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 vermicompost 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 coverd 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 to7.83; 0.003 to 0.007 ds/m ; 12.97 to 28.82%; 1.42 to 4.68%; 6.16 to 9.76%; 25.31 to 89.89 mg/kg and 33.23 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 foetida) than locally collected worm species and conventional compost. It should be recommended that multiplication, demonstration of Vermiculture and vermicompost produced using Eisenia fetid and integrated use with inorganic fertilizer is need in Sinana and similar agro - ecology.*

Keywords— Eisenia Fetida, Vermicompost, Conventional compost, Nutrient quality.

I. INTRODUCTION

In different parts of the world currently agriculture parcties characterized by excessive inputs of chemical fertilizers, pesticides, and herbicides, while the insufficient application of organic fertilizers (Gill and Garg, 2014). 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 like product vermicompost having an environmentally sound and economically viable technology particularly for the farming community (ThiruneelaKandan and Subbulakshmi, 2015). Vermicompost one of the enriched with critical nutrients such as Nitrogen, phosphorus, and potassium as well as high concentrations of highly decomposed organic matter that serve as resource for improving soil fertility and crop productivity.

Vermicompost 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 vermicompost process (Lim *et al.*, 2014). Earthworms play important roles in soil formation and fertility, functioning as an element of a food web and also responsible for altering dynamics of the ecosystem through the 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 (Lowe *et al*., 2014). Preparations of vermicompost technology utilizing earthworms, most frequently from the genus *Eisenia fetida* is plays an essential role in decomposing of **organic matter** and agro-wastes which supports as improving soil fertility, efficient natural recycling and enhanced plants' growth particularly economically, affordable for small holder farmers (Tajbakhsh *et al.*,2011; Bhat *et al.*,2017 and Kovacik *et al*.,2018).

The earthworms have different effects on the decomposition of **organic matter**, surface area and its quality. The mature and quality of vermicompost is 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 tend to hold more nutrients over a longer period without adversely impacting the environment (Mustafa *et al.,* 2019 and Moustafa *et al*., 2020).

In different areas of the world commonly traditional management practice of post harvest residues rather than incorporation into the soil or uses as sources organic inputs subjected to elimination by open air burning leads to release of green house gases (ThiruneelaKandan and Subbulakshmi, 2015). According to Sartaj *et al* (2016) mixing cow dung crop residues helping to improve their acceptability by *Eisenia fetida* and improved **physicochemical** characteristics of produced vermicompost. In this study in addition to worm collection and evaluate the adaptability 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 transformation of organic materials takes place through earthworm gut where the end materials contain high microbial activities, rich in nutrient contents, plant growth regulator (Fabio, 2012) 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 burn on the field. However, soil fertility declines as results of nutrient leaching, loss through soil erosion, due to limited inputs of both organic and inorganic fertilizer sources major problems for sustainable crop productions and agricultural productivity.

Therefore, mixed use of these locally available resources with farm yard manure have curtail role to improve crop productions and agricultural productivity in sustainable ways. Among this vermicompost is environmentally sound full and economically, affordable particularly for small holder farmers. Based on this, the study was initiated with the specific objectives to collect the earthworm from different agro ecology; to evaluate the adaptation of earthworm collected from different agro ecology and to characterize the nutrient contents vermicompost produced by earthworms using different mixed feed sources.

