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Vermicompost an Alternative in the Treatment of Organic Solid Waste, in Zones Altoandinas, Tarma, Junin 2019

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Abstract: In the present investigation, the weight, growth, adaptability and production of humus of a calf foot of Californian red worm (Eisenia foetida) fed with compost (made from animal excreta and organic waste) and organic remains were evaluated. The evaluation was carried out in Tarma, Junín Region. A breeding ground was built with 3.2 m^3 cement bricks (6.10 m long × 1.05 m wide and 0.50 m high); with a 5 cm thick screed with a 2” PVC drain pipe with a west-east slope, raised by the west side at 15°. A population of 10,000 individuals (10 kilograms) was sown, a sample of 370 individuals was extracted by applying a Simple Random Sampling (MAS) whose average weight and length was 0.3 g and 30 mm. they were fed for 3 months (90 days), the calf was divided into 21 sampling points from which 383 worms were weighed and measured whose average weight and length were 0.38 g and 33.24 mm (3.32 cm). Data were taken every day at 2:00 pm, hydrogen potential (pH) and humidity (soil peach meter), substrate temperature (digital thermometer), ambient temperature (thermohygrometer) were recorded. The average weight of the worms varied from 0.30-0.38 g, the average length varied from 30-33.24 mm. The presence of tiny heels and worms demonstrated their adaptability. The production of humus was 3 tons, the efficiency of the breeding stock was 93.75%. The final substrate had an average of 6.72 pH, 13.61°C temperature, 69.86% humidity and 19.5°C ambient temperature. Consequently, vermicompost is an alternative in the treatment of organic solid waste to be developed in high Andean areas.

Key words: vermicompost, breeding foot, humus, High Andean Zone

1. Introduction

At present, the city of Tarma, Junín region secretes 34,116 t/day of solid waste, of which 22.26 t/day is organic matter equivalent to 65.24% according to the last characterization of the solid waste of the city, whose final destination is The sanitary landfill of Pampaya where this organic matter is converted into methane (CH4) highly polluting gas or if it is burned it becomes Carbon Dioxide (CO_2) both gases considered as Greenhouse Gases (GHG), in addition to the water of the matter Organic becomes leachate that is highly polluting. In the high Andean areas the treatment of solid waste is a big problem, the percentage of organic waste ranges from 60% to 70% (traces of vegetables, fruits, foliage among others). The excreta of animals such as guinea pig, cattle, pigs and sheep called “Guano” are used in agriculture in rural areas, but in some cases they appear as organic waste that is taken to the landfill. This research aims to take advantage of organic waste, the “Guano”, sawdust, pruning and water to produce compost, which will then serve as food for Californian red worms (Eisenia foetida) which will convert these organic wastes into humus (organic

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fertilizer) which is used in agriculture, this technique is called vermicompost or vermicompost.

Of the total waste generated daily, by various human activities, in our country (3780 tons per day according to 2006 data), almost 55% corresponds to biodegradable materials. It is estimated that, in rural areas, the generation of waste is slightly lower than urban, although the proportion of organic materials is higher [1].

It is necessary to clarify that composting and vermicomposting are techniques used to transform organic solid waste into organic fertilizers (compost and vermicompost, respectively) whose physical, chemical and biological characteristics of the substrate directly affect soil improvement and growth of the plants; during the aerobic decomposition process, wastes are released that aggregate into the environment. The substrate used to feed Californian worms must go through a previous period of composting “known as precomposting”. Vermicomposting produces a material in which the majority of nutrients are more available to the plant than conventional composting [2].

They argue [2] that the composting process consists in the decomposition of organic waste by the action of microorganisms (bacteria, fungi and actinomycetes) under controlled aerobic conditions that allow the biodegradation of organic matter, until obtaining a homogeneous final product, suitable for be used as a fertilizer, called compost. Having as key factors for this process: humidity (55-60%), temperature (> 55°C to eliminate or reduce the presence of undesirable organisms), aeration and oxygen (with periodic flips in the cell), carbon/nitrogen ratio (C/N: 25-35/1), porosity and particle size (between 1 and 5 cm) and pH (5.5 and 8.5) [2, 3].

