RESEARCH ARTICLE

Worm collection and characterization of vermicompost produced using different worm species and waste feeds materials at Sinana on – station of Bale highland southeastern Ethiopia

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ABSTRACT

Soil fertility decline and high prices of inorganic fertilizers are among the major bottlenecks for sustainable crop production and agricultural productivity particularly for small holder farmers. Considering these issues this study was conducted at Sinana Agricultural Research Centre, on station to evaluate worm collected from different sites and characterizations of vermicomposting nutrient content made from different feed sources. Trials house or vermiculture was constructed on 15 m x 13 m land size having six worm bins in the house in which single worm bin 9 m^2 area. Inside worm bin were covered using plastic geo-membranes to make safe for earthworms while on the top and partially, the body of house covered by corrugated iron sheet in order protect from rain, flying predators and mesh wire for aeration purpose was used. The earthworm collection conducted contains two parts. The first part was locally collected from Sinana and Dinsho Districts from moist cool, around dead leaves (straw), moist bark dead trees leaves and farm yard manure stored for a long period of time at home garden. The second part was the red worm (*Eisenia fetida*) taken from Ambo Agricultural Research Center. Crop residue of field pea, faba bean, wheat and barley after chopped both using grinding machine and manually mixed with farm yard manure were used both for vermicompost and conventional compost. The major chemical properties such as pH, EC, OC, TN, available P, CEC, exchangeable bases (Ca, Mg, K and Na) and micronutrients (Fe, Mn, Cu and Zn) were conducted using standard laboratory procedures. Results for nutrient content characterizations indicated that 6.93-7.83; 0.003 ds/m to 0.007 ds/m ; 12.97% to 28.82%; 1.42% to 4.68%; 6.16% to 9.76%; 25.31 mg/kg to 89.89 mg/kg and 33.23 $cmol^+/kg$ to 65.43 $cmol^+/kg$ for pH; Ec; OC; TN; C:N; Av.P and CEC; respectively were obtained. Both exchangeable bases and micronutrients also follows similar trend for major essential plant nutrients in which relatively highest value obtained from vermicompost made using *Eisenia Fetida* while the lowest values obtained from conventional compost. It can be concluded that high vermicompost quality in terms of nutrient containing such as nitrogen, phosphorus, potassium, exchangeable bases and micro nutrients was produced from the mixture of field pea, faba bean, wheat and barley straw or residue using red earthworms (*Eisenia fetida*) than locally collected worm species and conventional compost. It should be recommended that multiplication, demonstration of Vermiculture and vermicompost produced using *Eisenia fetida* and integrated use with inorganic fertilizer is need in Sinana and similar agro - ecology.

Key Words: *Eisenia Fetida, Vermicompost, Conventional compost, Nutrient quality; Tanzania.*

INTRODUCTION

In different parts of the world currently, agriculture particles are characterized by excessive inputs of chemical fertilizers, pesticides, and herbicides, while the insufficient application of organic fertilizers. These excess uses of chemical fertilizers and pesticides have resulted in numerous negative effects on the environment, including water, degradation of soil quality, and losses of agricultural biodiversity. Vermicomposting is an eco-biotechnological process that transforms energy-rich and complex organic substances into stabilized humus products vermicomposting having an environmentally sound and economically viable technology, particularly for the farming community. Vermicomposting one enriched with critical nutrients such as Nitrogen, phosphorus, and potassium as well as high concentrations of highly decomposed organic matter that serve as a resource for improving soil fertility and crop productivity. Vermicomposting has many advantages over traditional compost in terms of its physical structure, nutritional content, and biochemical value due to the higher mineralization and humification rate through the vermicomposting process. Earthworms play important roles in soil formation and fertility, functioning as an element of a food web and also responsible for altering the dynamics of the ecosystem through maintenance and modification. The study of earthworms was started by Charles Darwin who made the first report on the role of earthworms in the breakdown of organic matter in the ecosystem . Preparations of vermicompost technology utilizing earthworms, most frequently from the genus *Eisenia fetida* plays an essential role in decomposing of organic matter and agro-wastes which supports improving soil fertility, efficient natural recycling, and enhanced plants' growth particularly economically, affordable for smallholder farmers .

