, chemical, and biological properties. Organic carbon serves as a primary energy source for soil microorganisms and contributes to nutrient retention, cation exchange capacity, and long-term soil fertility. Recent reviews have emphasized that vermicompost with adequate organic carbon enhances soil health by improving soil aggregation, increasing moisture retention, and supporting beneficial microbial communities, ultimately promoting sustainable crop production (Singh et al., 2024; Enebe & Erasmus, 2023).

Table 9. *Organic carbon (%) of vermicompost produced from noxious weeds and farm waste materials as substrates harvested at 7 weeks after vermicomposting*

Main Plot and Subplot		Organic Carbon (%)
Main plot –	Noxious weeds	
T_1	*L. camara*	12. 90^{a}
T_2	*C. odorata*	11. 20^{b}
T_3	*I. cylindrica*	11. 80^{b}
Subplot –	Farm waste materials	
S_1	Dried banana leaves + animal manure	11. 40^{b}
S_2	Rice straw + animal manure	12. 91^{a}
S_3	Corn stove + animal manure	12. 93^{a}
S_4	Fruit wastes + animal manure	10. 62^{c}
TREATMENTS' INTERACTION EFFECT		
T_1 S_1	*L. camara* + Dried banana leaves + animal manure	13. 00^{c}
T_1 S_2	*L. camara* + Rice straw + animal manure	16. 93^{a}
T_1 S_3	*L. camara* + Corn stover + animal manure	13. 45^{b}
T_1 S_4	*L. camara* + Fruit wastes + animal manure	8. 23^{d}
T_2 S_1	*C. odorata* + Dried banana leaves + animal manure	9. 65^{c}
T_2 S_2	*C. odorata* + Rice straw + animal manure	9. 58^{d}
T_2 S_3	*C. odorata* + Corn stover + animal manure	13. 33^{a}
T_2 S_4	*C. odorata* + Fruit wastes + animal manure	12. 25^{b}
T_3 S_1	*I. cylindrica* + Dried banana leaves + animal manure	11. 56^{c}
T_3 S_2	*I. cylindrica* + Rice straw + animal manure	12.23^{a}
T_3 S_3	*I. cylindrica* + Corn stover + animal manure	12. 01^{b}
T_3 S_4	*I. cylindrica* + Fruit wastes + animal manure	11. 39^{d}
p- value (a)		0. 000**
p- value (b)		0. 000**
p- value (axb)		0. 000**
cv (a)		0. 194%
cv (b)		0. 234%

[abcd] treatment means with the same letter superscript are not significantly different at 1% level of probability
** Highly significant at 1% level of probability

Total Nitrogen (%)

The total nitrogen (%) of vermicompost derived from noxious weeds and various farm waste materials as substrates is reflected on Table 10.

The result revealed that *L. camara* obtained the highest percent Total Nitrogen (1.11%) followed by *I. cylindrica* (1.01%), and *C. odorata* (0.96%). For farm waste materials, vermicompost obtained both from rice straw+ animal manure and corn stover + animal manure obtained the highest Total N of 1.11%, followed by dried banana leaves + animal manure (0.98%) and fruit wastes + animal manure (0.91%).

Significant ($p<0.01\alpha$) interaction effect between noxious weeds and farm waste materials was observed, which implies that combining noxious weeds with farm waste materials could significantly increase the total Nitrogen content of vermicompost. The Least Significant Difference (LSD) Test revealed that *L. camara* combined with rice straw + animal manure obtained the highest Total N (1.46%). Likewise, a significant difference ($p<0.01\alpha$) among noxious weeds and farm waste materials was also found. Least Significant Difference (LSD) Test of means revealed that vermicompost obtained from *L. camara* has a higher Total N (%) comparable to that obtained from *C. odorata* compost. *I. cylindrica,* on the other hand, obtained significantly different Total N among noxious weed species. Vermicompost obtained from rice straw + animal manure and corn stover + animal manure obtained higher Total N and is comparable to the rest of the treatments.

