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Comparative analysis of vermicomposts with different substrates of non-ruminants animals with African earthworms

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Abstract

The earthworm began to expand around the world in the 70s, and became the target of studies by the scientific community. The aim of this work is to evaluate the reproduction and development of giant African earthworms on different substrates with non-ruminant animal manure, Bushveld signal grass and Orelha-de-Onça. To evaluate the productive and reproductive development of African giant earthworms on different substrates of non-ruminant animals. The work was carried out at the Federal Rural University of Pernambuco (UFRPE) – Serra Talhada academic unit (UAST) - PE, being divided in two stages, in the first one the substrates were produced and in the second one the vermicompost was produced. After the end of 35 days the worms were counted, washed and weighed where they had the in-natura weight of each repetition of the treatments, after they were added in identified bags and these were taken to the definitive drying oven, at the end the bag was removed and weighed again obtaining the dry weight. Analysis of variance was performed for the following variables: N, Ca, Mg, P, K, Zn, Cu, B, Fe, Mn, CEC, pH and weight of adult worms. The vermicompost with the highest levels of macro and micronutrients is the substrate with rabbit manure.

Key-words: *Eudrilus eugenias*, Substrate, Composting, Vermicomposting, African Giant

Introduction

The earthworm culture or vermicomposting started to expand around the world in the 70's and from the 80's and 90's it became the target of studies by the scientific community. The worm culture has several applications and adapts easily to the field and to the urban environment, having double function: humus production and worm production (De Aquino, 2009).

The breeding on a bed started in the United States in the 40's and in South America in 1983. In many countries the main objective of worm farming is the production of baits for sport fishing, but the low investments for the beginning of breeding have aroused interest in exploring worm farming as a source of cheap protein for feeding small animals and for the production of humus for fertilization purposes (De Matos Macchi, 2013).

Nowadays, there are few worm farming jobs for vermicompost production, as it is a recent practice and mainly unknown by the agricultural producer (Minosso, 2015). Vermicomposting brings many benefits, reducing by up to 75% the volume of

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organic waste deposited in landfills. (Nadolny, 2009). Currently, crop residues and animal waste are widely used in vermicomposting.

The organic waste that serves as food for worms, when passing through their digestive tract, undergoes transformations that favor the formation of stabilized organic matter, in other words, organic fertilizer known as "earthworm humus". Bovine manure has been the most used because it is easy to handle and worms adapt very well to it, but horse and rabbit manure can also be used. Vegetable waste such as grass, leftover grass, legumes and leaves can also be used (De Aquino, 2009).

The worms used to produce the fertilizer need organic material (manure in general, leaves, food waste, etc.) to survive and reproduce. The quality of the humus will depend on the quality of the organic waste. Manure mixed with leguminous plants (rich in nitrogen, for example: guandu, leucene, crop residues, soy, etc.) provides excellent quality humus production and also favors the reproduction of earthworms (De Aquino, 2009).

An option for the semi-arid is the Urochloa mosambicensis grass, known as Bushveld signal grass, which has moderate resistance to drought and can be used for grazing the animals, as well as for hay production (Oliveira, 2005). Orelha-de-Onça (*Macroptilium martii* Benth) is a native legume of the Brazilian semiarid region, which participates in the diet of ruminants in grazing (Silva, 2010).

Among the commercial species of worm are the foetida Eisenia, *Lumbricus rubellus* and *Eudrilus eugeniae*. The latter is native to West Africa, known as the African giant, is rustic and has adapted very well to the Semiarid, allowing the use of coarser materials different from livestock manure. It has nocturnal habits and reproduces throughout the year, can reach 30 cm in length (De Matos MacchI, 2013).

In view of the large amount of organic and animal waste on farms and the idea of using these residues in vermicomposting, as well as knowing the efficiency and frequent use of manure in the composting process, it was thought to test new substrates, using as a technique the adaptation of the species of worms, *Eisenia eugeniae* that are used in this process. Thus, the objective was to evaluate the productive and reproductive development of giant African worms on different substrates of non-ruminant animals.

