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POPULATION DYNAMICS OF *EUDRILUS EUGENIAE* AND CHEMICAL CHARACTERIZATION OF VERMICOMPOSTS DERIVED FROM AGROECOLOGICAL RESIDUES

DINÂMICA POPULACIONAL DE *EUDRILUS EUGENIAE* E CARACTERIZAÇÃO QUÍMICA DE VERMICOMPOSTOS DERIVADOS DE RESÍDUOS AGROECOLÓGICOS

DINÁMICA POBLACIONAL DE *EUDRILUS EUGENIAE* Y CARACTERIZACIÓN QUÍMICA DE VERMICOMPOST DERIVADOS DE RESIDUOS AGROECOLÓGICOS

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Abstract

This study evaluated the population dynamics of the African giant earthworm (*Eudrilus eugeniae*) and the quality of the vermicompost produced under different diets. The experiment was conducted at the State University of Maranhão (UEMA) using a completely randomized 5 × 6 factorial design, in which combinations of cattle manure with *Clitoria fairchildiana* residue, grass residue, organic compost, and water hyacinth were tested over six evaluation periods. Earthworm population, the chemical properties of the vermicompost, and a bioassay using iceberg lettuce seedlings to assess seedling emergence and initial establishment were evaluated. The diets influenced earthworm population dynamics and the chemical composition of the vermicompost, with the greatest population increase occurring between 56 and 70 days. All treatments produced vermicomposts with alkaline pH and high nitrogen content. The germination bioassay indicated that the vermicomposts exhibited suitable physical and chemical properties for seedling production. The results indicate that the partial replacement of cattle manure with agroecological residues, particularly when previously stabilized, is a feasible strategy for vermicomposting, promoting nutrient recycling and the production of a high-

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quality organic fertilizer for horticultural applications.

Keywords: African giant earthworm; Nutrition; Organic compost; Humus.

Resumo

Este estudo avaliou a dinâmica populacional e os parâmetros morfométricos da minhoca gigante africana (*Eudrilus eugeniae*) e a qualidade do vermicomposto produzido sob dietas. O experimento foi conduzido na Universidade Estadual do Maranhão (UEMA), em delineamento inteiramente casualizado, em esquema fatorial 5 × 6, foram testadas combinações de esterco bovino com resíduos de *Clitoria fairchildiana*, grama, composto orgânico e aguapé, em seis períodos de avaliação. Analisaram-se a população das minhocas, as propriedades químicas do vermicomposto e realizado um bioensaio com mudas de alface-americana para avaliar a emergência e o estabelecimento inicial das plântulas. As dietas influenciaram a dinâmica populacional das minhocas e a composição química do vermicomposto, com o maior incremento populacional observado entre 56 e 70 dias. Todos os tratamentos produziram vermicompostos com pH alcalino e elevados teores de nitrogênio. O bioensaio de germinação indicou que os vermicompostos apresentaram propriedades físicas e químicas adequadas para a produção de mudas. Os resultados indicam que a substituição parcial do esterco bovino por resíduos agroecológicos, especialmente quando previamente estabilizados, constitui uma estratégia viável para a vermicompostagem, promovendo a reciclagem de nutrientes e a produção de um fertilizante orgânico de qualidade para aplicações hortícolas.

Palavras-chave: Gigante africana; Nutrição; Composto orgânico; Húmus.

Resumen

Este estudio evaluó la dinámica poblacional de la lombriz gigante africana (*Eudrilus eugeniae*) y la calidad del vermicompost producido bajo diferentes dietas. El experimento se llevó a cabo en la Universidad Estatal de Maranhão (UEMA), utilizando un diseño completamente aleatorizado en un arreglo factorial 5 × 6, en el que se evaluaron combinaciones de estiércol bovino con residuos de Clitoria fairchildiana, pasto, compost orgánico y jacinto de agua durante seis períodos de evaluación. Se evaluaron la población de las lombrices, las propiedades químicas del vermicompost y se realizó un bioensayo con plántulas de lechuga tipo iceberg para evaluar la emergencia y el establecimiento inicial de las plántulas. Las dietas influyeron en la dinámica poblacional de las lombrices y en la composición química del vermicompost, observándose el mayor incremento poblacional entre los 56 y 70 días. Todos los tratamientos produjeron vermicomposts con pH alcalino y altos contenidos de nitrógeno. El bioensayo de germinación indicó que los vermicomposts presentaron propiedades físicas y químicas adecuadas para la producción de plántulas. Los resultados indican que la sustitución parcial del estiércol bovino por residuos agroecológicos, especialmente cuando estos son previamente estabilizados, constituye una estrategia viable para la vermicompostación, promoviendo el reciclaje de nutrientes y la producción de un fertilizante orgánico de alta calidad para aplicaciones hortícolas.
Palabras clave: Lombriz gigante africana; Nutrición; Abono orgânico; Humus.

1. Introdution

Vermicomposting consists of the recycling of organic materials through the digestive tract of earthworms, which excrete coprolites known as humus (AHMAD et al., 2022; ENEBE; ERASMUS, 2023). Historically, this technique has been established as an effective alternative for the stabilization of solid waste, converting

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it into a material rich in macro- and micronutrients (DUCASSE; CAPOWIEZ; PEIGNÉ, 2022; MOHITE et al., 2024).

