REVISTA AGROAMBIENTAL

ARTIGO ORIGINAL

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PELAGRA MOÇAMBIQUE

Efeito da aplicação de composto orgânico decomposto por diferentes espécies de minhocas na produtividade da alface (*Lactuca sativa L.*)

Effect of the application of organic compost decomposed by different earthworm species on lettuce yield (Lactuca sativa L.)

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Informações do Artigo

Palavras-Chaves:
Alface.
Vermicompostagem.
Húmus de minhoca.
Adubação orgânica.
Produtividade agrícola.

RESUMO

O presente trabalho teve como objectivo avaliar o efeito da aplicação de composto orgânico decomposto por diferentes espécies de minhocas na produtividade da alface. O trabalho decorreu no Instituto Politécnico de Manica, entre junho e outubro de 2025, tendo sido instalado e conduzido um experimento em Delineamento em Blocos Casualizados (DBC), com 4 repetições e 4 tratamentos (T1 – sem fertilização; T2 – matéria orgânica decomposta pela minhoca local; T3 – matéria orgânica decomposta por minhoca importada; e T4 – adubo inorgânico composto por NPK e ureia). Aos 40 a 45 dias após o transplante, foram avaliadas as variáveis morfológicas e agronómicas da alface, a saber: número de folhas (NF), comprimento foliar (CF), comprimento radicular (CR), massa fresca (MF), massa seca (MS), humidade foliar (HF), teor de cinzas e colorimetria. Os dados colectados foram organizados no Excel 2021 e posteriormente analisados por meio da análise de variância, sendo as médias comparadas pelo teste de Tukey ao nível de significância de 5%, no programa Statistix 10. A partir dos resultados obtidos, verificou-se que houve efeitos significativos entre os tratamentos para todas as variáveis analisadas, com excepção do teor de cinzas. Em geral, os tratamentos T2 e T3 apresentaram maiores rendimentos médios do que os tratamentos T1 e T4. Quanto à colorimetria, a alface apresentou luminosidade para todos os tratamentos, com coloração verde-escura no tratamento T1 e coloração levemente amarelada nos tratamentos T2, T3 e T4.

***Keywords*:**
Lettuce.
Vermicomposting.
Earthworm humus.
Organic fertilization.
Agricultural productivity

This study aimed to evaluate the effect of applying organic compost decomposed by different earthworm species on lettuce yield. The study was carried out at the Polytechnic Institute of Manica between June and October 2025. The experiment was established and conducted using a Randomized Block Design (RBD) with four replications and four treatments (T1 – without fertilization; T2 – organic matter decomposed by the local earthworm; T3 – organic matter decomposed by an imported earthworm; and T4 – inorganic fertilizer composed of NPK and urea). At 40 to 45 days after transplanting, the morphological and agronomic variables of lettuce were evaluated, namely leaf number (LN), leaf length (LL), root length (RL), fresh mass (FM), dry mass (DM), leaf moisture (LM), ash content, and colorimetry. The collected data were organized in Excel 2021 and later analyzed by analysis of variance, with means compared by Tukey's test at the 5% significance level using Statistix 10. The results showed significant effects among treatments for all variables analyzed, except ash content. In general, treatments T2 and T3 showed higher average yields than treatments T1 and T4. Regarding colorimetry, lettuce showed lightness in all treatments, with a dark green color under treatment T1 and a slightly yellowish color under treatments T2, T3, and T4.

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DOI: https://doi.org/10.5281/zenodo.20250104

1. Introduction

The consumption of vegetables has been growing worldwide, due to the population's concern with well-being and health. Among the vegetables of great importance, lettuce (Lactuca sativa L.) stands out. One of the most commercially important and most consumed leafy vegetables in the world, stands out mainly as a source of vitamins and minerals (Santos, 2011).

In Mozambique this crop is of extreme importance in the human diet, consumed "in natura", which makes it preserve all its nutritional properties, produced using a conventional production system and generally produced in small portions of land called vegetable gardens. Maintaining soil quality in continuous cropping systems is critical to ensuring agricultural productivity and environmental quality for future generations.