Material and methods

Experimental area

The experiment was conducted in a worm farm, at the Rural Federal University of Pernambuco (UFRPE), Serra Talhada Academic Unit (UAST) located in the semi-arid region of Pernambuco. From July to October 2018, the geographical coordinates of the SIRGASS (Geocentric Reference System for the Americas) system are 7°57'21" south latitude and 38°17'45" west longitude, in the Mesoregion of the Sertão Pernambucano, Pajeú Microregion, at an altitude of 429 meters (Figure 1).

Twelve white plastic pots were made, with 30 cm diameter, 32 cm height and 15L volume, containing 0.5 cm drains at the bottom in which the substrates obtained from non-ruminant animal compounds and native vegetation were added (Figure 2). With three treatments with four repetitions. Different sources of animal manure were used: Poultry, rabbit and equine. The manure was obtained from rural properties of Serra Talhada-PE.

Fig. 1. Serra Talhada Academic Unit localization.
Google Maps

Fig. 2. Earthworm farm.

Climate

According to KÖPPEN, the climate is of the BSw'h' type very hot and semi-arid, with a temperature of the coldest month exceeding 18°C and summer autumn rainfall. The rainy season starts in November and ends in April. The average annual precipitation is 639 mm and average annual temperature around 25.2ºC (LAMEPE/ITEP, 2015).

Substrate Production

The substrates were produced from manure obtained from properties in the municipality of Serra Talhada-PE, and were transported to the campus where they were cleaned and sieved to be stored and tanned. The grass and legume were collected at the UAST itself, where they were chopped with the help of a crusher and a mixer (Figure 3).

Fig. 3. Experimental Units.
Source: Florentino, T. M. S. (2018)

The substrates were separated by treatments using Bushveld signal grass (*Urochloa mosambicensis*), Orelha-de-onça (*Macroptilium martii* Benth) and different sources of ruminant manure (Poultry, rabbit and equine). The three different substrates gave rise to Treatment 1 (T1) (poultry manure (50%) + Bushveld signal grass (25%) + (25%) Orelha-de-onça), Treatment 2 (T2) (rabbit manure (50%) + Bushveld signal grass (25%) + (25%)Orelha-de-onça) and Treatment 3 (T3) (equine manure (50%) + (25%) Bushveld signal grass + (25%) Orelha-de-onça), with four repetitions giving a total of 12 pots.

After defining the percentage of entrance of each material in its treatment and its repetitions, starting the production of the substrate on July 6, 2018, it was for a period of 45 days being irrigated with a quantity of one liter of water per pot every two days and being turned over the material every 8 days. The substrates were ready to be used when the color black or brown coffee, granulated consistency, homogeneous and without distinction of remains, pleasant smell and room temperature even if it is turned over (Figure 4).

Fig. 4. Preparation of the substrate: (A) Mincing orelha de onça, (B) mixing the substrate, (C) Placing the substrate in a pot.
Source: Florentino, T. M. S. (2018)

Production of vermicompost

The matrices of *Eudrilus eugeniae*, were acquired at the Earthworm farm in the Federal Rural university of Pernambuco (UFRPE), in the Academic Unit of Serra Talhada (UAST) - PE. A total of 600 worms were collected, separated manually, and distributed in 12 vessels, giving a total of 50 per unit, being washed, standardized, and added in the treatments (Figure 5).

The vermicompost started on August 17, 2018, and the worms spent 35 days decomposing the material. When the compost kept the same watering shift in the composting with an amount of 300 ml of water, and turned over together with the analyses, where in the last 15 days of experiment it was necessary to increase the amount of water to 600 ml due to room temperature during three days it stayed at an average of 25ºC (source: INMET, 2019) making the compost present a lower percentage of humidity (Figure 6). The vermicomposts were ready when they presented the following characteristics uniform dark coloration, absence of smell and texture similar to coffee powder.