Vermicompost acts as a soil conditioner that promotes plant growth, stimulates root system development, and enhances plant resistance to biotic and abiotic stresses (REHMAN et al., 2023). In addition to its agronomic benefits, the process mitigates severe environmental impacts, such as soil pollution and the eutrophication of water bodies resulting from the improper disposal of organic matter (MELO et al., 2020; WANG et al., 2024).

Although earthworms use organic materials as substrates, the food selection of these organisms is not random (BOUCHÉ, 1977). Studies have demonstrated that these organisms show preference for plant tissues with high nitrogen content and low concentrations of secondary metabolites (COTTA et al., 2015). Understanding these nutritional requirements may optimize production time and ensure efficiency in the biotransformation of residues. In this context, the earthworm *Eudrilus eugeniae* stands out due to its high adaptability to tropical climatic conditions and elevated reproductive potential, factors that favor its economic exploitation in low-investment production systems (SANTOS et al., 2021; GEBREHANA et al., 2023).

Despite its socioeconomic relevance for smallholder farmers and the commercialization potential of vermicompost, significant knowledge gaps remain regarding the most suitable diets for the development of *E. eugeniae*. Detailed information is needed on how combinations agroecological residues influence both the biological development of this species and the final chemical composition of the produced organic fertilizer. Therefore, this study aimed to evaluate the development of *E. eugeniae* and to compare the quality of vermicompost produced from organic diets.

2. Materials and Methods

2.1. Experimental area

The study was conducted in 2024 on an agroecological farm located in the rural area of São Luís, Maranhão, Brazil (2°37'40.31"S and 44°11'18.56"W).

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Laboratory analyses were performed at the Plant Mineral Nutrition, Bromatology, and Soil Chemistry Laboratories of the State University of Maranhão (UEMA), São Luís Campus.

According to the Köppen climate classification (1948), the region has an Aw climate, characterized as tropical hot and humid, with a rainy season during summer and a dry season during winter. The mean annual temperature is approximately 28 °C, with low annual thermal amplitude and monthly average temperatures ranging from 25 °C to 32 °C. The average annual rainfall is 2,156 mm, with the highest precipitation occurring between January and July and the lowest between August and December (INMET, 2022).

2.2. Experimental design

The Earthworms were maintained in pre-existing masonry tanks, internally subdivided by fixed, impermeable wooden partitions sealed with non-toxic, moisture-resistant resin to form experimental compartments measuring 50 cm × 50 cm in surface area and 40 cm in depth. The tanks were cleaned, insulated, and protected from direct sunlight, rainfall, and predators. Each tank had a tap at the bottom, allowing for the regulation of excess water and preventing flooding of the substrate. The tanks were independent, with no hydraulic or physical connection between them, ensuring complete isolation and preventing earthworm migration among the experimental units. A drip irrigation system was used to maintain adequate substrate moisture, ensuring earthworm survival and subsequent vermicompost production (ECKHARDT et al., 2016).

Throughout the experimental period, moisture levels in the substrates were maintained between 70% and 80% of field capacity, with temperatures ranging from 24 °C to 30 °C. These ranges align with the requirements for optimal earthworm activity described in the literature.

The experiment followed a completely randomized design (CRD) with a 5 × 6 factorial arrangement, consisting of five diets and six evaluation periods (14, 28, 42, 56, 70, and 84 days). The five treatments were assigned to the experimental units through a random number generation process.

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Periods were considered a within-unit factor, as repeated measurements were taken on the same experimental units over the study period, resulting in a repeated-measures structure. Statistical analyses for population dynamics were conducted using linear mixed-effects models to account for the temporal correlation inherent in repeated measures within the same subject.

Table 1. Composition of the diets supplied to *Eudrilus eugeniae* earthworms.

Treatments	Diets
T1	10 kg cattle manure (control)
T2	5 kg cattle manure + 5 kg *Clitoria fairchildiana* residue
T3	5 kg cattle manure + 5 kg grass clippings
T4	5 kg cattle manure + 5 kg pre-stabilized substrate
T5	5 kg cattle manure + 5 kg *Eichhornia crassipes* residue

2.3. Dietary treatment

The materials used in the earthworm diets were collected fresh from the farm and distributed into each tank at a 1:1 ratio, with 5 kg of cattle manure and 5 kg of the respective substrate (organic compost, grass clippings, water hyacinth residue, or *Clitoria fairchildiana* residue). The cattle manure was previously composted, and in the control treatment the manure amount was doubled (10 kg). The organic compost used in the experiment was produced from the decomposition of litterfall, poultry manure, and grass clippings (T4).

The experimental methodology prioritized the equivalence of volume and fresh mass to facilitate practical handling in the masonry tanks. The determination of dry mass for each daily subsample would render the provision of fresh feed to the earthworms unfeasible. However, it is noted that equal fresh masses do not equate to equal dry masses, which may influence the nutritional load provided.