The amount of organic matter depends on the input of organic material, its mineralization rate, soil texture, and climate, among other factors. According to INE (2011), in Mozambique there are problems that have not been given due importance by producers and consumers related to the consumption of products with a high level of chemical residues related to the excessive use of chemical compounds in the fertilization process.

The use of pesticides has implied several problems, mainly related to environmental contamination and public health. Due to the impact of inorganic fertilizers on soils, betting on the use of organic compounds can significantly minimize these worrying effects in horticulture.

Among several ways, using compounds from decomposed plant matter, we have to highlight the compound that is produced through the decomposition of plant material made by the earthworm (Lumbricina) that was introduced in Mozambique from India, through the Center for Research and Technology Transfer (CITT), located in Bandula, Manica and which has shown promising results, since it has optimal yields, simple production method and the wide availability of plant material.

Thus, the present research consists of evaluating the effect of the application of organic compounds decomposed by different species of earthworms in the yield of lettuce crops.

2. MATERIALS AND METHODS

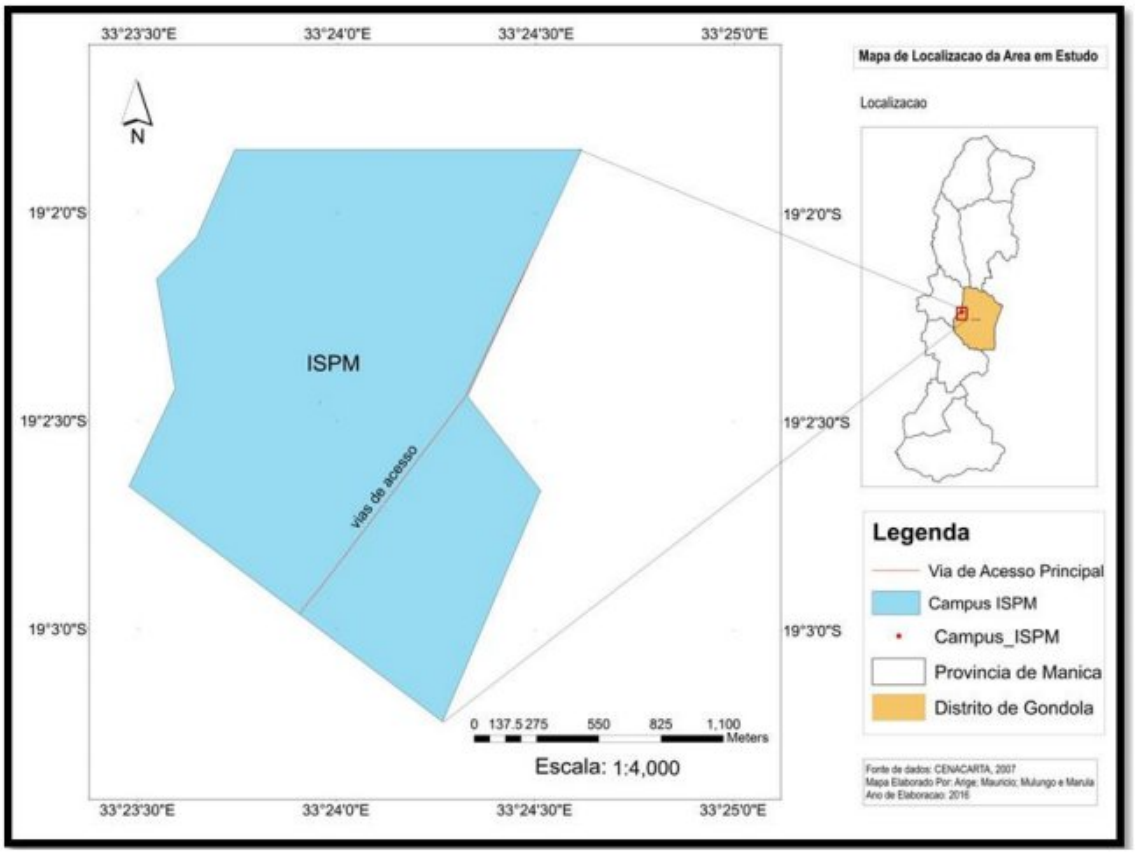
2.1 Location and characterization of the experimental area

The experiment was conducted between June and October 2025 at the Agricultural Production Unit of the Higher Polytechnic Institute of Manica (ISPM), located in Chiremera locality, Matsinho Administrative Post, Vanduzi District, Manica Province, approximately 15 km from Chimoio City (figure 1).