II. MATERIAL AND METHODS

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

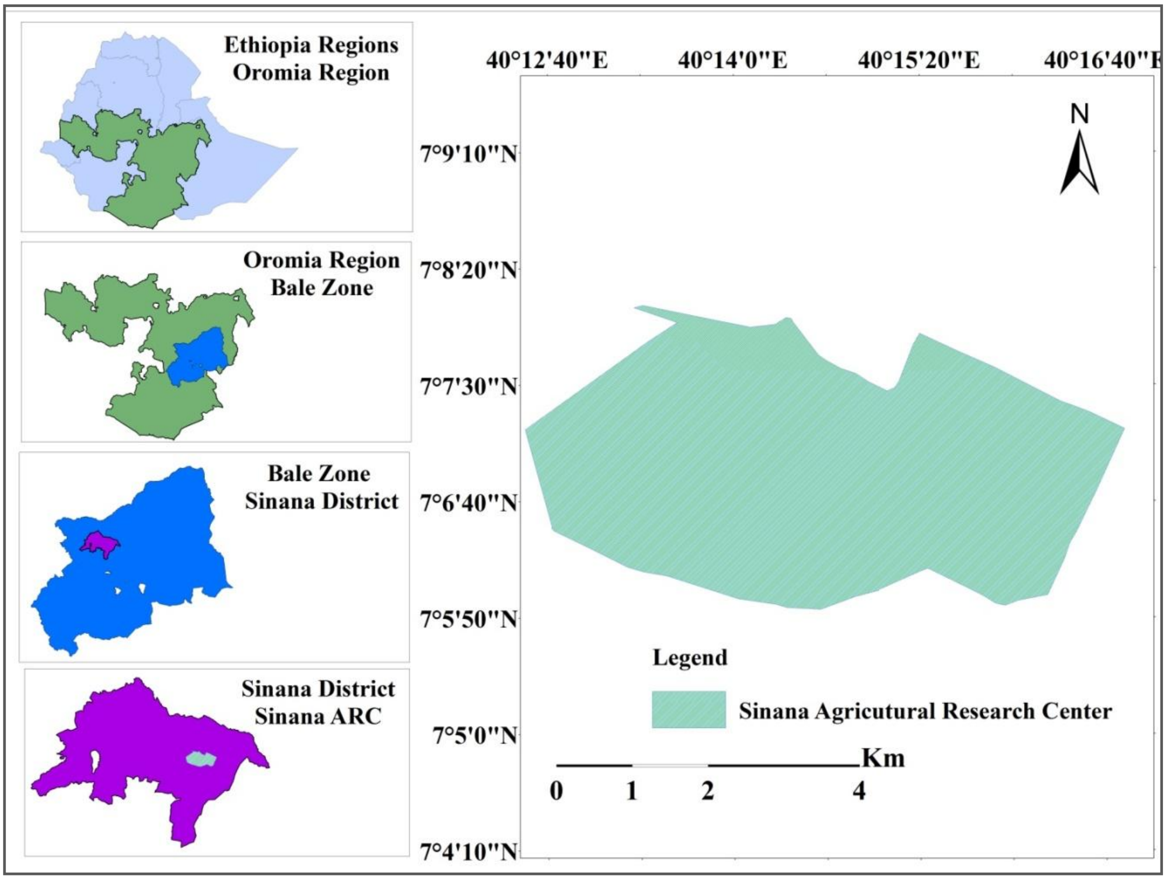

FIGURE 1: Map of the study site

2.1 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 worm bin in two replications were constructed from concrete cement in rectangle form at 60 cm depth having area 3 m x 3 m (9 $m^{2)}$ for each worm bin. Window or hole was developed at common sides for each box to make suitable horizontal vermicompost harvest method (figure 2). Inside worm bin were covered using plastic geo-membranes to make safe for earthworms. Partially, the house was covered by Corrugated iron sheet in order to protect rain, flying predators those attack worms and mesh wire was used for aeration purpose (figure 2).

Figure 2. Trail house for vermicompost and Vermiculture establishment at Sinana on- Stations

2.2 Feeds or substrates preparations and Earthworm Collection

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

The earthworm collection conducted contains two parts, one was the locally collected from Sinana and Dinsho Districts. After field survey on the availability and identification suitable area for earthworm the local worm collection were done 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. After 40th day the numbers of earthworms were taken data obtained indicated a significant variation among worm types collected (Table 1).