The chemical characterization of the raw residues was not performed prior to the vermicomposting process. This study focuses on the final properties of the vermicompost by evaluating the efficiency of the biological transformation process,

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its chemical characteristics, and its performance in a seedling emergence and initial establishment bioassay. Established literature for agroecological residues, such as cattle manure and water hyacinth, provides typical input values for these materials (Garg; Gupta, 2011; Suthar, 2007; Soobhany et al., 2015).

2.4. Earthworm rearing and evaluation

Adult earthworms of the species *E. eugeniae*, identified by the presence of a fully developed clitellum, were obtained from the earthworm-rearing facility located on the farm. To minimize variability among experimental units, adult individuals of similar size were selected following the protocol proposed by Devi et al. (2023). Earthworm development was evaluated separately over time within each tank.

Initially, five earthworms were introduced into each experimental unit, according to Devi et al. (2023), who reported that a low initial population density (5 earthworms kg^{-1}) favors population growth, reproduction, and substrate bioconversion efficiency. This density was adopted to standardize the inoculum, avoid early competition among individuals, and allow the assessment of population growth under different dietary treatments from a common starting condition.

Fourteen days after their introduction, earthworm counting was performed manually in each tank and at each evaluation period. The substrate from each experimental compartment was completely removed and transferred to a clean and non-reactive surface. The substrate was carefully sieved using a 5 mm mesh sieve to facilitate the manual recovery of earthworms. To prevent loss of individuals, the recovered earthworms were transferred into labeled plastic cups containing moist substrate from their respective experimental unit, preventing escape and desiccation during processing.

Earthworms were separated into adults and juveniles based on morphological criteria. Adults were identified by the presence of a fully developed clitellum, while juveniles were classified as individuals lacking this structure. Cocoons were monitored but not quantified in this study due to their small size and high burial depth, which made reliable recovery difficult within the experimental conditions. After counting, all individuals were returned to their respective

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experimental units together with the processed substrate, in order to maintain system continuity throughout successive evaluations.

Earthworm length was measured at the beginning and at the end of the experiment as an indicator of growth, since biomass was not quantified during the trial. The reproductive rate was evaluated every 14 days, totaling six evaluations throughout the experimental period.

2.5. Chemical analysis of vermicompost

After the final evaluation, the decomposed materials were sieved to remove the earthworms. Vermicompost samples (500 g) were collected from each tank, oven-dried at 65 °C for 48 h, ground, and sieved. Vermicompost quality was assessed through analyses of pH, phosphorus (P), carbon (C), nitrogen (N), potassium (K), calcium (Ca), and magnesium (Mg). Chemical analyses were performed at the Soil Laboratory of the State University of Maranhão according to the analytical procedures described by EMBRAPA (2017). The results are presented in the units established by the analytical methodology.

The pH was determined using the calcium chloride ($CaCl_2$) suspension method, whereas nitrogen (N) content was quantified by the Kjeldahl method (DETMANN et al., 2021). Carbon content was estimated from organic matter (OM) using the Van Bemmelen factor (1.724) and quantified by the sulfochromic solution method with absorbance readings at 645 nm (DIAS et al., 2010).

Sodium (Na) and potassium (K) concentrations were determined by flame photometry, while available phosphorus was analyzed using the colorimetric method (EMBRAPA, 1979). Calcium (Ca), magnesium (Mg), and aluminum (Al) were quantified following extraction with 1 N KCl solution, with Ca and Mg subsequently determined by EDTA titration.

2.6. Seedling production bioassay

The vermicomposts obtained from the five diets were used for the production of iceberg lettuce (*Lactuca sativa*) seedlings. The vermicomposts were mixed with black soil at a 1:1 ratio and distributed into two polyethylene trays containing 200

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cells each, with both trays including all treatments. Each vermicompost replicate occupied 20 cells, totaling 80 cells per treatment. The replicates were randomly distributed among the trays. The seedlings were grown in a greenhouse using pelleted seeds. For the evaluations, 12 plants were selected from each replicate, and the mean of these plants was used for the statistical analyses. Thus, each vermicompost replicate was considered the experimental unit.

At seven days after sowing (DAS), 12 seedlings per treatment were randomly selected to evaluate seedling vigor, root ball stability (RBS), shoot fresh mass (SFM), root fresh mass (RFM), shoot dry mass (SDM), root dry mass (RDM), number of true leaves (NL), and plant height (PH).

Seedling vigor was classified according to Franzin et al. (2005): score 1 (excellent, >5 leaves and height >5 cm); score 2 (good, 4–5 leaves and height >5 cm with slight chlorosis); score 3 (evident chlorosis, 4–5 leaves, height ≤5 cm, and signs of nutrient deficiency); and score 4 (severe nutrient deficiency, reduced height, and fewer leaves).

Root ball stability was assessed according to the methodology proposed by Gruszynski (2002): score 1 (≥50% of the root ball retained in the container); score 2 (30–50% retained); score 3 (root ball detached from the container but lacking cohesion); and score 4 (completely detached and >90% cohesive).

Shoot and root dry masses were determined after drying the samples in a forced-air oven at 65 °C for 72 h, followed by weighing on a precision balance.

