

Multiplication of Red Worms (*Eiseniafetida*) Using Different Feeding Materials and Its Effect on Yield and Quality of Vermicompost

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Abstract: The earthworms (*Eiseniafetida*) were collected from Adami Tulu Agricultural Research Center and introduced in cattle manure, paunch manure and cattle manure supplemented with wheat straw, paunch manure supplemented with wheat straw and cattle manure plus paunch manure supplemented with wheat straw. 300 numbers of red worms (*Eisenia fetida*) were introduced in to each treatment. At the end of vermicomposting, the earthworm population and vermicompost amounts were examined to assess the effect of feeding materials on multiplication of worms (*Eisenia fetida*), vermicompost yield and vermicompost qualities. The highest number of worms (688.3) was achieved in the paunch manure and lowest (333.7) in the cattle manure vermicompost as sole source of feeding material as compared to all treatments. But the amount of vermicompost was found to be highest (9.6 kg) in mixture of paunch manure and wheat straw vermicompost. The vermicompost samples were analyzed for the parameters: pH, EC, total nitrogen, organic carbon, available phosphorus. *The laboratory analysis results showed highest total nitrogen (3.03%), organic carbon (31.04%), and available phosphorus (1523 mg/kg) were recorded in case of vermicompost prepared paunch manure alone.* The C:N ratio of all vermicompost samples was in the optimum range (< 20%) and the EC of vermicompost prepared from *paunch manure* was in the optimum range and the rest were above the optimum range of EC values for plants growth. However, the bedding materials give different results and have their own characteristic on selected physico-chemical parameters, all the vermicompost samples contain sufficient amount of plant nutrients and optimum pH for the better seed germination, plant growth and best fertility and quality of soil. Therefore, all the vermicompost samples could be used as organic fertilizer in agriculture. But based on its highest number of red worms (*Eiseniafetida*), highest yield of vermicompost and highest *total nitrogen* contents, *organic carbon* and available phosphorus, vermicompost prepared from *paunch manure* as sole source of feeding material was considered as quality vermicompost.

Keywords: Vermicompost, Paunch Manure, Cattle Manure, Wheat Straw, Earthworm, Mineralization

1. Introduction

Earthworms vermi-compost is proving to be highly nutritive 'organic fertilizer' and more powerful 'growth promoter' over the conventional composts and a 'protective' farm input against the 'destructive' chemical fertilizers which has destroyed the soil properties and decreased its natural fertility over the years [2]. Vermi-compost is described as a perfect soil amendment and more eco-friendly as compared to chemical fertilizers. Similarly, vermicompost promotes

plant growth from 50-100% over conventional compost and 30-40% over chemical fertilizers [5]. In addition to providing soil organic carbon and plant nutrient, vermicompost also provides enzymes and hormones which stimulate plant growth [1].

The cost of production of vermicompost is simply insignificant as compared to chemical fertilizers and its production is also an 'economically productive' process as it 'reduces wastes' at source and consequently saves landfill space. Vermicompost use is an 'environmentally friendly,

protective and restorative' process as it diverts wastes from ending up in landfills and also reduces emission of greenhouse gases due to very small amount of energy used in its production process [4]. Vermicompost contains major and minor nutrients in plant-available forms, enzymes, vitamins and plant growth hormones. Also it has more beneficial impact on plants than normal compost [5]. Vermicompost can be processed from most organic wastes such as animal manures, agricultural waste, plant residues, etc, through interactions between earthworms and microorganisms, in a mesophilic process (up to 35°C).

The earthworm, *Eisenia fetida* characterized by rapid growth rate, early sexual maturity, high feeding capacity and extensive reproductive capabilities has been extensively used for vermicomposting of different plant residues, animal manures, and city refuse and sewage sludge.

Use of vermicompost over the years helps in building up the soil's physical, chemical and biological properties restoring its natural fertility. In the age of rapidly increasing waste, vermicomposting offers sustainable, ecofriendly and affordable technique for waste management [6].

