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Effect of Different Bedding Materials and Waste Feeds on Vermicompost Production and Local Earthworm Performance in Wondo Genet Ethiopia

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ABSTRACT

The experiment was conducted during 2013 and 2014 cropping seasons to evaluate the effect of different bedding_ materials and waste feeds on vermicompost production and local earthworm performance at Wondo Genet, Ethiopia. This activity was conducted in special constructed bins or divided cement-constructed pool (up to 35 cm long × 60 cm width × 45 cm depth) for each earthworm type under shade condition. Treatment arrangements were three earthworm species by four feeding materials, with the total number of 12 bins. Cow dung + Soil + Stevia leaves and Stevia leaves + Maize stalk + Fresh food scraps + Khat /Chat/ wastes were used as source of bedding and feed materials for vermicompost production respectively. The earthworm population and size increased during incubation for 90 days. The Meskan local worms increased from 70 to 6233, Zway local worms to 6198 and Ambo exotic worms increased to 6041when grown individually using maize stalks, chat and stevia leaves, and fresh food scraps. Meskan local and Zway local worms performed better than exotic Ambo worms. Maize stalk, chat and stevia leaves, and fresh food scraps were best to least feed materials for earthworm multiplication. The stinger number of worms (2067) was obtained by feeding worms on maize stalk, whereas the lowest worm number (713) was obtained on fresh food scraps. The highest cast was also produced (13.3) from worms fed with maize stalk, while the lowest cast was produced (9.3) from worms fed with fresh food scraps. Therefore, maize stalk, chat wastes, stevia leaves and fresh food scraps were also best to least feeding ZXmaterials for cast production. The nutrient contents of vermicomposts prepared from different crop residues and waste materials were indicated that higher N content was found in Ambo + stevia leaves followed by Zeway + stevia leaves, while P, K and Na contents were higher in Meskan + fresh food scraps, followed by Zway + fresh food scraps. The highest CEC, Mg, Mn and Ca contents were recorded from chat leaf vermicompost, followed by maize stalk waste vermicompost.

Key words: Vermicomposting, Earthworm, Bedding materials, Waste feeds

Introduction

The use of organic matter such as animal manures, human waste, food wastes, yard wastes, sewage sludge and composts has long been recognized in agriculture as beneficial for plant growth and yield and the maintenance of soil fertility. The new approaches to the use of organic amendments in farming have proven to be effective means of improving soil structure, enhancing soil fertility and increasing crop yields. Organic agriculture has been recognized to aid in increasing crop production and ensuring quality harvest. It involves the use of farm wastes, urban wastes and industrial wastes as source of nutrients for crops being raised. Traditional composting of organic matter wastes has been known for many years but new methods of thermophilic composting have become much more popular in organic waste treatment recently since they eliminate some of the detrimental effects of organic wastes in the soil. Composting has been recognized as a low cost and environmentally sound process for treatment of many organic wastes. A process related to composting which can improve the beneficial utilization of organic wastes is vermicomposting. It is a non-thermophilic process by which organic materials are converted by earthworms and microorganisms into rich soil amendments with greatly increased microbial activity and nutrient availability. There are several reasons why farmers will choose to practice vermicomposting. Vermicomposts have excellent chemical and physical properties that compare favorably to traditional composts. Furthermore, the diversity among epigeic earthworms enables them to be utilized across a wide range of environments and in processing many different organic materials **[1,2]**.

Vermicomposting is a non-thermophilic process by which organic materials are converted by combined action of earthworms and micro-organisms into soil amendments with greatly increased microbial activity and nutrient availability **[1,3,4]** Remarkable focusses have been given on vermiculture studies (rearing of useful earthworms species) for achieving quicker and cheaper solutions for waste management **[5,6]**, land and soil remediation **[3,7]** and safe and sustainable food production **[3,8,9]** with reduced use of agro-chemicals. Charles Darwin called them 'friends of farmers and unheralded soldiers of mankind working day and night under the soil'. Under optimum temperature (20–30°C) and moisture (60–70%), about 5 kg of worms (approximately 10,000 worms) can process about 1 ton of waste into vermicompost in just 30 days **[10,11]**.