2.7. Statistical analysis

The effects of treatments on earthworm population dynamics were evaluated using Generalized Linear Mixed Models (GLMMs) with a negative binomial distribution in R software version 4.3.1. Separate models were fitted for adult and juvenile earthworm counts, considering treatment, sampling time, and their interaction as fixed effects, while tank was included as a random effect. When significant effects were detected, pairwise comparisons among treatments were performed within each sampling period.

For seedling quality variables, ordinal variables such as vigor and root ball

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stability were analyzed using Cumulative Link Models (CLMs). Continuous variables that did not meet the assumptions of parametric tests, namely shoot dry mass (SDM) and root dry mass (RDM), were analyzed using the non-parametric Kruskal–Wallis test. Descriptive statistics, including means, medians, coefficients of variation, and median absolute deviation (MAD), were also calculated to characterize the response variables. The analyses were conducted using the glmmTMB, emmeans, ordinal, dplyr, and tidyverse packages, adopting a significance level of 5% (R Core Team, 2023).

3. Results and Discussion

Growth and development of *Eudrilus eugeniae* under dietary treatments.

The statistical analysis revealed a significant interaction between diets and evaluation time for the density of adult earthworms. At 14 days, treatment T5 showed higher counts than the control (T1) ($p=0.0225$), a pattern that changed at 28 days, when T5 surpassed T3 ($p=0.0003$) and T4 ($p=0.0014$). At 42 days, treatments T2 and T4 registered values significantly higher than the control T1 ($p=0.0006$ and $p<0.0001$, respectively). At 56 days, no statistical difference was detected among diets ($p>0.05$), indicating a temporary stabilization. At 70 days, treatment T4 exhibited higher counts than T2 ($p=0.0030$). Finally, at 84 days, treatment T4 achieved the highest numerical value, outperforming T1 ($p=0.0351$), T2 ($p=0.0001$), and T5 ($p=0.0010$), while not differing statistically from T3 ($p=0.0973$) (Figure 1).

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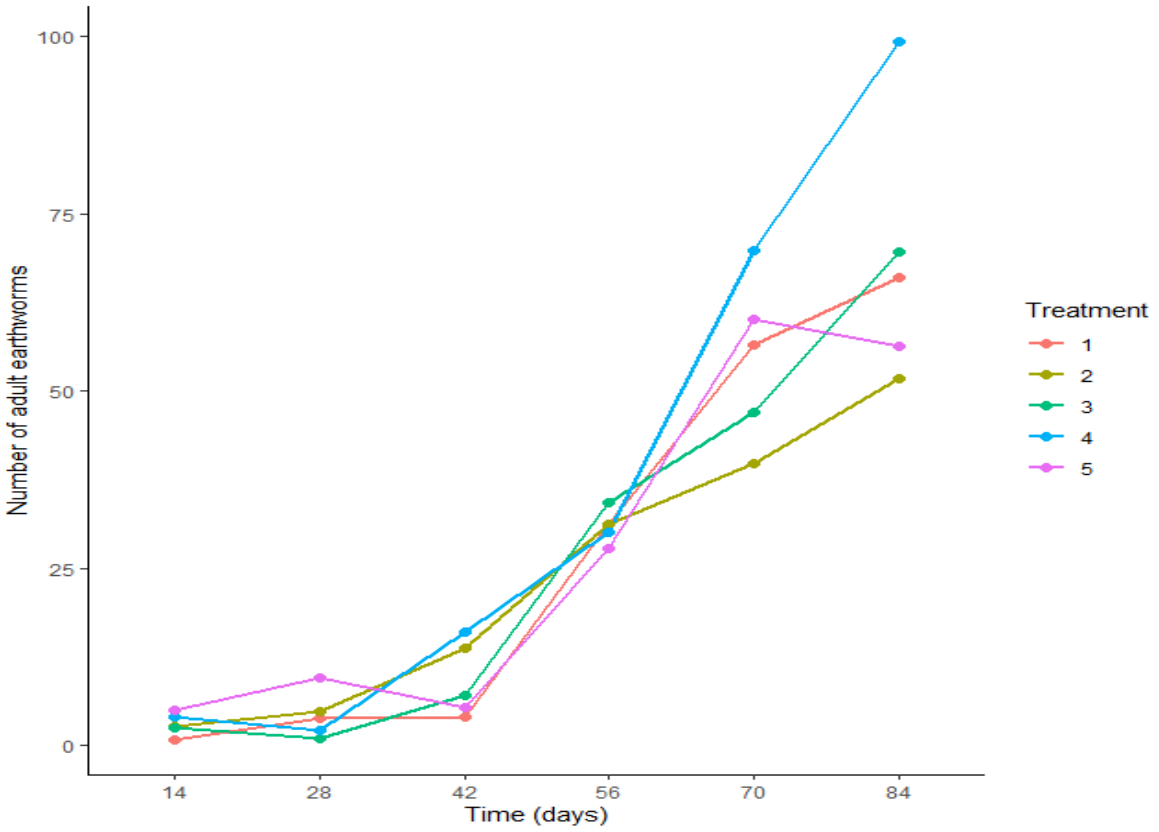


Figure 1. Population dynamics of adult *Eudrilus eugeniae* under dietary treatments over the experimental period. T1: Cattle manure; T2: Cattle manure + *Clitoria fairchildiana* residue; T3: Cattle manure + grass clippings; T4: Cattle manure + organic compost; T5: Cattle manure + water hyacinth residue.