Very high Total N (%) was found in vermicompost obtained from *L. camara* and *I. cylindrica,* while high Total N content was observed in *C. odorata* compost (Nutrient Index, Table 14). The result of the study concurred to the study conducted by *Bajal et al.* (2019) that any mixture of plant material with cow dung was found to be better in terms of Nitrogen content, with the highest amount of Total Nitrogen recorded in substrates with *L. camara.* It might be because the plant materials, specifically *L. camara* and *C. odorata* biomass was recorded to be 289.7 kg/ha per year and the Total N that was returned through litterfall was 57.3 kg/ha per year (Negi *et al.,* (2019). *C. odorata* biomass was also reported to have high nutrient content of 2.65% Nitrogen which has a potential to be used as alternative to organic fertilizer (Suri and Yudono (2020).

For farm waste materials, very high Total N (%) content was found on vermicompost produced from rice straw + corn stover combined with animal manure (Nutrient Index, Table 11). Cagasan *et al.* (2020), revealed that numerically higher percent Nitrogen content was observed on vermicompost derived from substrates with rice straw compared to other substrate combination.

Table 10. *Total nitrogen (%) of vermicompost produced from noxious weeds and farm waste as substrates harvested at 7 weeks after vermicomposting*

Main Plot and Subplot		Total Nitrogen (%)
Main plot –	Noxious weeds	
T_1	*L. camara*	1. 11^{a}
T_2	*C. odorata*	0. 96^{c}
T_3	*I. cylindrica*	1. 01^{b}
Subplot –	Farm waste materials	
S_1	Dried banana leaves + animal manure	0. 98^{b}
S_2	Rice straw + animal manure	1. 11^{a}
S_3	Corn stover + animal manure	1. 11^{a}
S_4	Fruit wastes + animal manure	0. 91^{b}
TREATMENTS' INTERACTION EFFECT		
$T_1 S_1$	*L. camara* + Dried banana leaves + animal manure	1. 12^{c}
$T_1 S_2$	*L. camara* + Rice straw + animal manure	1. 46^{a}

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$T_1 S_3$	*L. camara* + Corn stover + animal manure	1. 16[b]
$T_1 S_4$	*L. camara* + Fruit wastes + animal manure	0. 71[d]
$T_2 S_1$	*C. odorata* + Dried banana leaves + animal manure	0. 83[c]
$T_2 S_2$	*C. odorata* + Rice straw + animal manure	0. 82[c]
$T_2 S_3$	*C. odorata* + Corn stover + animal manure	1. 15[a]
$T_2 S_4$	*C. odorata* + Fruit wastes + animal manure	1. 05[b]
$T_3 S_1$	*I. cylindrica* + Dried banana leaves + animal manure	0. 99[c]
$T_3 S_2$	*I. cylindrica* + Rice straw + animal manure	1. 05[a]
$T_3 S_3$	*I. cylindrica* + Corn stover + animal manure	1. 03[b]
$T_3 S_4$	*I. cylindrica* + Fruit wastes + animal manure	0. 98[d]
p- value (a)		0. 000**
p- value (b)		0. 000**
p- value (axb)		0. 000**
cv (a)		0. 397%
cv (b)		0. 439%

[abcd] treatment means with the same letter superscript are significantly different at 1% level of probability
** Significant at 1% level of probability

Table 11. *Nutrient Index of Total Nitrogen and Organic Carbon*

Organic Matter (Carbon and Nitrogen)		
Rating	Carbon(%)	Nitrogen (%)
Very high	>20	>1.0
High	10 -20	0.6-1.0
Medium	4-10	0.3-0.6
Low	2-4	0.1-0.3
Very Low	<2	<0.1

Total Phosphorus

The mean total phosphorus (P) content of vermicompost produced from selected noxious weeds combined with different farm waste materials is presented in Table 12.

The results showed that vermicompost derived from Imperata cylindrica recorded the highest mean total phosphorus content (0.620%), followed by Chromolaena odorata (0.568%), while Lantana camara had the lowest (0.484%). Among the farm waste materials, vermicompost produced from fruit wastes combined with animal manure had the highest mean total phosphorus content (0.371%). Analysis of Variance (ANOVA) revealed a highly significant interaction effect ($p < 0.01$) between noxious weed species and farm waste materials, indicating that the combination of substrates significantly influenced the phosphorus content of the resulting vermicompost. The Least Significant Difference (LSD) test further showed that the combination of I. cylindrica with fruit wastes and animal manure produced the highest total phosphorus content (1.42%). Although no significant differences were observed among the noxious weed species as main effects, significant differences were found among the farm waste materials. Fruit wastes combined with animal manure consistently produced higher phosphorus content than the other substrate combinations, although it remained statistically comparable with some treatments.