Fig. 5. Giant African Earthworm.
Source: Florentino, T. M. S. (2018

Fig. 6. Watering the vermicompost.
Source: Florentino, T. M. S. (2018)

Analysis of earthworms

After the end of the 35 days, the worms of each treatment were counted manually (Figure 7). After that, the worms were washed and weighed in-nature for each repetition of the treatments. Afterwards, glass jars with 800ml of distilled water were added to be placed in the autoclave for 1h00min to be sterilized, after they were added in identified bags and these were taken to the final drying oven at 105º for 72 hours, at the end the bag was removed and weighed again obtaining the dry weight.

Fig. 7. Manual separation of earthworms. Source: Florentino, T. M. S. (2018)

Statistical analysis

The experiment was performed in an entirely randomized design (DIC), with three treatments and four repetitions. After identifying the significance between the treatments, the qualitative data were compared using the Tukey test at 1% (**) and 5% (*) probability depending on the coefficient of variation and the adequacy of the data to type I or type II error.

Analysis of variance was performed for the following variables: total nitrogen, calcium, magnesium, phosphorus, potassium, zinc, copper, boron, sodium, iron, manganese, CEC, pH, number and weight of adult earthworms.

Results and Discussion

In the second week it was observed the absence of 100% of the worms in the bird compound. According to Vieira Tiago (2008), bird dung should be used mixed with bovine or equine dung, as it is a very strong dung that used pure proved to be highly harmful to worms. Bird dung when used should preferably be mixed with bovine manure, to avoid nitrogen in the form of ammonia gas being toxic to worms.

After chemical analysis of the vermicomposts in the laboratory it was observed that the bird vermicompost had a high nitrogen content and an alkaline pH so it had a mortality rate of 100% of the worms. After 45 days of the experiment, *Eudrilus eugeniae* worms performed the vermicompost, multi plying according to the availability of food (substrate) offered. The worm input variants did not show significant difference (P>0.05). The worm output variants showed a significant difference (P<0.05). The treatment of rabbit and equine did not differ. The percentage of losses was calculated in order to quantify the real decrease of worms per treatment. Among the three treatments the one that presented the lowest result of loss was equine with the percentage of losses of 9%, according to rabbit with 20.5% and the highest was birds that had 100% of mortality, according to Table 1.

Table 1. Number of inlet, outlet and percentage of earthworm losses from vermicompost from non-ruminant animal dung.

Variables	Treatment			
	Poultry	**Rabbit**	**Equine**	**CV (%)**
Inlet	50,00 A	50,00 A	50,00 A	0,00
Outlet	0,00 B	39,75 A	45,60 A	13,36
% Loss	100%	20,5%	9%	

Averages followed by equal capital letters on the line for each variable, do not differ (P>0.05) according to Tukey's test.

For the output parameter it can be seen that there was no significant difference (P>0.05) between the treatments with rabbit and equine substrate, and these were superior to the treatment with Poultrys manure. The treatment of poultrys presented a high mortality rate at exit. What differs with the results found by Machado et al. (2012), it was found that in vermicompost with pure chicken manure, mortality was high, because the substrate showed high acidity, contributing to the death of individuals, as shown in Table 1.

It can also be believed that the transformation efficiency of the substrate into humus was more efficient for treatments in equine and rabbit vermicomposts, as the numbers at the exit of worms were lower and consequently than in bird vermicomposts. It can be seen that the treatment with bird vermicompost showed the worst results for worm perch. For the outgoing substrate parameters it can be seen that there was no significant difference (P>0.05) between the rabbit vermicompost and equine and rabbit vermicompost treatments, and these were superior to the treatment in which it was used to bird vermicompost.

The weight of natural matter and percentage of dry matter showed a significant difference (P<0.05), while the weight of dry matter of earthworms showed a significant difference (P<0.05), these results are shown in Table 2.

Table 2. Weight of natural matter, weight of dry matter and percentage of dry matter, vermicompost based on dung from non-ruminants.

Variables	Treatment			
(g/kg of DM)	**Poultry**	**Rabbit**	**Equine**	**CV (%)**
Weight NM	0,00 B	37,77 A	30,64 A	35,02
Weight DM	0,00 B	6,71 A	5,27 A	34,27
% DM	0,00 B	17,75 A	17,28 A	5,94

Averages followed by equal capital letters on the line for each variable, do not differ (P>0.05) according to Tukey's test.
NM = natural matter; DM = dry matter.