The superior performance of T4 can be attributed to the fact that it consisted of a pre-stabilized organic compost rather than a simple plant residue, since the composting process stabilizes organic matter through microbial decomposition, producing a substrate with lower phytotoxicity, greater nutrient availability, and more favorable conditions for the establishment and reproduction of earthworms (Huzir et al., 2026). In contrast, fresh plant residues may contain labile compounds, secondary metabolites, or an unfavorable C:N ratio, thereby limiting the efficiency of vermicomposting.

During the first 28 days, the absence of significant differences among treatments coincided with an initial reduction in the number of individuals relative to the stocking density. This pattern suggests an acclimation phase and/or low initial palatability of the diets, corroborating the findings of Lourenço et al. (2022), who

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demonstrated that substrate acceptance depends on both the nature of the residue and the aeration conditions of the medium.

Nevertheless, despite the gradual decline in nutrient availability due to the absence of external substrate replenishment, a marked recovery in population growth was observed across all treatments by 84 days. The increasing trend detected after the 70th day is consistent with the biology of the species, whose sexual maturity is reached between 35 and 50 days after hatching (VILJOEN; REINEKE, 1989; BEGUM et al., 2025). These results confirm the successful adaptation of *Eudrilus eugeniae* to the agroecological residues evaluated in this study.

Regarding biometric development, earthworm length did not differ significantly among diets (initial CV = 18.47%; final CV = 11.37%). The increase in body length observed across all treatments indicates that the dietary formulations adequately met the maintenance requirements of the species. As highlighted by Batista et al. (2021), although body length is an important indicator of biological vigor, its expression is influenced by environmental adaptations and by the burrowing capacity inherent to each species, which may explain the uniformity of this parameter across substrates.

Reproductive performance of *Eudrilus eugeniae* fed diets

The onset of reproductive development in *Eudrilus eugeniae* was observed 28 days after the establishment of the experiment in all treatments. A significant interaction between diet and time was detected for juvenile earthworm abundance, indicating that juvenile population dynamics were influenced differently by the type of organic residue throughout the experimental period. At 42 days, treatments T3 and T4 showed higher estimated means than the control treatment (T1) ($p=0.0244$ and $p=0.0204$, respectively). At 56 days, treatments T3, T4, and T5 exceeded the control (T1) ($p<0.01$ for all comparisons). From day 70 onward, treatment T5 (manure + water hyacinth) showed superior performance compared with T2 ($p=0.0029$) and T3 ($p=0.0186$). At 84 days, T5 maintained its superior performance, exceeding T2 ($p=0.0338$), T3 ($p=0.0003$), and T4 ($p=0.0023$). These results

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demonstrate that, although initial population growth was promoted by different organic substrates, the combination used in T5 provided more favorable conditions for sustaining juvenile populations over the long term, allowing the maintenance of population density throughout the experimental period (Figure 2).