Earthworms are called humus formers and comprise the epigeic and anecic forms. These worms, feeding beneath the surface, ingest large quantities of organically rich soil. Epigeics are surface dwellers and feed on organic matter on soil surface. Epigeic earthworms 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 in India, Australia, New Zealand, Cuba and Italy, but seldom in Africa. Epigeic earthworms do not burrow into the soil and are therefore more easily contained within vermicomposting systems than other types of earthworms.Earthworms have been identified as one of the major tools to process the biodegradable organic materials **[12,13]**. The utilization of waste materials through earthworms has given the concept of vermicomposting. The vermitech approach utilizes waste management process by involving earthworms. Improvement of soil through vermiculture has now become a popular part of organic farming. Vermicmpost is accepted as humus biofertilizer, soil fertility booster, soil activator and soil conditioner with required plant nutrients, vitamins, enzymes, growth hormones and beneficial microbes like nitrogen fixing, phosphate solubilizing, denitrifying and decomposing bacteria **[14]**.

The nutrient content and bio-availability of vermicompost is reported to be well higher for vermicompost than for traditional thermophilic process based compost **[10,15]**. Accordingly, application of vermicompost as fertilizer showed greater positive influence on crop yield, soil physicochemical, and microbial biomass and activities **[3,5]**. The vermicompost is not only nutrient rich but also contains high quality humus, plant growth hormones, enzymes, and substances which are able to protect plants against pests and diseases **[1,11]**. Different studies have also showed the potential of vermicompost as growth media for vegetable and fruit crops seedlings **[16,17-19]** where the seedling growth including seedling height, stem girth and seedling survival after filed plantation showed significant improvement. In Ethiopia, vermicomposting of different feedstocks including sorghum straw, tef straw, industrial waste, fruit waste and khat waste [20] and *Prosopisjulifera* **[21]**. using different earth worm species (Esiniafetida and local collections) revealedvariation between earthworms for their reproduction and vermicast production. Currently, the demands to this very high technology in Sidama and Gedio Zone have shown progressive increase. However, scientific references, Vermiculture/Vermicompost Production Unit as well as awareness on farmers are lacking. Numerous organic materials have been evaluated for growth and reproduction of earthworms since these materials directly affect the efficacy of vermicompost **[22].** Worms need bedding in addition to food. Shredded paper or newspaper, coir (coconut husk fiber), and shredded cardboard are common bedding materials used for worm composting. Normally, the bedding will soak well with clean water and then squeeze it to remove excess liquid. Selection of bedding and feeding materials is a key to successful vermicomposting process. Therefore, the objectives of this study were to establish functional vermiculture /vermicompost production units; to valuate earthworm reproduction on different beds and waste feeds and to evaluate vermicompost produced as a fertilizer.

Hypothesis

Therefore, the hypothesis of the study was whether different beds and waste feeds have an effect on earthworm reproduction and vermicompost production.

Material and Methods

The experiment was conducted in 2013 and 2014 cropping seasons at Wondo Genet Agricultural Research Center.

It is geographically located at 07° 03' 19.1" to 07° 04' 00.2" North latitude and from 38° 30' 08.4" to 38° 31' 01.8" East longitude. It receives mean annual rainfall of 1128 mm and minimum and maximum temperature of 11 and 26°c, respectively. The technology was practiced under shade or 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 using the same inputs – cattle manure, with straw used as bedding for the vermicomposting and bulking in the composting process **(Table 1)**. The products were dried, screened, and applied as a treatment. Adding soil to the worms, they need the grit to aid their digestion and provide sufficient moisture. The bedding material should be moist but not soggy. Moistened bedding was prepared two days prior to adding worms, as it may heat initially and harm the worms.

