Int.J.Curr.Res.Aca.Rev.2021; 9(12): 20-25

International Journal of Current Research and Academic Review

ISSN: 2347-3215 (Online) Volume 9 Number 12 (December-2021)

Journal homepage: http://www.ijcrar.com

doi: https://doi.org/10.20546/ijcrar.2021.912.003

Evaluation of Earthworm Multiplication Bedding Materials for Effective Vermicompost Production at Jimma, Southwestern Ethiopia

Habetamu Getinet[1*], Gebreslassie Hailu[2] and Hirut Birhanu[2]

[1]*Ethiopian Institute of Agricultural Research, Debre Markos Agricultural Research Center, Debre Markos, Ethiopia*
[2]*Ethiopian Institute of Agricultural Research, Jimma Agricultural Research Center, P.O. Box 92, Jimma, Ethiopia*

**Corresponding author*

Abstract

Rapid growth of urbanization and industrialization has led to generation of large quantities of wastes materials where majority of organic waste is dumped in landfill sites, creates the organic load on the ground water, and more emissions of landfill gases. The best possible alternative to reduce these potential pollutants is through vermicomposting because earthworms have the ability to convert organic waste into wealth (compost). This experiment was done to evaluate the effect of bedding materials for vermicompost production and performance of earthworm at Jimma, Southwestern Ethiopia. The experiment consisted of three types of bedding materials including (cattle manure, donkey manure and poultry droppings) and four incubation periods (40, 60, 80 and 90 days) arranged factorially in completely randomized block design (RCBD) with three replications. The performance was measured based on more suitable for vermicomposting including biological parameter, which measured the growth rate, compost (pH), number of worm, organic matter (OM), total nitrogen (Tot. N) and carbon to nitrogen ratio. All of the four biological parameters showed that there is a significant different observed on type of bedding materials used using ANOVA test. The LSD at ($p < 0.05$) test demonstrated that donkey manure followed by poultry dropping is more influential in worm biomass production, growth rate, total nitrogen and organic carbon content. For pH analysis, it reveals that the optimum pH for worm growth rate is near to neutral condition. As conclusion, different types of bedding material will influence the worm growth.

Article Info

Accepted: 16 November 2021
Available Online: 20 December 2021

Keywords

Vermicomposting,
Bedding materials,
Biological parameters.

Introduction

Now a day's more attention has been given to manage different organic waste materials in to wealth products at low-input as well as eco-friendly basis. Vermicomposting is one of the mechanisms to reduce this organic waste and it has been practically used all over the world. It is the process of producing compostby utilizing earthworms to turn the organic waste materials into high-quality compost that consists mainly of worm cast in addition to decayed organic matter (Ismail 2005; Devi and Prakash, 2015). Earthworms help to convert organic wastes materials (agro-wastes, animal manure and domestic refuse) into highly nutrient rich fertilizer sources for plants (Gajalakshmi and Abassi, 2004) and it is an eco- biotechnological process that transforms energy rich and complex organic substances into a stabilized humus-like product. It (worm cast) is a finely divided peat-like product with excellent physical characteristics such as structure, porosity, aeration, drainage and moisture-holding capacity (Edwards *et al.*, 2011). It is an organic nutrient source rich in major macronutrients including (NPK), micronutrients and beneficial soil microbes (nitrogen fixing and phosphate solubilizing bacteria and actinomycetes), is a sustainable alternative to substitute chemical fertilizers, which is an excellent growth promoter and protector for crop plants (Sinha *et al.*, 2011). Vermicompost not only add nutritional value of soil also improves the physical, chemical and biological properties and contributes to organic enrichment (Chauhan and Singh, 2013).

Research on Vermicomposting will provide farmers with an environment-friendly fertilizer and assist in promoting the agriculture sector towards a greener for the future. The use of such technology will help in cost management in agriculture, which is increase in the recent years and has added to the burden of farmers in terms of chemical fertilizers and chemical pesticides. Use of vermicompost could be an effective solution to the problem where it could substitute the chemical inputs in crop productivity and reduce the economic cost and on the other hand may also lead to organic produce which fetches higher price in the market. The increase in living standards around the world has created a growing demand for such organic produce, or cultivation using only natural pesticides and fertilizers, which are perceived to be healthier for consumers and environment friendly (Kaplan, 2016).