The higher phosphorus content observed in vermicompost produced from I. cylindrica combined with fruit wastes may be attributed to the chemical composition of the feedstock and the enhanced mineralization of organic phosphorus during vermicomposting. Fruit wastes are generally rich in readily degradable organic compounds and naturally occurring phosphorus, which become more available through microbial decomposition and earthworm activity. During vermicomposting, earthworms fragment organic materials, increasing the surface area available for microbial colonization, while phosphorus-solubilizing microorganisms convert insoluble phosphorus into plant-available forms, thereby increasing the total phosphorus content of the finished vermicompost (Enebe & Erasmus, 2023; Lim et al., 2023).

The findings of the present study differ from earlier reports that observed lower phosphorus content in vermicompost produced from I. cylindrica. Such variation may be attributed to differences in substrate composition, earthworm species, composting duration, environmental conditions, and the proportions of feedstock materials used during vermicomposting. Recent studies have demonstrated that nutrient enrichment, particularly phosphorus, is strongly influenced by the biochemical composition of the substrates and the efficiency of microbial mineralization during the composting process (Das & Tangjang, 2024; Balachandar et al., 2021).

The relatively high phosphorus values obtained in this study indicate that the vermicompost produced has considerable potential as an organic fertilizer for improving soil fertility and supporting plant growth. Phosphorus is an essential macronutrient involved in energy transfer, root development, flowering, and seed formation. Vermicomposting enhances phosphorus availability through the synergistic activities of earthworms and microorganisms, which accelerate organic matter decomposition, humification, and nutrient mineralization. Consequently, mature vermicompost serves as a valuable source of plant-available phosphorus while contributing to long-term soil productivity and sustainable agricultural production (Singh et al., 2024; Enebe & Erasmus, 2023).

Table 12. *Total Phosphorus (%) of vermicompost produced from noxious weeds and farm waste materials as substrates harvested at 7 weeks after vermicomposting*

Main plot and Subplot		Total Phosphorus (%)
Main plot –	Noxious weeds	
T_1	*L. camara*	0. 484^{c}
T_2	*C. odorata*	0. 568^{b}
T_3	*I. cylindrica*	0. 620^{a}
Subplot -	Farm waste materials	
S_1	Dried banana leaves + animal manure	0. 709^{a}
S_2	Rice straw + animal manure	0. 430^{b}
S_3	Corn stover + animal manure	0. 371^{c}
S_4	Fruit wastes + animal manure	0. 719^{a}
TREATMENTS' INTERACTION EFFECT		
$T_1 S_1$	*L. camara* + Dried banana leaves + animal manure	0. 72^{a}
$T_1 S_2$	*L. camara* + Rice straw + animal manure	0. 55^{ab}
$T_1 S_3$	*L. camara* + Corn stover + animal manure	0. 38^{bc}
$T_1 S_4$	*L. camara* + Fruit wastes + animal manure	0. 28^{c}
$T_2 S_1$	*C. odorata* + Dried banana leaves + animal manure	1. 31^{a}
$T_2 S_2$	*C. odorata* + Rice straw + animal manure	0. 19^{c}
$T_2 S_3$	*C. odorata* + Corn stover + animal manure	0. 31^{bc}
$T_2 S_4$	*C. odorata* + Fruit wastes + animal manure	0. 46^{b}
$T_3 S_1$	*I. cylindrica* + Dried banana leaves + animal manure	0. 09^{c}
$T_3 S_2$	*I. cylindrica* + Rice straw + animal manure	0. 55^{b}
$T_3 S_3$	*I. cylindrica* + Corn stover + animal manure	0. 42^{b}
$T_3 S_4$	*I. cylindrica* + Fruit wastes + animal manure	1. 42^{a}

p- value (a)	0. 093^{ns}
p- value (b)	0. 000**
p- value (axb)	0. 000**
cv (a)	22. 36%
cv (b)	20. 76%

^{abc} treatment means with the same letter superscript are not significantly different at 1% level of probability
^{ns} not significant at 5% level of probability
** significant at 1% level of probability

Total Potassium (%)

The mean Total K (%) of vermicompost produced from noxious weeds combined with different farm waste materials as substrates are shown in Table 13.