The earthworms have different effects on the decomposition of organic matter, surface area, and quality. The maturity and quality of vermicompost are important to predict its potential impact on soil fertility which depends on knowledge of the microbial structure and functions. Vermicompost is one excellent product technology used as plant growth hormones, higher level of enzymes, greater microbial population and tends to hold more nutrients over a longer period without adversely impacting the environment . In different areas of the world commonly traditional management practice of post-harvest residues rather than incorporation into the soil or uses as sources of organic inputs subjected to elimination by open air burning leads to the release of greenhouse gases mixing cow dung crop residues helps to improve their acceptability by *Eisenia fetida* and improves physicochemical characteristics of produced vermicompost. This study in addition to worm collection and evaluates the adaptability of determining vermicompost quality produced from mixed farmyard manure with crop residues such as wheat, barley, faba bean, and field pea straw or residue curtail role. The decomposition rate of vermicompost decomposition rate than conventional compost due to the transformation of organic materials takes place through earthworm gut where the end materials contain high microbial activities, rich in nutrient contents, plant growth regulator In Bale Zone particularly on the highland crop residues such as wheat, barley, faba bean, field pea are the major easily accessible residues mostly the farmers were burning on the field. However, soil fertility declines as a result of nutrient leaching, and loss through soil erosion, due to limited inputs of both organic and inorganic fertilizer sources major problems for sustainable crop production and agricultural productivity. Therefore, mixed use of these locally available resources with farm yard manure has a curtail role to improve crop production and agricultural productivity in

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sustainable ways. Among these vermicompost is environmentally sound full and economically, affordable particularly for smallholder farmers. Based on this, the study was initiated with the specific objectives to collect the earthworm from different agroecology; evaluate the adaptation of earthworms collected from different agroecology, and characterize the nutrient contents vermicompost produced by earthworms using different mixed feed sources[1-10].

MATERIAL AND METHODS

The study was conducted in Sinana District which is one of the Bale highlands in Oromia Regional State, Southeastern Ethiopia. This District is bordered by Goro District in the east, Dinsho District in the west, Agarfa, and Gasser in the north and northeast, and Goba District. Sinan Agricultural Research Center has located about 493 km from the capital city of Addis Ababa. Geographically, Sinana Agricultural Research Center is located at 7°4' 10" to 7°9' 10" N and 40° 12' 40" to 40° 16' 40" E Figure 1.

Worm shade construction and establishment of vermiculture.

Trials house or vermiculture was constructed on 15 m x 13 m land size. In the house, three worm bins in two replications were constructed from concrete cement in rectangle form at 60 cm depth having an area of 3 m x 3 m (9 m^2) for each worm bin. A window or hole was developed at the common sides of each box to make a suitable horizontal vermicompost harvest method (Figure 2). Inside worm bins were covered using plastic geo-membranes to make it safe for earthworms. Partially, the house was covered by Corrugated iron sheets to protect against rain, flying predators those attacked worms, and mesh wire was used for aeration purposes Figure 2.

Feeds or substrates preparations and earthworm collection

This the major locally easy available crop residues wheat, barley, faba bean and field pea straw or residue, and farmyard manure were used in mixed ratio as feed sources for vermicompost produced. The substrates or crop residue were chopped using a grinding machine and manually then finally mixed with decomposed farmyard manure in a ratio of 2 (field pea):2 (fava bean):1 (wheat straw):1 (barley straw) and 2 (farm yard manure) in a total of 8 kg mixed for each worm and one control (without worm or conventional compost) were used. Using water cane water was added to maintain optimum moisture for worms as needed and facilitated decompositions as suitable for worms. Feed sources and water were measured and uniformly added to the worm bin box (5 kg) for each was used. The vermicompost produced was started by uniformly releasing 50 worms independently according to their collections into the feed sources Table 1 while the conventional compost contains only the mixtures of all feed sources without any worms and the other managements were uniform for all.