Earthworms are surface dwellers and feed on organic matter on soil surface, they do not inhabit the soil rather they live in and consume surface litter. These worms are domesticated and, when fed plant and animal wastes, they produce vermicompost, a process that has many advantages over conventional composting. This technology serves both social and environmental goals of sustainable agriculture and is widely employed mainly, Canada, United States, France, India, Australia, New Zealand, Cuba and Italy (Martin *et al.*, 1988), but seldom in Africa.

The nutrient content and bioavailability of vermicompost is higher compared with conventional (traditional) thermophilic process based compost (Joshi *et al.*, 2015). Thus, application of vermicompost as fertilizer showed greater positive Influenced on crop yield, soil physicochemical and microbial biomass and activities (Hernandez *et al.*, 2010). Different studies showed the potential of vermicompost as growth media for vegetable and fruit crop seedlings (Bachman and Metzger, 2007 and Morales *et al.*, 2014) where the seedling growth including seedling height; stem girth and seedling survival after fled plantation showed significant improvement. In Ethiopia, vermicomposting was done using sorghum straw, teff straw, industrial waste, fruit waste and khat waste as bedding materials (Negash *et al.*, 2018) using different earth worm species (essp. *Esinia fetida*) revealed variation between earthworms for their reproduction. Currently, the demands to this technology in Jimma Zone have shown progressive increase. However, scientific references regarding vermicompost production media and awareness on farmers are still lacking. Worms need appropriate bedding material in addition to food. Therefore, this experiment was aimed to evaluate best earthworm bedding material and to determine best harvesting time combination for quality compost production.

Materials and Methods

Description of the study area

The experiment was conducted at Jimma Agricultural Research Center (JARC) Southwestern Ethiopia under greenhouse condition during 2017/2018 season. The center is located at about 358 km far from Addis Ababa city and 12 km from Jimma town to Southwest direction. Geographically it is located at 07° 40′.212″ N latitude, 036°47′.055″ E longitude and an altitude of 1763 masl. The average annual maximum and minimum air temperature were 27.2 ^{0}C and 11.8 ^{0}C, respectively and the area receives adequate amount of rainfall (1198mm) per annum.

Treatment set up and experimental procedure

The experiment consist three types of bedding materials (poultry dropping, cattle manure and donkey manure) with four harvesting time (45, 60, 80 and 90 days). It was laid out in a completely randomized block design (RCBD) in factorial arrangement with three replications. The experiment was done under shade in special constructed house for the process. Thus, the methods used for mass rearing and maintaining of earthworms were used for vermicompost preparation (cast harvest).

The materials were produced from three different inputs (cattle manure, poultry dropping and donkey manure) used as bedding material for vermicomposting and bulking in the composting process. The composting materials with the top layer (wetted shreds of card board) were mixed thoroughly by hand then earthworms *Eisenia fetida* were introduced uniformly to all beds. Moistened bedding was prepared prior to adding worms, as it may heat initially and harm the worms. This activity was started in special constructed bins with (1m long × 60 cm width × 45 cm depth) and the worms were predetermined by number. A well-adapted earthworm species (*Eisenia Fetida*) was put in all bins containing different bedding materials. Predetermined numbers of earthworms (350) were introduced into the bin. The required data, such as amount of cast produced, final number of earthworms in each unit, and compost nutrient analysis for N, OC, and pH was done. The collected agronomic data were subjected to analysis of variance using SAS (9.3 version) computer software.

Collection of bedding materials

The organic waste used to feed the earthworm was horses manure, poultry droppings and cow manure and was collected from nearby local farmers. The waste materials were partially dried in the shaded light first and washed with water before used.

The main reason is to avoid salt content of feeding media worms are very sensitive to salts and to leached out the urine because if the manure is from animals raised or fed off in concrete lots, it may contain excessive urine because the urine cannot drainoff into the ground. This manure was leached before use to remove the urine.

Excessive urine will build up dangerous gases in the bedding. Then accordingly, the worm product was harvested, partially dried and finally, screened the fully ingested compost from undigested materials.