According to Köppen and Geiger, the climate of the region is classified as Cwa (warm temperate), with an average annual rainfall of approximately 1200 mm and an average

annual temperature of 21.6 ºC. The soils of the experimental area are reddish, well-drained and characterized by undulating topography.

Figure 1. Location of the Polytechnic Institute of Manica



Source: Authors (2026).

2.2 Humus production and earthworm species used

Two earthworm species were used for humus production: the local earthworm (Lumbricus terrestris) and the California red earthworm (Eisenia fetida), obtained from the Center for Research and Technology Transfer (CITT), located in Bandula, Manica.

The humus was produced using artisanal vermicomposters made of 20-liter plastic containers containing household organic waste, plant residues and cattle manure. After an initial decomposition period of approximately 30 days, 100 earthworms were inoculated into each container. Vermicomposting occurred for approximately 50 days until a stabilized dark-colored material with an earthy odor was obtained.

2.3 Experimental design and treatments

The experiment was conducted in a Randomized Block Design (RBD) with four treatments and four replications. Each experimental plot consisted of 16 lettuce plants.

The treatments evaluated were: **T1:** without fertilization (control); **T2:** application of organic compost decomposed by the local earthworm; **T3:** application of organic compost

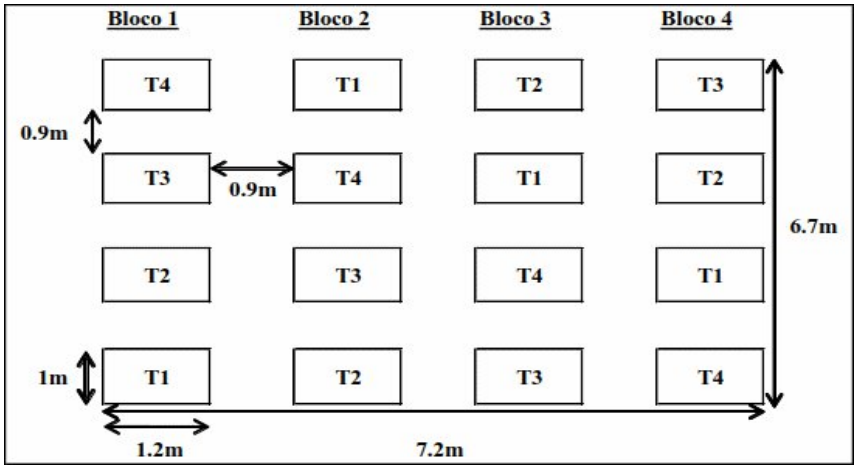
decomposed by the imported earthworm (Eisenia fetida); **T4:** application of inorganic fertilizer (NPK and urea).

For treatments T2 and T3, organic compost was applied at a rate equivalent to 20 t/ha and incorporated into the soil 15 days before transplanting. In treatment T4, fertilization was performed using NPK fertilizer and topdressing with urea (46% N) at a dose of 30 kg/ha at 23 days after transplanting.

2.4 Crop establishment and management

Land preparation was performed manually using a hoe, followed by plot demarcation with measuring tape, ropes and stakes (Figure 1).

Figure 2. Experiment Layout



Legend: T1- No fertilizer application (control);**T2-** Organic matter decomposed by the local earthworm**; T3-** Organic matter decomposed by imported earthworms**; T4-** Inorganic fertilizer.

Transplanting was carried out when seedlings had between 3 and 4 definitive leaves, using a spacing of 0.30 m between rows and 0.25 m between plants. Irrigation was performed manually twice daily and uniformly in all plots until harvest. Weed control was carried out manually at 20 days after transplanting. During the experimental period, no significant incidence of pests or diseases was observed; therefore, no phytosanitary control measures were required. Harvesting was performed between 40 and 45 days after transplanting.