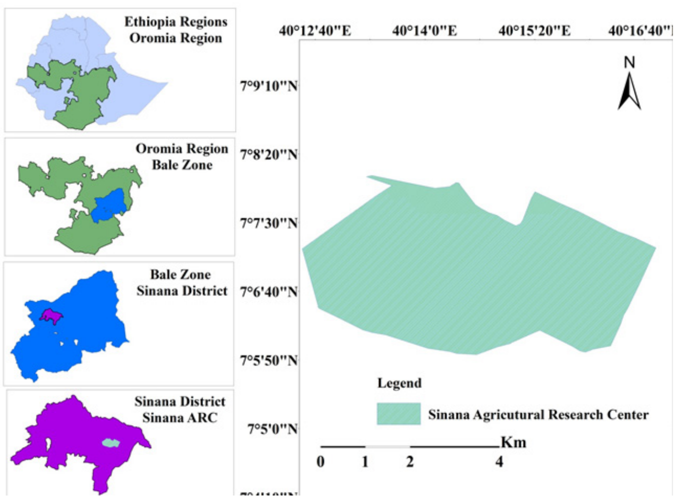

Figure 1) *Map of the study site*

Figure 2) *Trail house for vermicompost and vermiculture establishment at Sinana on- stations.*

The earthworm collection conducted contains two parts, one was locally collected from Sinana and Dinsho Districts. After a field survey on the availability and identification of suitable areas for earthworms, the local worm collection was done from moist cool, around dead leaves (straw), moist bark dead tree leaves, and farm yard manure stored for a long period at home garden. The second part was the red worm (*Eisenia fetida*) taken from Ambo Agricultural Research Center. After the 40th day, the numbers of earthworms were taken data obtained indicated a significant variation among worm types collected Table 1.

Vermicompost harvesting and laboratory analysis

At the end of experiment, a total number of parent earthworms and newly hatched earthworms were recorded. The Vermicompost in the containers were then harvested and sieved (2mm) to remove earthworms and undecomposed materials. The harvested homogeneous vermicompost was then stored separately and finally the vermin- compost quality was analyses at Sinana agricultural research center soil laboratory and at Haramaya university soil chemistry laboratory.

The pH and EC of both vermicompost and conventional compost was measured in the supernatant suspension of a 1:2.5 soil to water ratio using a pH meter and electrical conductivity; respectively (Rhoades, 1982). Walkley and Black (1934) were used for the determination of organic carbon. Total nitrogen was determined using the Kjeldahl method as described by Bremner and Mulvaney (1982). Available P was determined following the Olsen method (Olsen, 1954) using ascorbic acid as a reducing agent.

Total exchangeable bases (Ca^{2+}, Mg^{2+}, K^+, and Na^+) were conducted for Ca^{2+} and Mg^{2+} were determined by Atomic Absorption Spectrometry (AAS) while K^+ and Na^+ were determined by a flame photometer (Okalebo et al., 2002). Cation Exchange Capacity (CEC) was determined using (Chapman, 1965). Percent Base Saturation (PBS) was calculated as follows;

The available micronutrients (Fe, Mn, Cu, and Zn) were extracted by Diethylenetriaminepenta Acetic Acid (DTPA). Finally, their contents were quantified using AAS at their wave lengths as described by (Lindsay and Norvell, 1978).

Selected chemical properties vermicompost and conventional compost

The ph and electrical conductivity

As the laboratory analysis result revealed that pH value highest (7.83) while lowest (6.93) was recorded for vermicompost and conventional compost Table 2. According to Santamaria et al. (2001), the pH values of all type of vermicompost are found in suitable range for survival of earthworms since pH value>8.5 is harmful to microorganism. This finding agreement with finding of Jouquet et al. (2013) who stated that the values of pH was ranged from 6.8-8.41 for vermicompost. Additionally, Derib et al. (2017) reported that, the pH of vermicompost suitable as compared to conventional compost. Electrical Conductivity (Ec) values were not significant variation in which