Earthworm observation

The total biomass of the worms was determined by measuring the wet weight in each box at the beginning and end of the experiments and each week prior to feeding. To accomplish this, worms were removed from the bedding by hand, gently removed all of extraneous material. All of the worms within each box were weighed as a unit. The formula below was used (Suthar, 2006) to determine worm growth response to the different bedding material: Growth rate was determined with the formula:

$$R = \frac{N2 - N1}{T}$$

Where, R= Growth rate, N_1= Initial earthworm biomass (mg), N_2= Final earthworm biomass achieved (mg) and T= Time of the experiment day.

Parameters measured

Vermicompost pH

The sample was mixed with distilled water at a weight ratio of 1:2.5 (10g compost and 25ml distilled water). The beaker was covered and left for 2 hours and shake occasionally. The pH was measured with a pH meter (Sundberg *et al.*, 2004) and the sample solution was stir regularly. Temperature was measured daily to ensure the heat generated from decomposition process was not highly increasing.

Statistical analysis

The collected data were summarized and statistically analyzed using the analysis of variance (ANOVA) procedure for RCBD using SAS 9.3 version software (SAS, 2012). Treatment means that differed significantly was separated using LSD procedure at 5% level of significance.

Results and Discussion

Quality of Vermicompost

pH

From the results obtained as such significant variation was not observed regarding on vermi cast pH value due to different feeding material. In all bedding materials used, pH was ranged from slightly acidic to neutrality value (pH=7), the highest pH value (pH=8) was recorded from plots where cattle manure was used as bedding material incubated for 80 days as indicated (Table 1). The pH value of vermicompost around neutral might have been attributed due to the secretion of NH_4^+ ions during the vermicomposting process that reduce the pool of H^+ions and the catalytic fixation of CO_2 as $CaCO_3$ by carbonic anhydrase in the earthworms' gut (Pattnaik, 2010). Highly acidic media is harmful for growth and development of most of the plants (Islam *et al.*, 1980). These near-neutral and slightly alkaline pH values of these vermicompost show great potential to use as soil amendment for crop production (Ibrahim *et al.*, 2013).

Nitrogen content

Similar to pH of vermicast, a significant difference was not obtained in all these vermicompost bedding materials for nitrogen (N) content as shown (Table 1). Activities of endosymbiotic microbes and gut enzymes of earthworm aid in transformation of ingested organic matters into vermicompost constituting major macronutrients such as (N, P and K) in plant available forms (Kavshik and Garg, 2003 and Zhang *et al.*, 2000). The value of total N content ranged from 0.9-1.4% where the highest value (1.4 and 1.39 %) was recorded from feeding of poultry droppings incubated for 80 days and donkey manure incubated for 90 days among other. This might be due to high nitrification rate in which ammonium ions are converted into nitrates (Dominguez, 2004). The current result of total nitrogen content is in the range of normal vermicompost N value, which can range quite widely from 0.1% to 4% as reported by Ibrahim *et al.*, (2013). Earthworm processed waste material contains higher concentration of exchangeable K due to enhanced microbial activity during the vermicomposting process, which consequently enhances the rate of mineralization (Zhang *et al.*, 2000).

Carbon: Nitrogen (C:N) ratio

Carbon: Nitrogen (C:N) ratio is a factor related to the decomposition of the waste material and, even it is recognized as a factor related inversely with the growth of earthworms and reproduction activities. The current result showed, earthworm product show expected relations with beddings initial C: N ratio. Accordingly the highest C: N value (26.40) was obtained from donkey manure as bedding material with gestation period of 45 days. Although the worms do consume their bedding as it breaks down, it is very important that this be a slow process. High protein/nitrogen levels can result in rapid degradation and its associated heating, creating inhospitable, often fatal, conditions. Heating can occur safely in the food layers of the vermiculture or vermicomposting system, but not in the bedding. Different values of growth and reproduction rate were observed in bedding with high and low earthworm performance. Typically, bedding materials should stable compost (not high in soluble salts), retain moisture, remain loose, and not contain much protein or organic nitrogen compounds that readily degrade. These compounds would be quickly degraded with the release of ammonia, and this might temporarily increase the pH of bedding material, which is not good for the worms.