The result revealed that vermicompost derived from noxious weeds *L. camara* obtained highest percentage of Total K (0.77%), followed by *C. odorata* (0.76%) and *I. cylindrica* as the lowest (0.60%). Dried banana leaves + animal manure obtained the highest Total K of 0.80%, and rice straw + animal manure as the lowest having a Total K. analysis of Variance (ANOVA) revealed a significant ($p>0.05\alpha$) interaction effect between noxious weeds and farm waste materials. The Least Significant Difference (LSD) Test revealed that *L. camara* combined with dried banana leaves + animal manure and *C. odorata* combined with corn stover + animal manure obtained the highest Total K value of 0.91%. This result implies that combining noxious weeds with farm waste materials could significantly affect the Total K of vermicompost produced. Percent Total K was significantly different ($p>0.05\alpha$) among noxious weeds and farm waste materials. The Least Significant Difference (LSD) Test of means revealed that *L. camara* compost obtained significantly higher Total K but is also comparable to the rest of the treatments. Likewise, dried banana leaves + animal manure compost obtained higher Total K but is comparable to the rest of the treatments.

Table 13. *Total Potassium (%) of vermicompost produced from noxious weeds and farm waste materials as substrates harvested at 7 weeks after vermicomposting*

Main plot and Subplot		Total Potassium (%)
Main plot –	Noxious weeds	
T_1	*L. camara*	0. 77^a
T_2	*C. odorata*	0. 76^a
T_3	*I. cylindrica*	0. 60^b
Subplot –	Farm waste materials	
S_1	Dried banana leaves + animal manure	0. 80^a
S_2	Rice straw + animal manure	0. 66^c
S_3	Corn stover + animal manure	0. 71^b
S_4	Fruit wastes + animal manure	0. 67^c
TREATMENTS' INTERACTION EFFECT		
T_1 S_1	*L. camara* + Dried banana leaves + animal manure	0. 91^a
T_1 S_2	*L. camara* + Rice straw + animal manure	0. 67^c
T_1 S_3	*L. camara* + Corn stover + animal manure	0. 66^c

$T_1 S_4$	*L. camara* + Fruit wastes + animal manure	0. 85^{b}
$T_2 S_1$	*C. odorata* + Dried banana leaves + animal manure	0. 66^{c}
$T_2 S_2$	*C. odorata* + Rice straw + animal manure	0. 74^{b}
$T_2 S_3$	*C. odorata* + Corn stover + animal manure	0. 91^{a}
$T_2 S_4$	*C. odorata* + Fruit wastes + animal manure	0. 72^{b}
$T_3 S_1$	*I. cylindrica* + Dried banana leaves + animal manure	0. 82^{a}
$T_3 S_2$	*I. cylindrica* + Rice straw + animal manure	0. 57^{b}
$T_3 S_3$	*I. cylindrica* + Corn stover + animal manure	0. 55^{b}
$T_3 S_4$	*I. cylindrica* + Fruit wastes + animal manure	0. 45^{c}
p- value (a)		0. 000**
p- value (b)		0. 000**
p- value (axb)		0. 000**
cv (a)		3. 17%
cv (b)		4. 31%

^{abc} treatment means with the same letter superscript are not significantly different at 1% level of probability
** significant at 5% level of probability

Return on Investment (ROI)

The Return on Investment (ROI) of vermicompost produced from noxious weeds and various farm waste materials were reflected on Table 14. The result revealed that the highest (20.3 kgs) vermicompost produced from the combination of *Lantana camara* and rice straw + animal manure. Likewise, vermicompost produced from the combination of *Lantana camara* + rice straw and animal manure obtained the highest ROI of 85%. The lowest was found on vermicompost produced from *C. odorata* combined with fruit waste + animal manure. On the other hand, negative ROI was obtained by the vermicompost produced from the following substrate combinations; *L. camara* + dried banana leave + animal manure, *C. odorata* + dried banana leaves + animal manure, *C. odorata* + corn stover + animal manure, *I. cylindrica* + corn stover + animal manure, *I. cylindrica* + dried banana leaves + animal manure and *I. cylindrica* + fruit waste + animal manure. The total vermicompost produced was sold at Php 30.00/kg.