The treatment of weight of natural matter showed significant difference (P>0.05), the weight of rabbit and equine are higher than that of poultrys as shown in Table 2. The weight of DM showed significant difference (P<0.05), being rabbit and equine superior to poultrys only in numbers. In values relative to the percentage of dry matter showed the significant difference (P<0.05), where rabbit was superior, which showed a higher percentage of 17.75% when equine was 17.28% and poultry 0.00%.

The treatment of poultrys had 0.00% of NM and DM because 100% of worm loss. It had significant difference (P>0.05) for all macros nutrients found in both treatments. The rabbit vermicompost showed the best results, being inferior only in nitrogen. According to Mayer et al (2009), the nutrient macros present in the vermicompost of rabbits with California red worms (*Eisenia andrei*) is superior to the other treatments in quantity with nitrogen section, as shown in this work in Table 3.

Table 3. Macronutrients in vermicompost based on non-ruminant animal manure.

Variables	Treatment			
(g/kg de DM)	**Poultry**	**Rabbit**	**Equine**	**CV (%)**
Nitrogen (N)	9,50 A	7,13 AB	2,75 B	38,89
Calcium (Ca)	16,63 B	139,63 A	6,00 C	5,22
Magnesium(Mg)	6,83 B	21,25 A	2,85 C	8,84
Phosphorus (P)	10,68 B	24,08 A	3,47 C	19,59
Potassium (K)	11,38 A	12,13 A	2,38 B	15,96
CEC %	37,58 B	136,43 A	11,35 B	77,62
pH	8,60 A	7,63 B	6,88 B	5,83

Averages followed by equal capital letters on the line for each variable, do not differ (P>0.05) according to Tukey's test.

Martinez et al. (1990), the vermicomposts related that the largest reproductions of worms are present in materials with higher Ca content, so this result is in accordance with rabbit dung vermicompost, as shown in Table 3.

According to Mayer et al. (2009), rabbit dung vermicompost was the best substrate for worm development when compared to bovine, equine, and yerba mate dung when mixed with coffee grounds, so this result is in accordance with the analysis in Table 3. The rabbits feed is the base of a balanced ration providing a better quality of the vermicompost obtained in relation to the other residues.

According to Bassaco et al. (2015) the rabbit manure used in the vermicompost test showed the highest amount of chemical nutrients when compared to the others. The different chemical composition of rabbit manure can be explained by the diet, rich in nutrients, received by these animals.

According to the analysis of the vermicomposts (Table 3), it can be seen that the rabbit vermicompost presented the highest values of phosphorus, potassium, calcium and magnesium, and, intermediate values of nitrogen and pH. These data are in accordance with the results found by Mayer et al. (2009), in the table of Chemical Analysis of vermicomposts from different organic sources.

Luiz et al. (2012), observed that rabbit humus have high levels of phosphorus, potassium and magnesium in relation to bovine humus, which is in accordance with the analysis of the vermicompost of macronutrients in this study.

A balance between the macronutrients for the rabbit vermicompost can be verified,that is to say,it did not present very high or very low levels for the quantified nutrients. According to Vione (2018), higher levels of P, Ca and Mg were observed in the materials produced with poultry manure, which was accepted with the results of this study. Where the highest levels of P, Ca and Mg were found in rabbit vermicompost.

According to Souza and Resende (2003), because they do not produce urine, the poultrys, eliminating it together with the feces, produce manure richer in nitrogen than that of ruminants or pigs. The treatment with bird vermicompost has the highest nitrogen content 9.50 being followed by rabbit vermicompost with 7.13 and equine vermicompost with 2.75. These results are in accordance with those found in this work where the pH of poultrys 8.60, rabbit 7.63 and equine with 6.88. Chicken manure, from intensive farms and fed with feed, is rich in nutrients, especially nitrogen and phosphorus.