2.5 Evaluation of agronomic and laboratory variables

The following agronomic variables were evaluated: number of leaves, leaf length, root length, fresh mass, dry mass, leaf moisture, ash content and colorimetry.

The number of leaves was obtained by direct counting of leaves from plants within the useful area. Leaf and root lengths were measured using a graduated ruler, with results expressed in centimeters. Fresh mass was determined by weighing plants on an electronic scale, with results expressed in grams. Subsequently, samples were packed in paper bags and dried in a ventilated oven at 105 ºC for 24 hours to determine dry mass.

Ash content was determined in a muffle furnace at 525 ºC for 2 hours. Leaf moisture was calculated as the difference between fresh mass and dry mass using the following formula:

$$LM = FM - DM$$

Where: LM = leaf moisture; FM = fresh mass; DM = dry mass.

Colorimetric evaluation was performed using a colorimeter based on the coordinates (L∗, a∗, b∗) corresponding respectively to lightness, green/red coloration and blue/yellow coloration.

2.6 Statistical analysis

The collected data were organized in Microsoft Excel 2021 and subjected to analysis of variance (ANOVA). Treatment means were compared using Tukey's test at the 5% significance level with the aid of Statistix 10 software.

3. RESULTS AND DISCUSSION

Based on the statistical analysis by the F testin table 1, it was found that there were significant statistical effects between the treatments on the lettuce crop for all variables analyzed, except for the ash content variable, where the effects of the treatments applied did not differ from each other.

Table 1. Analysis of variance of treatments in lettuce crop

Source of variation	DF	NL	LL	RL	FM	DM	LM	Ash
Treatment	3	*	*	*	*	*	*	Ns
Average	-	26.5	26.18	10.88	407.5	124.7	291.75	1.56
CV (%)	-	25.6	6.15	18.71	16.32	67.74	19.32	57.36

Where: DF – Degrees of Freedom; NL – Number of Leaves; LL – Leaf Length; RL – Root Length; FM – Fresh Mass; DM – Dry Mass; LM – Leaf Moisture; ∗ – Significant by the *F*test; Ns – Not significant by the *F*test; CV (%) – Coefficient of Variation.

In view of this finding, the treatments were broken down by applying Tukey's test of comparison of means at the level of 5% of significance to analyze the significance of the treatments observed in the lettuce variables.

Table 2 shows the average yields of the morphological and agronomic variables of lettuce and the respective results of Tukey's test of comparison of means at 5% significance. The results of the comparison of means show that there were significant effects among the treatments for the average number of lettuce leaves. Treatments T2, T1, and T3 presented higher average values and did not differ statistically from one another, with mean values of 32.25, 29.5, and 29 leaves per plant, respectively. Treatment T4 presented the lowest average value, with 15.5 leaves per plant.

Table 2. Average yield observed in lettuce

Treatment	Morphological and agronomic variables of lettuce						
	NL	LL (cm)	RL (cm)	FM (g/plant)	DM (g/plant)	LM (g/plant)	Ash content (g/plant)
T1	29.5ab	23.35b	10ab	348.75bc	82.50ab	266.25b	1.98a
T2	32.25a	26.40ab	11.25ab	537.91a	120ab	471.92a	1.91a
T3	29ab	27.5a	13.5a	447.50ab	255a	249.59b	1.77a
T4	15.5b	27.4a	8.75b	295.75c	41.25b	233.25b	1.40a

Where:T1 – No fertilization; T2 – Local earthworm fertilizer; T3 – Imported earthworm fertilizer; T4 – Inorganic fertilizer; NL – Number of Leaves; LL – Leaf Length; RL – Root Length; FM – Fresh Mass; DM – Dry Mass; LM – Leaf Moisture; g/plant – grams per plant.

Inferior results were found by Silva et al.(2014) evaluating the production of lettuce (Lactuca sativa)seedlings using different substrates, having found an average production of leaf numbers ranging between 7 and 10 leaves per plant. Also according to the same authors, the treatments composed of humus allowed good productivity when the number of leaves, shoot height and root green matter were evaluated.