Table 14. *Cost and return analysis of vermicompost produced from noxious weeds and various farm waste materials as substrates at 7 weeks after vermicomposting*

TREATMENTS ITEM	T_1S_1	T_1S_2	T_1S_3	T_1S_4	T_2S_1	T_2S_2	T_2S_3	T_2S_4	T_3S_1	T_3S_2	T_3S_3	T_3S_4
A. Gross Income												
Yield	8.4	20.3	12.4	15.7	9.7	12.7	10.4	11.1	8.9	11.9	9.4	8.25
Price/kg (Php)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Total	252.00	609.00	372.00	471.00	288.00	381.00	312.00	333.00	267.00	357.00	282.00	247.50
B. Expenses												
Screen net	79.17	79.17	79.17	79.17	79.19	79.19	79.19	79.19	79.19	79.19	79.19	79.19
Sakoline	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00

Construction of vemished	58.33	58.33	58.33	58.33	58.33	58.33	58.33	58.33	58.33	58.33	58.33	58.33
Collection and Preparation of substrates	116.67	116.67	116.67	116.67	116.67	116.67	116.67	116.67	116.67	116.67	116.67	116.67
TOTAL	329.17	329.17	329.17	329.17	329.17	329.17	329.17	329.17	329.17	329.17	329.17	329.17
C. Net Profit (Php)	-77.17	279.83	42.83	141.83	-47.17	51.83	-17.17	3.83	-62.17	27.83	-47.17	-81.67
D. ROI (%)	-23	85	13	43	-13	16	-5	1	-19	8	-14	-25

CONCLUSION

Based on the findings of the study, the physicochemical properties and economic viability of vermicompost varied significantly depending on the combination of noxious weed species and farm waste materials used as substrates. The physical and chemical characteristics of the vermicompost, including organic matter, organic carbon, total nitrogen, total phosphorus, and total potassium, were significantly affected by the interaction between the two factors, demonstrating that substrate composition plays a critical role in determining compost quality. Significant differences among treatment combinations further confirmed that both the type of noxious weed and the farm waste material contributed to the variability in vermicompost quality. Among the treatments evaluated, *Lantana camara* combined with rice straw and animal manure consistently produced vermicompost with superior physicochemical properties, including the highest organic matter, organic carbon, total nitrogen, yield, and return on investment. Conversely, *Imperata cylindrica* combined with fruit wastes and animal manure produced the highest total phosphorus, while treatments containing dried banana leaves or corn stover enhanced total potassium content. These findings indicate that different substrate combinations may be selected depending on the desired nutrient composition of the vermicompost. Economically, vermicompost production was profitable only for selected treatment combinations. The combination of *Lantana camara*, rice straw, and animal manure generated the highest net income and an 85% return on investment, making it the most economically viable treatment. Overall, the study demonstrated that selected noxious weeds, when combined with appropriate farm waste materials, can be effectively utilized as alternative substrates for producing nutrient-rich and economically viable vermicompost, thereby contributing to sustainable weed management, agricultural waste recycling, and environmentally sound organic fertilizer production.

Recommendations

Based on the findings of the study, the following recommendations are proposed:

Farmers, organic fertilizer producers, and agricultural practitioners may adopt the combination of Lantana camara, rice straw, and animal manure for vermicompost production because it consistently produced superior physicochemical properties and the highest economic return.

Local government units, agricultural extension agencies, and environmental organizations should promote the utilization of noxious weeds as raw materials for vermicomposting to reduce invasive weed infestation while simultaneously converting agricultural wastes into value-added organic fertilizer.

Future studies should evaluate the agronomic performance of the produced vermicompost on different agricultural crops through greenhouse and field experiments to determine its effects on plant growth, yield, and soil fertility.

Further investigations should include additional quality parameters such as micronutrient composition, heavy metal content, microbial population, compost maturity indices, carbon-to-nitrogen ratio, and greenhouse gas emissions to provide a more comprehensive assessment of vermicompost quality and environmental sustainability.

Economic studies involving large-scale production, market feasibility, life-cycle assessment, and long-term profitability are also recommended to support the commercial adoption of vermicompost produced from noxious weeds and farm waste materials.

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