Slaughterhouses and livestock industry generates huge amounts of manures as waste which contain significant plant nutrients and organic matters. The waste is often left unattended at the disposal sites and creating a health hazard and environmental pollution. Paunch manures or rumen contents are major source of waste and generated by the slaughterhouses and livestock industries to the streams and rivers [7]. In Ethiopia from the increasing human population, uncontrolled urbanization and waste disposal cause serious quality degradation of surface waters. Now a day's water pollution from disposal of industrial wastewater is becoming an environmental concern in Addis Ababa city and its vicinity areas. Paunch manure is the partially digested feed material of rumen contents of cattle at slaughter house and it has similar characteristics to livestock manure and an ideal material for composting through vermi-worm. Composting paunch manure has a benefits of agricultural sustainability and safe way of disposing or use to create healthy environment [8]. Hence, this research was aimed to investigate the effect of paunch manure, paunch manure mixed with wheat straw, cattle manure, cattle manure mixed with wheat straw, and paunch manure mixed with cattle manure and wheat straw on yield, quality of vermi-compost, multiplication red worm of (*Eisenia fetida*). Therefore, based on the facts mentioned above, the present study has been initiated with the following objectives:

Objectives:

To evaluate the effect of feeding materials on multiplication of red worms (*Eisenia fetida*), yield and yield quality of vermicompost.

To provide an environmentally friendly alternative raw material for earthworm multiplication and quality vermicompost production and

To improve waste management of slaughter houses.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at Tade FTC, Lume District, East Shewa Zone of Oromia Regional State, which capital town located at 73 kilometers far from Finfine (Addis Ababa) to the East. Geographically Lume district located between 8°24'300" to 8°49'30" North and 39°01'00" to 39°17'00" East with total area coverage 67514.73 hectares. The Elevation ranges from 1590 to 2512 meters above sea level, whereas the average elevation is 1909 meters above sea level.

2.2. Experimental Design

Treatments: cattle manure alone, cattle manure with wheat straw, paunch manure alone, paunch manure with wheat straw, and paunch manure with cattle manure plus wheat straw. Each with three replications, were used and laid down in a completely randomized design.

2.3. Vermiculture Construction and Vermicompost Preparation

The vermiculture was constructed for vermicompost production and multiplication of worms. Also, shallow boxes where constructed from wood. In the vermiculture, beds were constructed and all the boxes were set on the beds.

For vermicompost preparation; the raw materials were mixed and water was sprayed to the mixture to moist enough and makeready for worms. The mixtures were left with moisture for monthpartial degestion to make it palatable for the worms. After one month eleven kg of pre decomposed bedding materials was taken into the box and three hundreds number of worms (*Eisenia fetida*) were introduced to it [11].

2.4. Data Collection

At the end of the experiment, watering the vermicompost was stoped and the worms were made to move down to the heap of the compost. Then the vermicompost was easily removed from the upper and lastly the worms were counted and the weight of harvested vermicompost was determined. Then vermicompost samples of each treatment was brought to the laboratory and tested for selected parameters (moisture, pH, EC, OC, TN, Av. P, Av. K and C: N).

2.5. Data Analysis

The moisture content the vermicompost samples were measured gravimetrically. The pH and EC (H₂O; 1:5) of vermicompost samples were measured by a digital pH meter and conductivity meter, respectively. Total N, available P and K contents of the samples were analyzed by Kjeldahl, Olsen and Flame photometer method respectively. The C: N ratio was calculated from the measured values of C (%) and N (%). The laboratory analysis result of vermicompost was properly managed using the Excel computer software. Then, the data was subjected to analysis of variance (ANOVA) as per the

experimental design using GenStat, 2012 (15th edition) software. The Least Significance Difference (LSD) at 5% level of probability was used to determine differences between treatment means.

3. Results and Discussions

Number of earthworms and vermicompost yield.

Table 1. Average number of earthworms, and vermicompost yield in different feeding materials.