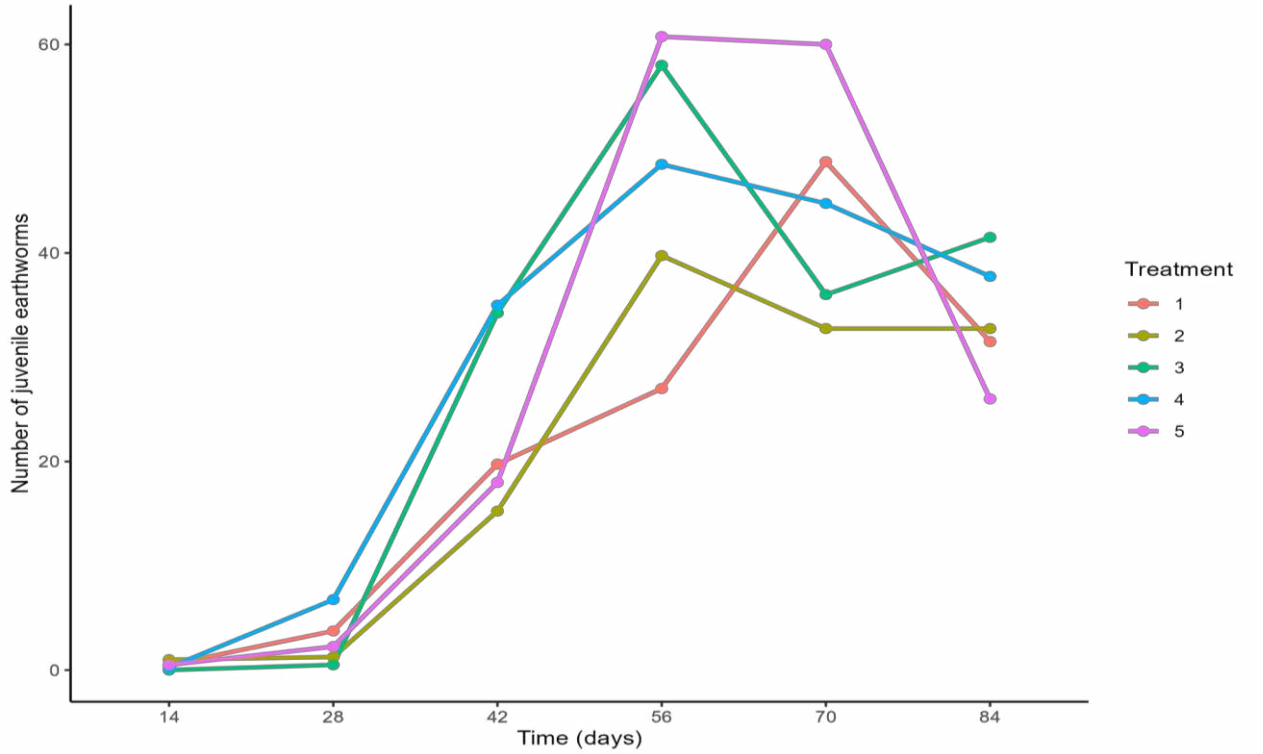


Figure 2. Population dynamics of juvenile *Eudrilus eugeniae* under different dietary treatments over the experimental period. T1: Cattle manure; T2: Cattle manure + *Clitoria fairchildiana* residue; T3: Cattle manure + grass clippings; T4: Cattle manure + organic compost; T5: Cattle manure + water hyacinth residue.

The absence of juvenile individuals during the initial evaluation (14 days) can be explained by the reproductive biology of the species. According to Kabi et al. (2020) and Begum et al. (2025), *E. eugeniae* produces approximately one cocoon every two days, with each cocoon containing between 2.0 and 2.7 hatchlings and an incubation period ranging from 12 to 16 days. Therefore, the elapsed time before the first sampling was insufficient for cocoon hatching and subsequent visualization of the offspring within the substrate.

At the end of the experimental cycle (84 days), only the treatment composed exclusively of cattle manure (T1) maintained a continuous increase in juvenile

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recruitment. In the remaining treatments, the stabilization or decline in birth rates may be associated with population self-regulation mechanisms. According to Lourenço et al. (2022), food limitation resulting from high population density, together with the reduction in individual biomass, affects cocoon production, thereby limiting the emergence of new individuals once the carrying capacity of the system is reached.

Chemical quality of vermicompost

The chemical composition of the vermicomposts showed significant differences among diets, corroborating the findings of Soobhany et al. (2015) and Dube et al. (2024), who reported that the nutritional composition of the final product depends on the type and proportion of residues used in the substrate. This dynamic directly influences earthworm population density and, consequently, the rate of organic matter mineralization.

Regarding carbon (C) content, the highest concentrations were observed in treatments T2 (cattle manure supplemented with *Clitoria fairchildiana* residue) and T1 (cattle manure alone), although T1 did not differ statistically from the other treatments (Table 2). Considering the carbon parameter established by the Brazilian Ministry of Agriculture Normative Instruction (MAPA) No. 25/2009, treatment T2 exceeded the minimum required carbon content of 10% (approximately 100 g dm^{-3}, assuming 1 g dm^{-3} ≈ 0.1% on a mass basis), reaching 112.54 g dm^{-3}. However, this comparison is restricted to carbon content and should not be interpreted as evidence of overall compliance with the Brazilian regulatory requirements for organic fertilizers, since other mandatory quality and safety parameters were not evaluated in the present study (BRAZIL, 2009).

Table 2. Chemical composition of vermicomposts produced from different earthworm diets.

Treat-ments	C (g/dm^3)	N (g/kg)	pH ($CaCl^2$)	P (mg/dm^3)	K	Ca	Mg	Na
					$mmolc/dm^3$			
T1	97.85ab	21.77ab	7.00 a	842.17 a	10.83ab	144.25 a	99.00 a	20.78 a

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T2	112.43a	24.54 a	7.19 a	517.41 a	3.08 b	160.50 a	86.50ab	16.98ab
T3	92.68 b	20.11ab	7.38 a	707.59 a	15.06ab	138.75ab	82.50ab	18.08ab
T4	94.53 b	16.62 b	7.03 a	328.92 a	13.63ab	144.75ab	64.00 b	12.43 b
T5	95.52 b	24.74 a	7.30 a	788.25 a	18.03 a	137.00 b	91.50 a	18.40ab
CV (%)	7.19	11.11	2.89	50.38	48.29	6.92	12.23	18.06
p	0.00895	0.00121	0.08083	0.1936	0.02576	0.0355	0.00326	0.02401

Means followed by the same lowercase letter within a column do not differ significantly according to Kruskal-Wallis test ($p<0.05$). T1: Cattle manure; T2: Cattle manure + *Clitoria fairchildiana* residue; T3: Cattle manure + grass clippings; T4: Cattle manure + organic compost; T5: Cattle manure + water hyacinth residue.

In the treatment containing *Clitoria fairchildiana* residue (T2), a tendency toward slow decomposition was observed. According to Young (1997) and Moura et al. (2024), this behavior is attributed to the presence of highly recalcitrant compounds, such as lignin and polyphenols, which result in elevated residual carbon contents. This characteristic corroborates the findings of Gomes et al. (2008) and Bugni et al. (2020), reported substantial carbon concentrations in substrates composed of leguminous residues and *Clitoria fairchildiana* leaves, respectively. Such dynamics directly affect nitrogen (N) availability, an essential element for earthworm metabolism, considering that approximately 70% of earthworm body composition consists of protein (GENODEPA; APINES-AMAR, 2024).