TABLE 1

Treatments feed combination and data collected on earthworm adaptation

No. Bin	Worm Types	IW	WPB	AWL (cm)	FPS	FBS	FROM	WS	BS	TFPB
							Kg			
1	*Eisenia fetida*	50	616.00	3.00	2.00	2.00	2.00	1.00	1.00	8
2	*Eisenia fetida*	50	740.00	3.00	2.00	2.00	2.00	1.00	1.00	8
3	*Dinsho Worm*	50	269.00	2.30	2.00	2.00	2.00	1.00	1.00	8
4	*Dinsho Worm*	50	186.00	2.40	2.00	2.00	2.00	1.00	1.00	8
5	*Sinana Worm*	50	25.00	2.00	2.00	2.00	2.00	1.00	1.00	8
6	*Sinana Worm*	50	71.00	2.30	2.00	2.00	2.00	1.00	1.00	8

totally it ranges from 0.003 ds/m to 0.007 ds/m Table 2. According to Santamaria et al. (2001), EC values of both conventional and vermicompost were free from salinity. The current values of EC obtained both from vermicompost and conventional compost made from mixed materials are suitable for earthworm feeds sources, survival for earthworms and applicable for crop production. Similarly, Tadele et al. (2020) also obtained suitable range of vermicompost EC values for both earthworm and crop production.

Organic carbon and total nitrogen

The mean value organic carbon varied from 12.97% to 28.82% in which the highest mean value were obtained vermicompost prepared from *Eisenia fetida* while the lowest from conventional Compost Table 2. Different authors Eyasu et al. (2015); Hiranmai et al. (2016) and Derib et al. (2017) also found the higher percentage of organic carbon for vermicompost prepared using *Eisenia fetida* as compared to conventional compost. The values of total nitrogen in this study ranged from 1.42% to 4.68% in which the highest mean value were obtained vermicompost prepared from *Eisenia fetida* while the lowest from conventional Compost Table 2. This might be due to the high nitrification rate in which ammonium ions are converted into nitrates in case of vermicompost produced using *Eisenia fetida*. This result line with the finding of Ibrahim who stated that Total nitrogen content in vermicompost can range quite widely from 0.1% to 4% or more and 3.04% to 4.26%; respectively [11-19].

Carbon to nitrogen ratio and available phosphorous

Carbon to Nitrogen Ratio (C: N)

The calculated Carbon to Nitrogen ratio (C: N) varied from 6.16% to 9.76% Table 2. As the result indicates that the lowest (6.16%) was registered under vermicompost prepared using *Eisenia fetida* while the highest (9.76) was from worms collected Table 2. The C: N ratio values for worms collected locally and that of conventional compost almost no significant variation in which all values greater than the C: N ratio of vermicompost prepared using *Eisenia fetida*. This result was confirmed by different authors who stated that vermicompost had the lowest C: N ratio as compared to conventional compost.

Available phosphorous

The laboratory analysis for available phosphorus (Av. P) shows that the highest (89.89 mg/kg) and the lowest value (25.31 mg/kg) values were recorded under vermicompost prepared using *Eisenia fetida* and conventional compost; respectively Table 2. This might be due to hormone releases of *Eisenia fetida* that improve decomposition rate and full decomposition materials used that increase the content of phosphorus in the vermicompost. Similar, Zarei et al. (2011) and Jayanta et al. (2015) reported the highest available phosphorus contents in vermicompost. The results of the current study revealed a significant variation among locally collected worms, conventional compost, and vermicompost prepared using *Eisenia fetida*. Muzafer and Pinky (2017) also reported available phosphorus content in vermicompost which depend on the types of earthworms and feed materials used.

Cation exchangeable capacity and exchangeable bases

Cation exchangeable capacity

Cation Exchangeable Capacity (CEC) values of vermicompost prepared using different earthworm species and that of conventional compost using different mixed feed sources varied from 33.23 cmol^{+}/kg to 65.43 cmol^{+}/kg Table 3. As the results revealed that the highest (65.43 cmol^{+}/kg) and the lowest (33.23 cmol^{+}/kg) were obtained from vermicompost prepared using *Eisenia fetida* and conventional compost; respectively. This might be due to vermicompost made using *Eisenia fetida* high nutrient rich particularly due to high organic carbon content, better mineralization, and full decompositions of substrates. This result was a garment with the finding of Tadele et al.