Treatments	Total earth worm number at the end of composting	Vermicompost Yield (kg)
PM	688.3	7.167
CM	536.7	7.000
PM-WS	554.7	9.600
CM-WS	333.7	7.067
PM-CM-WS	467.3	8.267
LSD (0.05)	232.6	4.604
CV (%)	23.9	31.3

The result showed that there was no significant difference

Table 2. Mean data of moisture, pH, EC, OC, TN, available P and available K of vermicompost for each treatment.

Treatments	Parameters					
	pH	EC (mS/cm)	OC (%)	TN%	C:N	Av. P (P ₂ O ₅ mg/kg of vermicompost)
PM	7.78 ^a	2.17 ^a	31.04 ^a	3.03 ^a	10.31 ^d	1523 ^a
CM	7.61 ^a	3.76 ^a	28.95 ^b	2.01 ^b	14.38 ^c	1329 ^c
PM-WS	7.78 ^a	3.97 ^a	25.68 ^c	1.58 ^c	16.26 ^b	1226 ^d
CM-WS	7.88 ^a	4.73 ^a	27.09 ^c	1.55 ^c	17.51 ^a	1023 ^c
PM-CM-WS	7.63 ^a	5.16 ^a	29.78 ^{ab}	2.08 ^b	14.34 ^c	1408 ^b
LSD (0.05)	0.68	2.26	1.75	0.26	1.19	9.92
CV (%)	4.6	23.0	3.3	6.6	4.3	2.4

pH of the vermicompost

The pH is a numeric scale which is used to identify the acidity or basicity of a particular medium. pH value is also one of the most important factors affecting the survival of worms. Different pH value largely affected the activity of worms. There is a certain range of pH value for earthworms to survive. The substrate is unsuitable and harmful for worms if it is too acidic or too alkaline. The best pH condition for the growth of the worm is pH that near to neutral.

Vermicomposts tend to have pH values near neutrality, which may be due to the production of CO₂ and the organic acids produced during microbial metabolism [10]. The optimum pH value was in the range of 6.5~8.5. A pH greater than 8.5 was found to harm earthworms and the earthworm numbers decreased greatly (died) [11] and [12]. Results of this study revealed that there was no significant difference in pH value between the treatments and ranges from 7.61-7.88 (table 2) which was in the range of optimum pH values for growth of the worms.

Electric conductivity (EC)

Electric conductivity is the measurement of total amount of soluble salts present in the sample. The EC reflects the salinity of any material and is a good indicator of the applicability of vermicompost for crop production as different plants show different responses to EC values. The soluble salt content can be estimated from the electrical

(P<0.05) among the different treatments that influences these parameters (Table 1). However the difference was insignificant between the treatments, the number of *Eisenia Fetida* (688.3) and vermicompost yield (9.60 kg) were found to be highest in the vermicompost prepared from PM and PM-WS respectively as feeding material. Also next to PM, higher numbers (554.7) of *Eisenia Fetida* and vermicompost yield (8.267 kg) were recorded PM-WS and PM-CM-WS respectively. The lowest number of worm population (333.7) and vermicompost yield (7.00 kg) were recorded in a vermicompost prepared from CM-WS and CM vermicompost. The maximum vermicompost yield (9.60 kg) recorded in PM bedding material might be due to the material contain easily metabolizable organic matter and low concentration of growth retarding substances that favored the worm's growth in the substrate leading to more yield of compost. The low vermicompost yield (7.00 kg) obtained in CM vermicompost is might be due to high moisture content in Cattle manure [9].

Quality of Vermicompost

conductivity of the vermicompost suspension in distilled water. In this study, the results showed that there was no significant difference in EC value between the treatments and ranges from 2.17 - 5.16 (mS/cm) (table 2). In this study, it was recorded maximum (5.16 mS/cm) in the PM-CM-WS vermicompost followed by 4.73 mS/cm in CM-WS vermicompost and was found least (2.17) in the PM vermicompost sample. Also, similar result was reported by [9] which were ranges from 2.96-4.46 mS/cm.