In this context, treatments T2 (*Clitoria fairchildiana* residue) and T5 (water hyacinth residue) exhibited the highest N concentrations (above 24 g kg^{-1}), although they did not differ statistically from cattle manure alone (T1) or grass clippings (T3). The high N content of water hyacinth (*Eichhornia crassipes*) has been documented by Martins (2014), Agami and Reddy (1990), and Nunes and Silva (2025), who highlighted the capacity of this aquatic macrophyte to accumulate nitrogen in its biomass. In contrast, treatment T4, composed of cattle manure and organic compost, exhibited lower N concentrations, which may be explained by the absence of fresh plant material in the diet and by the already stabilized and homogeneous nature of the organic compost used (INACIO; MILLER, 2009). Despite these

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variations, all treatments met the minimum requirement of 5 g kg^{-1} established by MAPA (BRAZIL, 2009).

No significant differences were observed in pH values among treatments. All recorded values complied with the guidelines established by MAPA (BRAZIL, 2009), which stipulate a minimum pH of 6.0 for organic composts.

Similarly, phosphorus (P) content did not differ significantly among treatments, although high concentrations were maintained in all vermicomposts produced. According to Yadav and Garg (2019), the abundance of P in vermicomposts results from the combined action of fecal phosphatase activity and microorganisms present in the earthworm digestive tract, processes that enhance organic matter mineralization and nutrient mobilization. These results indicate a strong potential for the material to alleviate P deficiency in tropical soils, where 73% of agricultural areas exhibit low P levels (<9 mg kg^{-1}) and 16% display medium levels (9–25 mg kg^{-1}) (Sampaio et al., 2009). Phosphorus plays a fundamental role in energy transfer within plants and is closely associated with physiological activity, promoting plant metabolism and contributing to nitrogen fixation processes (Araújo; Machado, 2006; Khan et al., 2023).

Regarding potassium (K), significant differences were detected among diets. Treatment T5 (cattle manure + water hyacinth residue) recorded the highest value (18.03 mmolc dm^{-3}), whereas T2 (cattle manure + *Clitoria fairchildiana* residue) exhibited the lowest concentration (3.08 mmolc dm^{-3}). The reduction in K content during vermicomposting may be attributed to the leaching of the element in its ionic form (K^+) as a consequence of the moisture management required for the process (Frederickson et al., 2007). However, the low K concentration observed in the *Clitoria fairchildiana* based diet contrasts with the findings of Gomes et al. (2008) for composting systems containing leguminous residues and agrees with the observations of Oliveira (2013), who reported reduced K concentrations in soils influenced by this plant species.

Calcium (Ca) and magnesium (Mg) contents also differed significantly among treatments, with Ca consistently predominating over Mg in all samples. Treatment T2 exhibited the highest Ca concentration, although it did not differ statistically from

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treatments T1, T3, and T4. Magnesium content was highest in T1, which showed behavior similar to that observed in T2, T3, and T5. In the present study, Ca (160.50 mmolc dm^{-3}) and Mg (86.50 mmolc dm^{-3}) concentrations exceeded those reported by Gerude Neto et al. (2023) for conventional composting systems (96.33 and 57.33 mmolc dm^{-3}, respectively), highlighting the greater efficiency of vermicomposting in nutrient release. According to Patra et al. (2022) and Regasa et al. (2025), the organic colloids present in vermicompost possess high adsorption and cation-exchange capacities, which enhance the retention and subsequent availability of these ions in the soil solution.

Finally, the final C/N ratios for the vermicomposts were, T1= 45.33; T2= 45.88; T3= 46.43; T4= 57.97 and T5= 38.78. According to Ratnasari et al. (2023), biological decomposition during vermicomposting involves complex shifts in organic matter structure. Although a reduction in the C/N ratio indicates the evolution of the humification process, values above the threshold of 20 signify the presence of complex carbon still under degradation. Therefore, the obtained vermicompost functions as an input at an intermediate stage of maturation, as complete stabilization depends on the profound biochemical transformation of lignocellulosic compounds, a phenomenon that continues even after the experimental period.

Seedling quality

Regarding seedling quality, data on Shoot Dry Mass (SDM) and Root Dry Mass (RDM) indicated distinct responses according to the diet provided to the earthworms. For SDM, the Kruskal-Wallis test ($p=0.17$) showed no statistical difference among groups, with aerial biomass production stable, from 0.00741 g to 0.0913 g. Conversely, for RDM, the p-value of 0.036 confirmed a significant treatment effect. The test revealed a superior performance ($p=0.01$) for treatments involving the partial substitution of cattle manure with plant residues regarding root development. These results suggest that the diet composition provided to the earthworms influences the quality of the vermicompost produced, with specific substrates promoting enhanced root biomass accumulation in lettuce seedlings (Figure 3).