On the other hand, vermicomposting consists in combining aerobic digestion and the transformation of organic materials through the action of composting worms. The final product of this process is known as vermicomposta or earthworm humus which is a stable, uniform substrate, with excellent physical structure, porosity, aeration, drainage, nutritional content and moisture retention capacity [2, 4].

According to E. T. Bun [5], he argues that the adaptability, status and multiplication of the different earthworm species, mainly the Californian red worm, are directly affected by the characteristics of the substrate or growth material, which must pass through a previous period of maturation so that the microorganisms that make up the earthworm diet develop, since these are microphages and expect organic matter to be broken down so that they can be digested.

It is recommended when working with vermicompost, that the inoculation of the worms occur after the organic compounds have been previously composted and the thermophilic stage has been overcome, otherwise the temperatures that occur in this phase can cause mortality In worms, if we control this, pre-composted residues may be more acceptable and cause less mortality to worms, because potentially toxic components such as ammonium or salts are removed in animal manure, or tannins and acids in green waste [6].

Domínguez and Pérez [7], argue that vermicomposting is the process of decomposition that involves the interaction between worms and microorganisms by degrading organic matter. Although microorganisms are the real ones responsible for the biochemical degradation of organic matter, earthworms are important vectors of the process since they fragment and condition the substrate, increasing the surface for microbiological activity, and altering its biological activity in an important way. The worms through the processing of organic matter modify their physical, chemical and biological characteristics, act as a “biological mill”, progressively reducing their C: N ratio, increasing the area exposed to the activity of microorganisms, and making it much more susceptible for microbiological activity therefore generate greater decomposition. This organic matter when passing through the digestive system of the earthworm, the fragments and excrements rich in bacteria are removed, homogenizing the material, the final product obtained is called vermicompost.

Vermicompost is mineralized and unstabilized organic matter. It must be stabilized for humification to occur. Humification is a process carried out by Humidifying Microorganisms that, under appropriate conditions, stabilize mineralized organic matter, converting it into humic substances, humic acids, fulvic fractions and humines. The greater the amount of mineralized organic material contained in the vermicompost, the greater its quality, and the greater the proportion of humic substances it will provide. A vermicompost will be humidified in conditions of mild temperatures of 20°C and constant humidity of 40% with good aeration and always protected from direct sun (called maturation), this process lasts an average of three months. Humidity and aeration conditions must always be maintained, it must be considered as a living macro-organism [8].

In his research [9], carried out at the Mario Gonzales Farm (GMGA) Aranda of the National University of Colombia, Palmira headquarters, he records Table 2 “Collection of information on age discrimination of the Californian red worm Eisenia foetida” taken from M. Schuld, A. Rumi, D. E. Gutiérrez (2005), C. Henriquez and G. Cabalceta (1999) [10, 11] of it we can determine the following: that there are adults with a clitoral whose average weight is 0.25 g and whose length is greater than 3 cm. Similarly, adults over 3 cm are considered adults without a clit (Table 2).

In Moreno et al. (2012) [12], cited by V. M. Villegas and J. R. Laines (2017) [13] we are informed in Table 3 “Biological characteristics and environmental conditions of the main species of temperate earthworms used in vermicomposting processes”, applied to different types of worms including Eisenia foetida, within which we have:

• As for the adult size in (mm) it is between 50 to 100 mm.

• Regarding the average adult weight (g), it is 0.55.

• Regarding the variable optimum temperature and limits (°C) 25 (0-35).

• Regarding the optimum humidity and limits (%) 80-85 (70-90).

They argue [7] that vermicomposting as a process is considered a clean ecotechnology, without environmental impact and whose investment, energy, and maintenance costs are moderately low. Its use provides the following benefits: a) elimination of harmful organic waste; b) generation of a useful final product (vermicompost) of great value as an organic amendment of high quality soil, and which can function as a chemical fertilizer; c) production of a large earthworm biomass, high protein content and high quality for animal feed (poultry, pig and fish, mainly).

According to C. Henriquez and G. Cabalceta (1999) [11] organic fertilizers, they improve the chemical, physical and biological properties of the soil and contribute to the solution of the problem of environmental pollution.