According to [10], soluble salt concentrations (measured by electrical conductivity) in saturated extracts of high quality plant growth media should not exceed 1-3 mS/cm. According to the result of this study EC of PM vermicompost sample was in the optimum range and the rest were above the optimum range of EC values for plants growth. However the difference was not significant between the treatments, this higher EC might have been due to release of different mineral ions, such as phosphate, ammonium, potassium etc. in greater amount from the initial feeding material during the vermicomposting process [12].

Organic Carbon (OC)

Organic carbon is an important ingredient in all soils and has an important role to play in maintaining soil structure, nutrient availability and water holding capacity. It also serves as a vital role in maintaining healthy soil ecology (Kefyalew and Tilahun, 2018). Organic carbon decreases in the organic

wastes during vermicomposting. Earthworms break and homogenize the ingested material through muscular action of their foregut and, also add mucus and enzymes in ingested material, this increase the surface area for microbial action. According to [14] during the process of respiration in earthworms the process of combustion of carbon into CO₂ brings down the amount of carbon in the organic material. Also, earthworms and microorganisms uses large portion of carbon as sources of energy and nitrogen for growth during the process of decomposition of organic materials in which carbon gets released as CO₂.

In this study the organic carbon result of vermicompost samples ranges from 25.68 - 31.04% (table 2). The result revealed that there was significant difference between the treatments in OC. and it was recorded maximum (31.04%) in the PM vermicompost followed by 29.78% in PM-CM-WS vermicompost and was found least (25.6%) in the PM-WS vermicompost sample. This result was similar to the findings of [11] that reported the organic carbon in the vermicompost which range from 21.26-34.66%.

Total Nitrogen

In this study, the average total nitrogen content of vermicompost samples ranges from 1.55-3.03% and the maximum total nitrogen (3.03%) was recorded in case of PM vermicompost sample. The variation of total nitrogen content among the treatments may be attributed to the type of substrates and their content of nitrogen. Similar result was reported for total nitrogen by [1], which ranges from 0.86-3.87% and by [11] which ranges from 3.04 -4.26%.

However, the nitrogen content of vermicomposts varies from country to country and substrate to substrates; standard total nitrogen content of compost will normally range from 1.5-3.5% and a compost having fertilizing capabilities and for it to be used in agriculture the total nitrogen content must be over 1% (Kefyalew and Tilahun, 2018). Similarly it was reported by [10] the total nitrogen content of vermicomposts can range quite widely (from 0.1% to 2-4% or more). It was reported by [14] that increase in the nitrogen content by the earthworm might be due to the reduction in the microbial immobilization. Similarly it was reported that, the enhancement of nitrogen in vermicompost was probably due to mineralization of the organic matter containing proteins and conversion of ammonium-nitrogen into nitrate [6]. In this study, the total nitrogen content of all treatments was over 1% and below 4% (1.55-3.03%). Therefore, all the vermicompost samples can be used as organic fertilizer in agriculture.

Carbon to Nitrogen Ratio (C: N)

The C: N ratio is one of the most widely used indicators of vermicompost maturation, decreases sharply during vermicompost process. Higher nitrogen level and lower C: N ratio in vermicompost could be attributed to alteration of microbial nutrient spectrum in earthworm casts due to increased presence of nitrogen-fixing microbes which in turn enhance total nitrogen concentration in vermicompost [16]. There was a significant difference between the treatments and the average result ranges from 10.31-17.51% (table 2). In this study, the highest (17.51%) C: N ratio was recorded in

CM-WS vermicompost and the lowest (10.31%) in PM vermicompost sample.

According to [11], the C: N ratio < 20% indicated advance in organic matter stabilization and reflects a satisfactory degree of maturity of organic wastes. The C:N ratio of organic matter that has been sufficiently stabilized will typically have C:N ratios below 20-22. The C:N ratios much higher than this may indicate the presence of bioavailable carbon and therefore material that is not completely stabilized [10]. Lower organic carbon% in vermicompost can be explained as due to vermicomposting process lowering organic carbon from substrates through microbial respiration in the form of CO₂ evolution. Lower C: N ratio in vermicompost could be explained as due to mineralization and decomposition of organic matter, loss of carbon as carbon dioxide due to respiration, increased total N production through microbial activity and mucus and nitrogenous excreta during vermin-composting process. Higher C: N ratio in vermicompost could be attributed to the presence of high percentage of resistant constituents such as cellulose and lignin content. Therefore, the C: N ratio of all treatments was below 20 and application of the vermicompost samples to the soil could help plants to assimilate mineral nitrogen in the vermicompost.