In general, the chemical nature of the organic waste influences the palatability by earthworms directly or indirectly, which consequently affect earthworms' efficiency in decomposition system. Absorbency (bedding material should have high in absorbency and retain water fairly), bulking potential (if the material is too dense to begin with, or packs too tightly, then the flow of air is reduced or eliminated) and porosity of the bedding materials are amongst all. Another characteristic for good bedding material is low protein and/or nitrogen content (high Carbon: Nitrogen ratio). Although the worms do consume their bedding as it breaks down, it is very important that this be a slow process. High protein/nitrogen levels can result in rapid degradation and its associated heating, creating inhospitable, often fatal, conditions. Therefore, it is hypothesized that earthworm growth patterns in this study were related to the chemical profile of the bedding. Moreover, beddings, in which earthworm showed better growth patterns, were probably with supplying of easily metabolizable organic matter, non-assimilated carbohydrates, and even low concentration of growth-retarding substances, which favors earthworm growth in waste system (Suthar, 2007).

From the results obtained, we concluded that type of bedding used gave different kind of result on selected biological parameters and compost production. Each of bedding material has its own characteristic that differ from one another and can influence the parameter that has been studied. The result showed that donkey manure bedding was better in term of growth rate and biomass production of worm compared to cattle manure and poultry droppings bedding materials that gave better result in number of worm and compost quality. Better results of biomass as well as growth rate potential of composting with earthworm can be observed using donkey manure beddings. From that we can specify the use of this bedding material to achieve the desire objective. pH also affecting the growth rate of worm during composting period. It was stated that pH near the neutral state are the best pH for vermicomposting. So, using appropriate bedding and/or feeding material for earthworm culture could optimize vermicomposting practices. There are vast opportunities to study the influence of bedding interrelating with environmental variables in the field of earthworm biotechnology. Although still a great work is required to establish the optimal conditions for culturing of tropical earthworms for sustainable vermiculture operations. Further studies are required to explore the potential of utilization of Cattle manure and poultry dropping bedding in mixture with horse manure.

Table.1 Effect of bedding materials and harvesting time on compost quality

Treatments	pH (1:2.5)	TN (%)	OC (%)	OM (%)	C:N
Poultry droppings inoculated 45 days	7.26	1.18	27.06	46.65	22.93
Poultry droppings inoculated 60 days	7.09	1.65	27.14	46.79	16.45
Poultry droppings inoculated 80 days	7.43	1.39	24.79	42.74	17.83
Poultry droppings inoculated 90 days	7.18	1.30	22.97	39.60	17.67
Cattle manure inoculated 45 days	7.14	1.55	21.57	37.19	13.92
Cattle manure inoculated 60 days	7.92	1.17	20.26	34.93	17.32
Cattle manure inoculated 80 days	8.00	1.26	21.49	37.05	17.05
Cattle manure inoculated 90 days	7.75	0.60	14.20	24.48	23.66
Donkey manure inoculated 45 days	6.65	0.70	18.48	31.86	26.40
Donkey manure inoculated 60 days	6.67	1.15	20.92	36.05	18.19
Donkey manure inoculated 80 days	6.35	0.90	18.35	31.65	20.39
Donkey manure inoculated 90 days	6.72	1.40	13.79	23.77	9.85

Where, TN = Total nitrogen, OC = Organic carbon, OM = Organic matter and C: N Carbon to nitrogen ratio.

Acknowledgement

Ethiopian Institute of Agricultural Research for sponsorship to conduct the experiment.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Bachman G R, Metzger J D. Growth of bedding plants in commercial potting substrate amended with vermicompost. *Bioresour Technol*. 2007, 99:3155–3161.