2. Material and Methods

To evaluate the weight, growth, adaptability and production of humus, a breeding ground was built with cement bricks whose dimensions were 6.10 m long by 1.05 m wide and 0.50 m high (3.2 m^3 capacity); With a 5 cm thick cement screed that carries a 2” PVC drainage pipe covered with fine mesh to serve as a filter for leachate (liquid humus), this module has a west-east slope along the west side raised by 15° (Fig. 1). The evaluation time was 90 days (3 months), where data were taken every day at 2:00 pm, where the following were measured: the potential of hydrogen (pH) and humidity with a soil meter, substrate temperature with a digital thermometer, ambient temperature with a thermohygrometer. The amount of compost, organic matter and water fed to the brood was recorded that worked with 6.10 m long by 1.05 m wide and 0.47 m high producing a volume of 3.0 m^3 (3 tons) of humus.

The efficiency of the breeding stock was evaluated, which was 93.75%. From a previous research module by ruma, a population of 10,000 individuals (10 kilograms of worms) were separated from them, a sample of 361 individuals calculated with the STATS 2.0 Decision Analyst Software was taken for sampling, the Simple Random Sampling was applied (MAS) whose weight and average length was 0.3 g and 30 mm respectively.

The worms of the brood were fed with compost, organic matter and water (Fig. 2). To assess the weight, growth and adaptability of the worms, the area of the breeding foot was divided into 21 sampling points, a MAS was applied and a sample of 383 worms was taken from each sampling point (18 on average) that were weighed and measures to obtain the average weight and length that were 0.38 g and 33.24 mm (3.32 cm) respectively. These data allowed estimating the population of the breeding stock that was 146 053 worms which increased considerably.

Fig. 1 Breeding foot built to evaluate the weight, growth, adaptability and production of humus in the city of Tarma, province of Tarma, Junín region.

Fig. 2 Preparation of compost, main food of worms in the breeding foot, where we use a crusher designed and built by the research group.

The average weight of the worms varied from 0.30-0.38 g, the average length varied from 30-33.24 mm. The presence of tiny heels and worms demonstrates their adaptability. The production of humus was 3 tons, the efficiency of the breeding stock was 93.75%. Average results of 6.72 pH, 13.61°C substrate temperature, 69.86%, substrate humidity and 19.5°C ambient temperature were obtained. It was fed with an average of 3000 kg of compost, 1000 kg of traces of organic matter (fruits and vegetables), 1000 liters of water, the compost fed had an average of 5.7 pH, 59.1% humidity, 16.5°C substrate temperature and 24.1°C ambient temperature.

2.1 Equipment and Instruments Used

For the elaboration of the compost and feeding of the worms: The organic waste crusher, of 1.5 HP of power, shovel, beak, rake, fork, polyethylene hose was used.

To determine the weight of the worms, a 2-digit digital scale MIHEE brand model MH-999 was used, to determine the length of the worms a digital electronic ruler was used, for the pH and the moisture of the substrate the soil peach meter was used "Moisture" brand manufactured in Russia, for the substrate temperature the "BOECO" digital thermometer manufactured in Germany was used and to determine the ambient temperature the HTC-2 model digital thermohygrometer made in China was used, in addition large magnifying glass was used, wash bottle among others (Fig. 3).

The breeding ground was built, installed and evaluated in the researcher's home located at Jr. Antonio Khuinner No. 272, Tarma, Junín region, Peru; located at 3050 masl; with coordinates 18L 0424625 - UTM 8737361 with Latitude 11°25´ 16.21° S - Longitude 75°41´27.44° W (Fig. 4).

Fig. 3 Equipment and instruments used for research.

Fig. 4 Breeding foot built for research located in the Antonio Khuinner Passage No. 272 - Tarma, Junín region, Peru.