This activity was started in special constructed bins or divided cement constructed pool (up to 35 cm long × 60 cm width × 45 cm depth) for each earthworm type, and the worms were predetermined by number. The earthworms included three species, i.e. *Eisenia fetida* (Ambo exotic) and two local earthworm collections (Meskan and Zeway local). There were three earthworm species to be fed with four feeding materials listed in Table1. Each earthworm species was tested on a uniform bedding material. Treatment arrangements were three earthworm species by four feeding materials, with the total number of 12 bins. The experiment was laid in randomized complete block design in factorial arrangement with three replications. Predetermined numbers (70) of each earthworm species were introduced into the bin management work. The required data, such as amount of cast produced, weight of bedding and feeding materials, number of earthworms in each alternative method, and the amount of water used were collected three times in three-month intervals. Cast nutrient analysis were performed for N, P, K, OC, CEC, S, pH and Mn in the cast harvested from each bin. The collected agronomic data were subjected to analysis of variance using SAS (version 9) computer software.

Result and Discussion

Comparative performance of three different species of earthworm in relation to different bedding materials and change in amount of cast produced

Growth performance of earthworms is affected with the earthworm species and Feedstock types provided to them. The earthworm population and size increased during incubation for 90 days (Table 2). The Meskan local worms increased from 70 to 6233, Zway local worms to 6198 and Ambo exotic worms increased to 6041 when grown individually using maize stalks, chat and stevia leaves, and fresh food scraps (Table 2). Meskan local and Zway local worms performed better than exotic Ambo worms (Table 2). Maize stalk, chat and stevia leaves, and fresh food scraps were best to least feed materials for earthworm multiplication **[23]**. The stigher number of worms (2067) was obtained by feeding worms on maize stalk, whereas the lowest worm number (713) was obtained on fresh food scraps. Likewise, maize straw was found to be the most suitable feed material compared to soybean (*Glycine max*) straw, wheat straw, chickpea (*Cicer arientinum*) straw and city refuse for the tropical epigeic earthworm, *Perionyx excavatus* **[24]**. The highest cast was also produced (13.3) from worms fed with maize stalk, while the lowest cast was produced (9.3) from worms fed with fresh food scraps (Table 2). Therefore, maize stalk, chat wastes, stevia and fresh food scraps were also best to least bedding materials for cast production **[20,25].**

Lower multiplication of earth worms, and lower cast production in the fresh food scraps might be due to the creation of unfavorable environment related to suffocation, which may cause death of worms. Excessive moisture combined with poor aeration conspire to cut off oxygen supplies, areas of the worm bed, or even the entire system, can become anaerobic, and may kill the worms very quickly **[15]**.

The Vermicompost Quality

The quality of vermicompost samples was determined for plant nutrients, hormones, microorganisms, enzymes and humus. [14] Reported that vermicompost contains more plant growth promoters, high vitamin B12, inorganic P and

Table 1 Source of bedding and feed materials for vermicompost production.

Locations	Beds made of	Treatments/feed materials on top
W/Genet	Cow dung + Soil + Stevia leaves	Stevia leaves Maize stalk Fresh food scraps Khat /Chat/ wastes

exchangeable K as well as trace elements. Vermicompost is rich in ammonium and nitrate. It does not contain any disease pathogens because pathogenic bacteria in the worms gut. The casts are also rich in humic acids, which condition the soil, have a perfect pH balance. The pH determines both quality and quantity determinants of nutrient contents in the vermicompost. The vermicompost quality can be variable due to process types and raw feeding materials used for composting **[26,27]**.

Nutrient contents of vermicomposts prepared from different crop residues and waste materials are indicated in **Table 3**. Higher nutrient concentration was obtained from vermicompost application of organic matter including vermicompost favorably affects soil pH, microbial population and soil enzyme activities **[28]**. The pH of all the vermicomposts prepared from the wastes ranged from slightly acidic to neutral, which is in conformity with **[29]**. Higher N content was found in Ambo + stevia leaves followed by Zeway + stevia leaves, while P, K and Na contents were higher in Meskan + FF, followed by Zway + FF. The highest CEC, Mg, Mn and Ca contents were recorded from chat leaf vermicompost, followed by maize stalk waste vermicompost **[12]** (Table 2). Similarly, **[30]** observed a pH value of 8.6 from sheep manure, while **[15]** documented pH of 7.73 for vermicompost made from cattle manure. In addition, **[31]** recorded a pH value of 5.3 for vermicompost made from pig manure. They justify those differences in the substrates used for compositing would result in the formation of vermicompost with different pH values.