TABLE 2

Nutrient contents of vermicompost and conventional compost for selected chemical parameters at Sinan

Treatments	Ph-H_2O	EC (ds/m)	OC	TN	C:N	Ava. P (mg/Kg)
			%			
Sinan Worms	7.3	0.005	18.83	1.93	9.76	43.29
Eisenia fetida	7.83	0.007	28.82	4.68	6.16	89.89
Dinsho Worms	7.35	0.005	20.19	2.14	9.43	56.27
Conventional Compost	6.93	0.003	12.97	1.42	9.13	25.31

TABLE 3

Cation exchangeable capacity and exchangeable bases status of vermicompost and conversational compost at Sinan

Treatments	CEC	Exchangeable base				PBS
		Ca	Mg	K	Na	
	cmol^{+}/kg					%
Sinan Worms	46.67	28.29	0.68	1.99	0.42	67.80
Eisenia fetida	65.43	34.77	1.40	2.25	0.55	59.16
Dinsho Worms	45.44	29.71	0.73	1.23	0.42	70.62
Conventional Compost	33.23	22.00	0.31	0.99	0.35	71.17

TABLE 4

Available micronutrients status of vermicompost and conversational compost at Sinan

Treatments	Micronutrients			
	Fe	Mn	Cu	Zn
	mg/kg			
Sinana Worms	0.72	1.48	1.65	2.25
Eisenia Fetida	0.72	1.48	1.89	3.18
Dinsho Worms	0.80	1.16	1.64	0.08
Conventional Compost	0.71	1.20	1.40	0.04

(2020) who reported that CEC in vermicompost ranges from 57 mg/kg-68.70 mg/kg for vermicompost made from different substrates.

Exchangeable bases (Ca, Mg, K and Na)

The analyzed result showed that the values for exchangeable bases (Ca, Mg, K and Na) were varied from 22 cmol^{+}/kg to 34.77 cmol^{+}/kg, 0.3 cmol^{+}/kg to 1.40 cmol^{+}/kg, 0.99 cmol^{+}/kg to 2.25 cmol^{+}/kg and 0.35 cmol+/kg to 0.55 cmol+/kg for Ca, Mg, K and Na; respectively Table 3. In all exchangeable bases (Ca, Mg, K and Na) values the highest were obtained from vermicompost made using *Eisenia fetida* while the lowest was obtained from conventional compost. In general, the vermicompost obtained using *Eisenia fetida* using mixed farm yard manure and other straw was rich in exchangeable cations than conventional compost. The resulting agreement with the findings of Amir and Fouzia (2011) reported that the exchangeable bases (Ca, Ma and K) were significantly increased in vermicompost as compared to pit compost. The calculated Percent Base Saturations (PBS) were valued at 59.16% to 71.17% the highest value was obtained from conventional compost while the lowest was from vermicompost made using *Eisenia fetida*. The lowest Percent Base Saturations (PBS) in vermicompost made using *Eisenia fetida* might be due to high CEC contents.

Micronutrients contents

The analyzed result for micronutrient contents ranges from 0.80 to 0.71, 1.20 to 1.48, 1.40 to 1.89, and 0.04 to 3.18 for Fe, Mn, Cu, and Zn; respectively Table 4. The highest Zn values were obtained from vermicompost made using *Eisenia fetida*. Similarly, Rajiv et al. (2010) found the highest Zn contents in vermicompost. As the results revealed that vermicompost has better micronutrient contents than conventional compost for the study conducted using different worms and different mixed feed sources.

CONCLUSION

The quantity and characteristics of most chemical properties such CEC, NT, Av. P, K, Zn, and the like depend on the types of the earth warms spices (locally collected or the worldwide adapted *Eisenia fetida*) and types of compost (vermicompost or conventional compost). High vermicompost quality in terms of nutrients containing such as nitrogen, phosphorus, potassium, exchangeable bases and micronutrients was produced from the mixture of field pea, faba bean, wheat and barley straw or residue using red earthworms (*Eisenia fetida*) than locally collected worm species and conventional compost. It should be recommended further multiplication of *Eisenia fetida* and demonstration of Vermiculture in Sinana and similar agroecology. A farther study should be recommended on vermicompost equivalence with inorganic fertilizers to use this technology in integrated ways for crop productions.

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