3. Results and Discussion

3.1 Results

Experimental data were recorded for 90 days (3 months) while the investigation lasted, during this time data were taken every day at 2:00 pm, where they were measured: the potential of hydrogen (pH) and moisture with a peachmeter Soil temperature, substrate temperature with a digital thermometer, ambient temperature with a thermohydrometer the following results were obtained:

• The average weight of the worms varied from 0.30-0.38 g and their average length varied from 30 - 33.24 mm. The presence of tiny heels and worms demonstrated the adaptability of earthworms to the climate of Tarma and its feeding with compost and organic matter remains. The production of humus was 3 tons, the efficiency of the breeding stock was 93.75%. Average results of 6.72 pH, 13.61°C substrate temperature, 69.86%, substrate humidity and 28.3°C ambient temperature were obtained (Table 1).

Table 1 Results of the variables pH, humidity, weight, length, substrate temperature evaluated in the investigation.

Sampling points	No. of samples caught	T ° of the substrate (°C)	pH	Humidity (%)	Weight (g)	Length (mm)
1	18	13.2	6.8	60	0.44	31.90
2	18	12.8	6.2	48	0.45	33.17
3	18	13.2	6.8	60	0.34	30.50
4	18	12.6	6.6	68	0.37	32.00
5	18	12.8	6.4	76	0.34	31.07
6	18	14.2	6.8	66	0.37	31.90
7	18	14	6.8	75	0.40	32.17
8	18	14.1	6.8	78	0.35	32.47
9	18	14.1	6.8	76	0.41	32.60
10	18	14.3	6.6	76	0.37	34.33
11	18	14.4	6.8	77	0.37	34.33
12	18	14.2	6.6	75	0.37	32.00
13	18	14	6.8	75	0.39	39.77
14	18	13.4	6.8	76	0.38	35.70
15	18	13.2	6.8	62	0.38	35.73
16	18	13.3	6.8	62	0.32	30.40
17	18	13.7	6.8	70	0.39	35.27
18	18	12.8	6.8	68	0.40	31.20
19	18	13.5	6.8	70	0.33	31.07
20	18	14	6.8	74	0.38	35.97
21	23	14	6.8	75	0.33	34.50
Average	383	13.61	6.72	69.86	0.38	33.24

• The amount of compost, organic matter and water fed to the brood was recorded, which worked 6.10 m long by 1.05 m wide and 0.47 m high, producing a volume of 3.0 m3 (3 tons) of humus. The efficiency of the breeding stock was evaluated, which was 93.75%.

• The estimated worm population increase was 136,053 worms (10,000 individuals to approximately 146,053 worms).

• It was fed with an average of 5000 kg of food: 3000 kg of compost, 1000 kg of traces of organic matter (fruits and vegetables), 1000 liters of water, the compost fed had an average of 5.7 pH, 59.1% of humidity, 16.5°C substrate temperature and 24.1°C ambient temperature.

3.2 Discussion

In his research [9] it carried out at the Mario Gonzales Aranda Farm (GMGA) of the National University of Colombia, Palmira Headquarters, Table 2 taken from Refs. [10, 11] cited by Ref. [9] where the following could be determined:

That there are adults with clitelo whose average weight is 0.25 g and whose length is greater than 3 cm. Similarly, adults over 3 cm are considered adults without a clit (Table 2).

Table 2 Collection of information on age discrimination of the California redworm Eisenia foetida.

Category	Weight (g)	Length (cm)	Observations
Adults with clitelo	0.25	greater than 3	Animals with clitelo
Adults without clitelo		greater than 3	Postclitelated animals (there is an ecological age called productive dessert) that cannot be differentiated at a glance from juveniles
Youth A		under 1.5	Freshly hatched animals, transparent or with insufficient red pigment density to prevent the digestive tract from being visible by transparency
Youth B		1.5 – 3	Animals whose intestine is not appreciated for transparency and lacking clitelo

The average weight of the worms obtained in Tarma was 0.38 g and the average length was 33.24 mm (3.24 cm) according to the comparison of the data in Table 2 this population would be considered as adult with clitelo and without clitelo. Population ready to reproduce and obtain better results in the vermicompost in the next worm planting (new breeding ground).