Available Phosphorus

Vermicomposting can be an efficient technology for the transformation of unavailable forms of phosphorus to easily available forms for plants. Phosphorus plays a role in photosynthesis, respiration, energy storage and transfer within plants, cell division, cell enlargement and several other processes in plants [13]. However the content of available phosphorus in vermicompost is based on raw material used for composting and management of the process, the uptake of bacteria, fungi and other microorganisms by the earthworms, excretion and decomposition by the earthworms and microorganisms might be the reason of releasing and increasing the content of phosphorus in the vermicompost [14].

According to the laboratory analysis result of vermicompost samples (table 2); the available phosphorus content ranges from 1023-1523 mg/kg. There was a significant difference between the treatments in available phosphorus and the maximum phosphorus content (1523 mg/kg) was observed in case of PM vermicompost followed by 1408 mg/kg in PM-CM-WS vermicompost and was least (1023 mg/kg) found in CM-WS vermicompost sample. This result was similar to the finding of [16] that reported the available phosphorus in vermicompost ranges 1300-1600 mg/kg. Also, similar result was reported by [15] for vermicompost which ranges from 1056-1643 mg/kg.

4. Conclusion

The present study concludes that different type of bedding materials give different results on selected physico-chemical parameters. Each of bedding material has its own characteristic that differ from one another and can influence

the parameter that been studied. *Eisenia Fetida* showed a great potential of converting the animal waste and plant material mixture into a valuable product, vermicompost. Both PM and PM-WS are recommended as suitable feeding material for *Eisenia foetida* multiplication and vermicomposting respectively.

The C: N ratio of all vermicompost samples was in the optimum range (<20%) and soil could help plants to assimilate mineral nitrogen in the vermicompost. Also, it can be concluded that PM vermicompost is rich in organic carbon and contains more supply of organic nitrogen than CM vermicompost. PM Vermicompost is nutrient rich organic fertilizer and contains sufficient (recommended) amount of dissolved salts (minerals) and optimum pH for the better seed germination, plant growth and best fertility and quality of soil. On other hand PM-CM-WS vermicompost contains sufficient amount of available phosphorus relative to the rest vermicompost samples. This means that the efficiency of vermicomposting is affected by the bedding materials and worm food source. Therefore, using appropriate feeding material for earthworm culture could optimize vermicomposting efficiency.

According to a data we have collected from Luna slaughter house, 30 to 35 cattle were slaughtered per a day and averagely a fresh of single cattle's paunch manure weighs 40 kg. This means 1200-1400 kg (1.2 -1.4 tones) of paunch manure was discharged per a day. Which means 438 –1277 tones of paunch manure was discharged per a year as a waste. Since, the paunch manure is discharging from slaughterhouses continuously; farmers, graduates and any concerned bodies around the slaughterhouses can be organized and produce vermicompost for marketing purpose using this paunch manure waste as vermicomposting material. Hence, they enhance crop production and productivity, and support sustainable agriculture and waste management programs. Therefore, it can be concluded that, if this volume of waste properly managed; in addition to reducing the sanitation and health challenges round the facility, it can be used for vermicomposting and help a farmers around the slaughterhouses as a potential resource for vermicompost production.

5. Recommendations

Further studies are required to explore the potential of utilization of paunch manure bedding in mixture with different weeding and substrates. However, this finding can already be used as additional basis to establish the optimal conditions in terms of substrate to be used for multiplication of Red worms (*Eisenia fetida*) and vermicomposting in support to sustainable agriculture and waste management programs, further studies are recommended to explore the utilization of paunch manure for biogas production. Also future research is needed for further studies on application rate of paunch manure vermicompost and its effect on crop production and productivity, and soil physico-chemical properties under field conditions.

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