Table 2. Comparative performance of three different species of earthworm in relation to different bedding materials and change in amount of cast produced

Treatment	TN %	Available p (ppm)	OC %	CEC	Na	K	Mg	Ca	Mn	pH
(Cmol/kg)										
Ambo + stevia leafs	2.06	12.083	3.33	35.2	1.38	15.44	11.25	16.38	47.22	6.85
Meskan + maize stalk	1.58	14.962	3.94	35.0	1.67	17.5	12.50	40.50	60.50	7.00
Ambo + maize stalk	1.76	23.447	4.65	38.3	1.75	17.65	11.62	36.71	58.54	7.21
Zway + chat wastes	1.74	20.038	4.12	39.1	1.53	16.11	11.34	50.39	69.20	6.86
Meskan + chat wastes	1.82	17.841	4.68	37.1	1.17	13.85	14.36	45.51	107.5	6.03
Zway + stevia leafs	1.88	22.310	4.75	34.8	1.30	17.99	11.85	39.56	89.28	7.17
Zway + maize stalk	1.51	20.038	3.46	31.4	1.64	15.58	12.39	40.61	49.60	7.28
Ambo + FF	1.60	19.583	2.16	31.4	2.58	17.17	10.56	17.35	31.20	7.36
Meskan + stevia leafs	1.67	21.670	4.68	37.1	1.44	16.76	12.71	48.58	81.72	7.00
Ambo + chat wastes	1.86	16.375	4.25	37.9	1.38	13.80	12.19	47.99	114.8	6.40
Zway + FF	1.87	27.593	3.19	28.9	2.33	18.34	14.21	38.73	35.84	7.28
Meskan + FF	1.85	31.565	3.27	28.3	3.19	18.38	12.28	43.73	41.92	7.42

Table 3 Comparative performance of three different species of earthworm in relation to the different bedding material and change in cast nutrient analysis.

Treatment	TN %	Available p (ppm)	OC %	CEC	Na	K	Mg	Ca	Mn	pH
(Cmol/kg)										
Ambo + stevia leafs	2.06	12.083	3.33	35.2	1.38	15.44	11.25	16.38	47.22	6.85
Meskan + maize stalk	1.58	14.962	3.94	35.0	1.67	17.5	12.50	40.50	60.50	7.00
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Zway + chat wastes	1.74	20.038	4.12	39.1	1.53	16.11	11.34	50.39	69.20	6.86
Meskan + chat wastes	1.82	17.841	4.68	37.1	1.17	13.85	14.36	45.51	107.5	6.03
Zway + stevia leafs	1.88	22.310	4.75	34.8	1.30	17.99	11.85	39.56	89.28	7.17
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Ambo + FF	1.60	19.583	2.16	31.4	2.58	17.17	10.56	17.35	31.20	7.36
Meskan + stevia leafs	1.67	21.670	4.68	37.1	1.44	16.76	12.71	48.58	81.72	7.00
Ambo + chat wastes	1.86	16.375	4.25	37.9	1.38	13.80	12.19	47.99	114.8	6.40
Zway + FF	1.87	27.593	3.19	28.9	2.33	18.34	14.21	38.73	35.84	7.28
Meskan + FF	1.85	31.565	3.27	28.3	3.19	18.38	12.28	43.73	41.92	7.42

The vermicompost quality can be variable due to process types and raw feeding materials used for composting **[32]**. Accordingly, application of vermicompost as fertilizer showed greater positive influence on crop yield, soil physicochemical, and microbial biomass and activities **[3,5]**.

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