In Moreno et al. [12], cited by V. M. Villegas and J. R. Laines (2017) [13] in his research conducted in Mexico, he mentions in Table 3. Biological characteristics and environmental conditions of the main temperate earthworm species used in vermicomposting processes, applied to different types of worms among them the Eisenia foetida species with which one worked in the city of Tarma, it can be deduced and discussed with the results found in the present investigation.

Moreno et al. [12] argue the following:

• As for the adult size in (mm) is between 50 to 100 mm, the average size of the worms in Tarma was 33.24 mm, that is to say that this population on average is not yet adult, with 16.76 mm missing. to reach the size of adulthood which means that the next worm sowing will be more optimal with better results, since there will be adult worms.

• As for the average adult weight g is 0.55, in Tarma the average weight was 0.38 g, that is to say that this population is mostly young, with 0.17 g missing to reach the minimum adult weight.

• Regarding the variable optimum temperature and limits (°C) 25 (0-35), in Tarma the average of the ambient temperature was 28.3°C at 2:00 pm and the substrate temperature was 13.61°C. that are within the permissible.

• Regarding the optimum humidity and limits (%) 80-85 (70-90), in Tarma the average humidity was 69.86% rounding it would have 70% complying with the limits set out in Table 3.

4. Conclusion

• That the Californian red worm breeding foot designed and built with cement bricks whose dimensions were 6.10 m long by 1.05 m wide and 0.50 m high (3.2 m^3 capacity), with a floor of 5 cm thick cement that carries a 2” PVC drainage pipe covered with fine mesh to serve as a filter for leachate (liquid humus), with a west-east slope on the west side raised by 15°. It was optimal and deserves to be reproduced to continue with a greater production of earthworm humus (Fig. 4).

Table 3 Biological characteristics and environmental conditions of the main temperate earthworm species used in vermicomposting processes.

Characteristics	Eisenia foetida	Eisenia Andrei	Dentrobaena veneta	Dendrobilus rubidus	Lumbricus rubellus	Dravida nepalensis
Adult size (mm)	4-8*50-100	4-8*50-100	5-7 * 50-80	3-4 * 35- 60	4 * 70-100	2-3*40-50
Average weight adults (g)	0.55	0.55	0.92	0.25	0.8	0-82
Life cycle (days)	45-51	45-51	100-150	75	120 – 170	150
Maturation time (days)	28-30	21-26	65	54	74 – 91	34-42
Number of capsules/day	0.35-0.5	0.35-0.5	0.28	0.2	0.07-0.35	0.15
Hatching viability (%)	73-80	72	20	80	60 -80	75-88
Number of descendants/capsule	2.5-3.8	2.5-3.8	1.1	1.67	1	1.93
Optimum temperature and limits (°C)	25 (0-35)	25 (0-35)	25 (15-25)	25 (15-25)	0	25
Optimum humidity and limits (%)	80-85 (70-90)	80-85 (70-90)	75 (65-90)	75 (65-90)	0	75

Fig. 5 The worms in average weight, length and handling comply with the parameters established by other investigations. The efficiency in humus production was 93.7%.

• The evaluation time was 90 days (3 months), it served to take the data of hydrogen potential (pH), humidity, substrate temperature and environmental variables important variables in the vermicompost.

• A population of 10,000 individuals (10 kilograms of earthworm) was sown in the breeding ground. A sample of 370 individuals calculated with the STATS 2.0 Decision Analyst Software was taken for sampling. Simple Random Sampling (MAS) was applied. For the collection of data, 21 sampling points were located in the area of the breeding ground, at the end of 3 months for the final evaluation a sample of 383 worms was taken from each sampling point (18 on average) that were weighed and measures to get the average weight and length. These data allowed estimating the population of the breeding stock that was 146 053 worms which increased considerably.

• The average weight of the worms that varied from 0.30-0.38 g was determined, and the average length that varied from 30-33.24 mm. The presence of tiny heels and worms demonstrated the adaptability of earthworms to the climate of Tarma and its feeding with compost and organic matter remains.

• Humus production was 3 tons, the efficiency of the breeding stock was 93.75%. Average results of 6.72 pH, 13.61°C substrate temperature, 69.86%, substrate humidity and 28.3°C ambient temperature were obtained.