TABLE 1
TREATMENTS, FEED COMBINATION AND DATA COLLECTED ON EARTH WORM ADAPTATION

No. Bin	Worm Types	IW	WPB	AWL (cm)	FPS	FBS	FYM	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

Where: IW = initial worm; WPB = worm per bin; AWL= Average Worm Length; FBS = field pea straw; FBS = Faba bean straw; FYM = Farm Yard Manure; WS=Wheat Straw; BS = barely straw; TFPB = total feeds per bin

2.3 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 un decomposed materials. The harvested homogeneous vermin-compost 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) 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 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 flame photometer (Okalebo *et al.*, 2002*)*. Cation exchange capacity (CEC) was determined using (Chapman, 1965). Percent base saturation (PBS) was calculated as follows;

$$PBS\ (\%) = \left\{\frac{Ca^{+2} + Mg^{+2} + K^{+} + Na^{+}}{CEC} \times 100\right\}$$

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).

III. RESULT AND DISCUSSION

3.1 Selected chemical properties of Vermicompost and conventional compost

3.1.1 The pH and Electrical Conductivity

As the laboratory analysis result revealed that the highest (7.83) and the lowest (6.93) pH value was recorded for vermicompost and conventional compost; respectively (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 greater than 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 totally it ranges from 0.003 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.

3.1.2 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 *et al* (2013) and Tadele *et al.*, (2020) 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.

3.2 Carbon to Nitrogen Ratio and Available Phosphors

3.2.1 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* whiles the highest (9.76) from worm collected from (Table 2). The C: N ratio values for worm collected from locally and that of conventional compost almost no significant variation in which all values greater than C:N ratio of vermicompost prepared using *Eisenia Fetida*. This result confirmed with different authors Kalantari *et al* (2009); Hiranmai *et al* (2016) and Derib *et al* (2017) who stated that vermicompost had lowest C: N ratio as compared to conventional compost.

3.2.2 Available Phosphorus

The laboratory analyzed for available phosphorus (Av. P) shows that highest (89.89 mg/kg) while the lowest value of (25.31 mg/kg) values was 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 increased 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 current study revealed that 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 earthworm's and feed materials used.

TABLE 2
NUTRIENT CONTENTS OF VERMICOMPOST AND CONVENTIONAL COMPOST FOR SELECTED CHEMICAL PARAMETERS AT SINANA

Treatments	PH-H2O	EC (ds/m)	OC	TN	C:N	Ava. P (mg/Kg)
			%			
Sinana 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

3.3 Cation exchangeable capacity and Exchangeable bases

3.3.1 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 were varied from 33.23 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 garment with the finding of Tadele *et al.* (2020) who reported that CEC in vermicompost ranges from 57- 68.70 mg/kg for vermicompost made from different substrates.

3.3.2 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 to 34.77 $cmol_+/kg$, 0.31 to 1.40 $cmol_+/kg$, 0.99 to 2.25 $cmol_+/kg$ and 0.35 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 were rich in exchangeable cations than conventional compost. The result 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) valued was varied from 59.16 to 71.17 % in which the highest value was obtained from conventional compost while the lowest was from vermicompost made using Eisenia Fetida (*red worms*). The lowest PBS for vermicompost made using *Eisenia Fetida* might be due to the highest CEC contents as compared to vermicompost made using local earthworm and conventional compost.

TABLE 3
CATION EXCHANGEABLE CAPACITY AND EXCHANGEABLE BASES STATUS OF VERMICOMPOST AND CONVERSIONAL COMPOST AT SINANA

Treatments	CEC	Exchangeable base				PBS
		Ca	Mg	K	Na	
	$cmol_+/kg$					%
Sinana 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

IV. MICRO NUTRIENTS CONTENTS

The analyzed result for Micro nutrients contents ranges 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 was 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 have better micro nutrients contents than conventional compost for the study conducted using different worms and different mixed feed sources.

TABLE 4
AVAILABLE MICRO NUTRIENTS STATUS OF VERMICOMPOST AND CONVERSIONAL COMPOST AT SINANA

Treatments	Micro nutrients			
	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

V. SUMMARY AND CONCLUSION

The quantity and characteristics of most chemical properties such CEC, NT, Av. P, K, Zn and the like depends on the types of earth warms spices (locally collected or the world wide adapted *Eisenia fetid)* and types of compost (vermicompost or conventional compost). 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 foetida) than locally collected worm species and conventional compost. It should be recommended further multiplication of *Eisenia fetid* and demonstration of Vermiculture in Sinana and similar agro - ecology. 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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