Chauhan H K, Singh K (2013) Effect of tertiary combinations of animal dung with agrowastes on the growth and development of earthworm *Eisenia fetida* during organic waste management. Int J Recy Org Agric 2:11. https://doi.org/10.1186/2251-7715-2-11

Devi J, Prakash M (2015) Microbial Population dynamics during vermicomposting of three diferent substrates amended with cowdung. Int.J.Curr.Microbiol.Appl.Sci. 4(2):1086–1092 https://www.ijcmas.com

Dominguez J, State-of-the-art and new perspectives on vermicomposting research, *Earthworm Ecology*, C. A. Edwards (Ed.), CRC Press LLC, 2004, 401–424. https://doi.org/10.1201/9781420039719.ch20

Edwards C A, Subler S, Arancon N (2011) Quality criteria for vermicomposts. In: Edwards CA, Gajalakshmi S, Abassi S A (2004) Earthworms and vermicomposting. Int J Biotechnol 3:486–94 http://hdl.handle.net/123456789/5894

Hernandez A, Castillo H, Ojeda D, Arras A, Lopez J, *et al.*, Effect of vermicompost and compost on lettuce production. *Chil J Agric Res*. 2010, 70: 583–589.

Ibrahim M H, Quaik S & Ismail S, Vermicompost, Its Applications and Derivatives, *Prospects of Organic Waste Management and Significance of Earthworms*, 2013, 199-130.

Islam A K M S, Edwards D G & Asher C J, pH optima for crop growth, *Plant and Soil*, 1980, 339-357.

Ismail S A (2005) The earthworm book. Other India Press, Mapusa, pp 101

Joshi R, Singh J, Vig A P. Vermicompost as an effective organic fertilizer and biocontrol agent: effect on growth, yield and quality of plants. *Rev Environ SciBiotechnol*. 2015, 14: 137–159

Kaplan M (2016) The National Master Plan for Agricultural Development in Suriname. Final Report. Kaplan Planners Ltd. Regional and Environmental Planning, pp 255. https://www.share4dev.info/kb/documents/5426.pdf

Kaushik P & Garg V K, Vermicomposting of mixed solid textile mill sludge and cow dung with the epidemic earthworm *Eisenia fetida*, *Bioresource Technology*, 90 (2003), 311–316.https://doi.org/10.1016/S0960-8524(03)00146-9

Morales-corts M R, Gomez-sánchez M A, Pérez-sanchez R. Evaluation of green/pruning wastes compost and vermicompost, slumgum compost and their mixes as growing media for horticultural production. *SciHortic (Amsterdam)* 2014, 172:155–160.

Negash D, Yohannes B, Waktoli S. Effect of Different Earthworm Feedstocks on vermicompost Quality and Local Earthworm Performance. In: Getachew, A., Gebreyes, G., Tolera A, Daniel M (Eds.), Soil Fertility and Plant Nutrient Management. Ethiopian Institute of Agricultural Research, Addi Ababa, Ethiopia, pp: 193–202. 2018.

Pattnaik S & Reddy M V, Nutrient Status of Vermicompost of Urban Green Waste Processed by Three Earthworm Species — *Eisenia fetida*, *Eudrilus eugeniae*, and *Perionyx excavates*, *Applied and Environmental Soil Science*, Hindawi Publishing Corporation,2010,1 13.https://doi.org/10.1155/2010/967526

Sinha K, Valani D, Soni B, Chandran V (2011) Earthworm vermicompost: a sustainable alternative to chemical fertilizers for organic farming. Agriculture issues and policies. Nova Science Publishers Inc, New York, p 71

Suthar S, Vermicomposting potential of *Perionyx sansibaricus* (Perrier) in different waste materials, *Bioresource Technology*, 98 (2007), 1231–1237.

Suthar, S. (2007). Vermicomposting potential of *Perionyx sansibaricus* (Perrier) in different waste materials. *Bioresource Technology*, 98, 1231–1237.

Zhang B G, Li GT, Shen T S, Wang J K & Sun Z, Changes in microbial biomass C, N, and Pandenzyme activities in soil incubated with the earthworms *Metaphire guillelmi* or *Eisenia fetida*, *Soil Biology and Biochemistry*, 32 (2000), 2055–2062. https://doi.org/10.1016/S0038-0717(00)00111-5

How to cite this article:

Habetamu Getinet, Gebreslassie Hailu and Hirut Birhanu. 2021. Evaluation of Earthworm Multiplication Bedding Materials for Effective Vermicompost Production at Jimma, Southwestern Ethiopia. *Int.J.Curr.Res.Aca.Rev*. 9(12), 20-25. doi: https://doi.org/10.20546/ijcrar.2021.912.003