3.1 Root length

The results shown in Table 3 indicate significant differences among treatments for root length. Treatment T3 showed the highest average root length, with 13.5 cm, but it did not differ statistically from treatments T2 and T1, which presented 11.25 cm and 10.0 cm, respectively. Treatment T4 showed the lowest average root length, at 8.75 cm.

Silva et al.(2014) found mean values for root length ranging from 8.85 to 7.53cm, with no statistical differences between them.

3.2 Leaf length

For leaf length, the results in Table 3 show that there were significant differences between the treatments. The average leaf lengths were 26.40 cm for T2, 27.5 cm for T3, and 27.4 cm for T4, whereas T1 showed the lowest average leaf length, at 23.35 cm.

These results are superior to those found by Watthier (2014), with an average variation in leaf length of 15.7 to 17.8 cm.

3.3 Fresh mass

There were significant effects among the treatments on the average fresh mass of lettuce. Treatment T2 had the best average performance, with 537.91 g/plant, and did not differ statistically from treatment T3, which produced 447.50 g/plant. Lower fresh mass values were observed for treatments T1 and T4, with average yields of 348.75 and 295.75 g/plant, respectively.

Similar results were observed by Vallone et al.(2011), studying forms of fertilization with humus in iceberg lettuce, where they found the average total production oscillating between 341 and 596g/plant. According to the same authors, they found that earthworm humus was efficient in the production of lettuce.

Santos et al.(2016) explain that the increases in the fresh matter of the lettuce plant due to the application of doses of vermicompost are probably attributed to the ability of the fertilizer to provide necessary amounts of nutrients for the crop, as it is readily humified and mineralized promoted by the actions of earthworms during the solubilization of the cattle manure that gave rise to vermicompost, which influenced the growth of this agronomic characteristic in comparison to the treatment that did not receive fertilization.

3.4 Dry mass

The results obtained for this variable show that the treatments presented significant effects. Treatment T3 (255 g/plant) stood out from the others; however, it did not differ statistically from treatment T2 (120 g/plant). The lowest dry mass production was observed in treatment T4 (41.25 g/plant).

According to the results obtained by Abreu et al.(2010), evaluating different organic fertilizers, obtained average dry matter production between 2.12 and 4.01g/plant, with the lowest production as a control. Peixoto et al.(2013) found higher dry matter production of lettuce in the first crop with vermicompost equivalent to 5.4g/plant and in the second cycle there was a highlight for sheep manure with 6.69g/plant. Oliveira et al.(2014), using different organic compounds, obtained 4.82g/plant of dry matter. However, the results of the present study were superior to those found by other authors.

3.5 Leaf moisture

The results presented in Table 3 show that there were statistically significant differences among the treatments regarding average leaf moisture. The best average yield was observed in treatment T2, with 471.92 g/plant, differing from T1 (266.25 g/plant), T3 (249.59 g/plant), and T4 (233.25 g/plant), which did not differ from one another. These values are lower than those obtained by Gonçalves (2016), where the average results of leaf moisture in lettuce ranged from 570.4 to 778.5 g/plant.

3.6 Ash content

The results in Table 3 show that there were no statistically significant differences among the treatments applied to the lettuce crop, with average values ranging from 1.40 to 1.98 g/plant. These results are within the range of values found by Gonçalves (2016), with a range of 0.30 to 2.08 g/plant. However, the ash content presented is within the quality standards for human consumption, with no risk to consumer health (Neto et al.,2014).

3.7 Colorimetry

The results regarding the colorimetry of lettuce are shown in Tables 4 and 5. Table 4 refers to the analysis of variance by means of the F test, where it was observed that there were significant differences between the treatments for the color coordinates, and it was

found that for the Luminosity coordinate (L∗), the treatments did not present different effects, however, for the coordinates of color angle (a∗) and chromaticity (b∗), the treatments differed from each other.