• It was fed with an average of 5000 kg of food: 3000 kg of compost, 1000 kg of traces of organic matter (fruits and vegetables), 1000 liters of water, the compost fed had an average of 5.7 pH, 59.1% of humidity, 16.5°C substrate temperature and 28.3°C ambient temperature.

• According to the research carried out in Colombia and it is Tarma, the average weight found in Tarma is 0.38 g with an average length of 33.24 mm (3.24 cm), according to the results of Colombia the population studied would be considered as adult with clitelo and without clitelo. Population ready to reproduce and obtain better results in the vermicompost in the next worm planting.

• According to the Research conducted in Mexico, you have:

- As for the adult size in (mm) is between 50 to 100 mm, the average size of the worms in Tarma was 33.24 mm, that is to say that this population on average is not yet adult, with 16.76 mm missing. to reach the size of adulthood which means that the next worm sowing will be more optimal with better results, since there will be adult worms.

- As for the average adult weight (g) is 0.55, in Tarma the average weight was 0.38 g, that is to say that this population is mostly young, with 0.17 g missing to reach the minimum adult weight (Fig. 6).

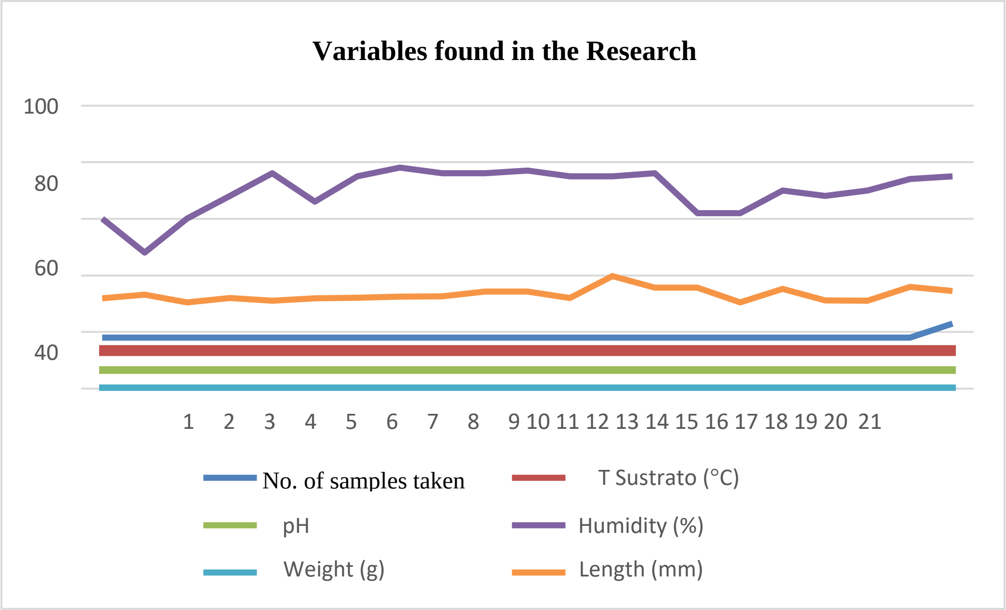

Fig. 6 Variables found in the research conducted in the city of Tarma that meet the parameters of the research conducted in Mexico.

- Regarding the variable optimum temperature and limits (°C) 25 (0 -35), in Tarma the average of the ambient temperature was 28.3°C at 2:00 pm and the substrate temperature was 13.61°C that are within the permissible.

- Regarding the optimum humidity and limits (%) 80-85 (70-90), in Tarma the average humidity was 69.86%, rounding it would be 70% and it would be complying with what is stated in Table 3.

• The results obtained in the research carried out in the city of Tarma are within the parameters established in other investigations carried out in Latin America (Colombia and Mexico), being that of Mexico the one that most validates the research carried out in Tarma (Fig. 5).

• Vermicompost is an alternative in the treatment of organic solid waste in high Andean areas since it allows to give an economic value to solid waste and as a process it is considered as a clean ecotechnology, without environmental impact. As an organic fertilizer, it improves the chemical, physical and biological properties of the soil and contributes to the solution of the problem of environmental pollution.

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