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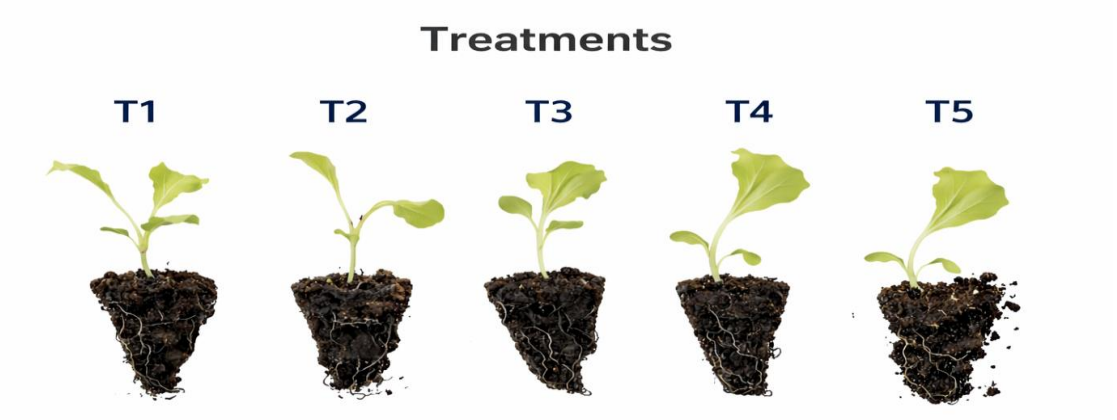


Figure 3. *Lactuca sativa* seedlings after 7 days of germination, grown in vermicompost, from different diets. T1: Cattle manure; T2: Cattle manure + *Clitoria fairchildiana* residue; T3: Cattle manure + grass clippings; T4: Cattle manure + organic compost; T5: Cattle manure + water hyacinth residue.

Although the vermicompost produced from the T1 diet exhibited favorable chemical attributes, it was not the treatment with the highest nutrient content. Therefore, it cannot be concluded that differences in substrate composition influenced lettuce seedling development. It should be considered that, at the evaluation period of 7 DAS, although the seedlings had already reached the optimal stage for transplanting, with two to three true leaves and an average height of approximately 5 cm (Jeong et al., 2024), they were likely still relying primarily on seed reserves as their main source of energy for growth.

According to Araújo (2011), a greater number of leaves per plant (NL) results in increased leaf area, higher fresh biomass accumulation, and, consequently, greater productivity. However, despite T1 exhibiting the highest shoot fresh mass (SFM), it did not present the highest number of leaves.

Finally, the technical feasibility of incorporating agroecological residues into the diet of *E. eugeniae* is confirmed by the production of vermicomposts with chemical quality compatible with plant nutritional requirements. Furthermore, lettuce seedling performance during the initial growth stage (7 DAS) and the physical stability of the root ball demonstrate that these alternative substrates possess the physical properties required for seed germination and root establishment. Thus, the partial replacement of cattle manure represents an effective and sustainable

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strategy for the production of organic inputs. Future studies should extend this evaluation throughout the entire crop phenological cycle to further validate the fertilizing potential of these materials during stages of greater nutritional demand.

4. Limitations of the study

This study focused on the population dynamics and technical feasibility of using agroecological residues in the vermicomposting of *Eudrilus eugeniae*, adopting field-based methodologies applicable to the reality of small-scale farmers. Regarding the biological assessment, population counts and morphometric measurements were selected instead of direct biomass quantification to minimize stress and excessive handling of individuals, thereby preserving the integrity of natural reproductive cycles within the experimental units.

Concerning diet formulation and initial substrate characterization, the experiment prioritized practical management based on equivalent volume and fresh mass, reflecting field conditions. Although this approach may introduce variability in dry matter inputs, it enhances the reproducibility and applicability of the system for local producers without requiring complex laboratory infrastructure for routine subsample analyses.

Finally, chemical quality indicators and a seedling germination bioassay were used to assess the chemical quality of the vermicompost and its potential to support seedling emergence and initial establishment. While additional maturity indices and regulatory parameters could be incorporated in studies conducted at an industrial scale, the results obtained demonstrate the effectiveness of the proposed bioconversion process for seedling fertilization purposes. Therefore, future studies should expand the evaluation of vermicompost effectiveness throughout the entire crop life cycle in order to quantify not only initial seedling vigor but also final productivity and plant biomass accumulation.

5. Conclusion

The results indicate that the partial replacement of cattle manure with agroecological residues in the diet of *E. eugeniae*, particularly when the residues

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are previously stabilized, is a viable and effective strategy. The ability of this species to adapt to substrates containing plant residues, such as water hyacinth and *C. fairchildiana*, without compromising population growth supports the use of these materials in vermicomposting as an alternative approach for organic waste management in agroecological systems.

The germination bioassay demonstrated that the resulting vermicompost possesses suitable physical and chemical properties for seedling production, promoting seedling vigor and root stability. These findings reinforce the value of vermicompost as a high-quality input for horticultural applications.

Therefore, the bioconversion of organic residues by *E. eugeniae* not only enhances nutrient recycling but also provides farmers with a sustainable alternative for producing their own organic fertilizers. This practice reduces dependence on external inputs and mitigates the environmental impacts associated with the improper disposal of organic waste.

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