Table 3. Analysis of variance of treatments for lettuce colorimetry

Sources of variation	DF	L∗	a∗	b∗
Treatment	3	Ns	*	*
Average	-	53.86	-15.93	28.46
CV (%)	-	11.25	-8.75	13.5

Where: DF – Degrees of Freedom; L∗ – Lightness; a∗ – Color coordinate; b∗ – Chromaticity; Ns – Not significant; * – Significant by the *F* test; CV (%) – Coefficient of Variation.

Having found significant differences between the coordinates in responses to the treatments applied in the lettuce crop, the means were compared using Tukey's test at 5% significance, in order to interpret the observed significance.

Table 4. Average colorimetry yield in lettuce

Treatments	Colorimetry		
	L∗	a∗	b∗
T1	55.34a	-17.28b	31.30a
T2	51.38a	-15.75a	27.60a
T3	52.03a	-14.7a	24.87b
T4	56.67a	-15.99ab	30.07a

Where: T1 – No fertilization; T2 – Local earthworm fertilizer; T3 – Imported earthworm fertilizer; T4 – Inorganic fertilizer; L∗ – Lightness; a∗ – Color coordinate; b∗ – Chromaticity.

3.7.1 Coordinate L∗

The L∗ values presented in Table 5 did not differ statistically between the treatments applied to the lettuce crop. These results are within the range of the values found in the study by Neto et al.(2014) with Elba lettuces cooled to 5°C, where the authors found values of 56.19 to 60.46. And in the studies by Cassetari (2012) with lettuce of the Verónica variety of the curly type, a value of 57.27 was found for the colorimetric component L∗.

For the L∗ colorimetric component in this work, the values ranged from 51.38 to 56.67, with higher values indicating greater light refraction, according to Pinto (2016) obtained in his work that the organic lettuce sample has a darker color, as shown in this work.

3.7.1 Coordinate a∗

The values found in this study for the colorimetric component a∗ ranged from -14.7 to -17.28. It can therefore be stated that there were significant effects among the treatments in the lettuce crop, since the green region of the colorimeter reading showed negative values for this coordinate. Treatment T1 presented a darker green color, while treatments T2, T3, and T4 showed a slightly less intense green coloration.

In the work of Neto et al.(2014) values of -16.35 to -20.09 were found for Elba lettuces. And in the studies by Cassetari (2012) with lettuce of the Verónica variety, of the curly type,

a value of -16.37 was found for the colorimetric component a∗. Higher values were found by Pinto (2016) in his study for the colorimetric component a∗, which ranged from -21.18 to -24.32.

3.7.2 Coordinate b∗

For the values of chromaticity b∗, the results of Table 5 show that there were significant effects between the treatments on the physical composition of the lettuce crop, where they presented values ranging from 31.30 to 24.87 indicating yellow color in medium proportions in the lettuce. Pinto (2016) obtained values ranging from 37.11 to 42.81 for b∗ chromaticity in lettuce samples.

In studies conducted by de Neto et al.(2014) with Elba lettuces cooled to 5°C, values ranging from 35.11 to 38.95 were found. And in the studies of Cassetari (2012) with lettuce of the Verónica variety of the curly type, a value of 22.94 was found for the colorimetric component b∗.

4 CONCLUSION

The application of different organic and inorganic compounds in lettuce production showed significant effects on the average yields of leaf numbers, leaf length, root length, fresh mass, dry mass, leaf moisture and for the ash content variable, the treatments did not differ from each other.

As for colorimetry, there were significant effects for all color coordinates, except luminosity, for this component, no statistical differences were recorded in the lettuce crop, and a slightly dark green color was observed in the lettuce leaves.

However, the treatments T2 and T3 (local and imported earthworm fertilizer) were the ones that presented the best average yields, not differing significantly from each other, thus, it is concluded that the production of lettuce based on organic compost from the local earthworm is a viable, safe and environmentally correct alternative for producers in the family and commercial sector.

5. ACKNOWLEDGEMENTS

I would like to thank the technical team of CITT and the professors of the Agricultural Engineering course at the Polytechnic Institute of Manica for the opportunity, guidelines, resources and the space for experimentation.

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Submitted: March 31, 2026

Accepted: April 5, 2026