The pH showed a significant difference ($P<0.05$), with the pH of poultrys with 8.60 alkaline being above the indication that worms tolerate pH values between 5 and 8, which may have caused mortality of worms. The pH of rabbit and equine are between 7.63 and 6.88 are among the acceptable values. According to Carlesso et al. (2011) earthworms have a preference for low-acid organic matter. However, there are indications that worms tolerate pH values between 5 and 8, with damage to their activities only when they are outside this range, this result is in accordance with analysis of this work.

According to Ivone et al. (2018), the higher levels of P and Ca, with the use of laying poultrys manure, are due to the addition of the elements by means of minerals in the rations, is not in accordance with this work. Where the highest levels of P and Ca are found in the treatment of rabbits with levels of P 24,08 and Ca 139,63.

The treatment of poultrys in comparison to the treatment of rabbits and horses presented higher values only of nitrogen and pH. The vermicompost of poultrys presented the pH 8.60 is alkaline compared to the vermicompost of rabbit 7.73 pH and equine with 6.88 being neutral.

Borali et al. 2000, nitrogen is found in the soil but not in sufficient quantities, therefore the importance of vermicompost, because it is a rich material in this element supplying the lack that the soil presents of it, being the most important element for the plants for participating in several vital processes for it. The vermicompost of poutrys and rabbit had the highest levels of nitrogen with 9.50 and 7.3 being the most indicated to supply the lack in the soil while the equine manure with 2.78 being the least indicated. The values of phosphorus found in this study were in rabbit dung 24.08, the vermicompost of poultrys with 10.68 being higher than the value found in equine dung with 3.47.

According to Borali et al. (2000), potassium is important for agriculture because it has the function of promoting resistance to some diseases and also about extreme climatic conditions, it collaborates in the formation of strong roots and also in the quality of fruits, stressing that the soil has a great deficiency of this element. The highest levels of potassium were found in rabbit and bird vermicomposts with levels of 12.13 and 11.38 being the most indicated to promote resistance to some diseases and equine manure with levels of 2.38 being the least indicated.

There was a significant difference ($P<0.05$) for all micro nutrients found in both treatments. The treatment with rabbit vermicompost presented the highest levels of micronutrients in relation to other treatments, according to Table 4. The values of copper show significant difference ($P<0.05$), and the treatment with rabbit vermicompost 0.142 showed higher value in relation to birds 0.081 and equine 0.052.

The values of Boron found in this study showed a significant difference ($P<0.05$), and the the values of birds 0.018, rabbit 0.011 and equine 0.007.

Table 4. Micronutrients in vermicompost based on non-ruminant animal manure.

Variables	Treatment			
(g/kg de DM)	**Poultry**	**Rabbit**	**Equine**	**CV (%)**
Copper (Cu)	0,081 AB	0,142 A	0,052 C	43,38
Boron (B)	0,018AB	0,011 A	0,007 C	39,67
Iron (Fe)	8,96 B	5,63 A	5,14 B	21,00
Manganese (Mn)	0,31 B	0,80 A	0,15 B	44,86
Zinc(Zn)	0,21 B	0,61 A	0,10 B	46,68
Sodium (Na)	2,81A	2,01A	0,20 B	42,28

Averages followed by equal capital letters on the line for each variable, do not differ (P>0.05) according to Tukey's test.

There was a significant difference (P>0.05) for CEC where the treatment of rabbit with 136.43, while the treatment of poultrys and equine are statically equal. Chacón (2006), rabbit dung, chicken dung and poultry had higher levels of Fe and Cu which is related to the fact that these micronutrients are present in the diets of breeding, is in accordance with this work. Where the highest levels of Fe and Zn are in the treatment of birds and rabbits with the Cu values of 0.081 and 0.142 and Fe 0.21 and 0.61. The highest levels of micronutrients are found in the treatment of rabbits in relation to the other treatments. Where the treatment of rabbit has been shown to be superior having the highest levels of micro nutrient in relation to birds and equine.

Conclusion

The worms presented the best productive and reproductive development in the substrate with rabbit manure.

The vermicompost with the highest levels of macro and micronutrients is the substrate with rabbit manure. Where the treatment of rabbit manure has been shown to be superior to the others, having the highest levels of both macro and micronutrients in relation to poultrys and horses.

Conflict of interest: All authors declare no conflict of interest.

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