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Research Article

Evaluation and Characterization of Nutrient Content of Vermicompost Made from Different Locally Available Substrates at Haro Sabu Onstation, Kellem Wollega Zone, Oromia, Ethiopia

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Abstract

Locally available materials could be used to address soil fertility constraints. Vermicomposting is a promising technology where various organic materials are converted into processed compost by earthworms. This study was conducted at the Haro sabu Agricultural Research Center on-station during the consecutive two years (2021 - 2022 years) with the aim to evaluate the quality of vermicompost made from different locally available waste materials to explore the possibility of using organic fertilizers for sustainable agriculture and minimize the use of chemical fertilizers in the crop production and reduce soil pollution. The experiment consisted of ten different treatments in the ratio of 1:1 cattle manure to crop residues on a weight basis viz., T1: Cow manure + maize straw, T2: Cow manure + haricot bean straw, T3: Cow manure + coffee husk/pulp, T4: Cow manure + green leaf, T5: Cow manure + haricot bean straw + maize straw, T6: Cow manure + coffee husk/pulp + maize straw, T7: Cow manure + green leaf + maize straw, T8: Cow manure + haricot bean straw + coffee husk/pulp, T9: Cow manure + haricot bean straw + green leaf, and T10: Cow manure + maize straw + haricot bean straw + coffee husk/pulp + green leaf. Water was sprayed to maintain optimum moisture for worms as it needed. The substrates were chopped and added to the worm bin. A red worm (Eisenia fetida) was used for the preparation of vermicompost. Matured composite vermicompost samples were prepared and collected for laboratory analysis. The laboratory result showed that the pH values of all feeding substrates are found in a suitable range for the survival of earthworms and also for plant growth. The OC, TN, available P, C:N ratio, and CEC of vermicompost made from all material were excellent and promise improvement of soil properties. The highest value of available P and K was also registered from vermicompost prepared from all materials. Even if the values of recorded nutrients were different, the vermicompost obtained from all substrates was rich in selected micronutrients. Therefore, the nutrient content of vermicompost prepared from all substrates showed the highest values for all selected micro plant nutrients. Thus, the vermicompost made from all materials could correct the plant nutrient imbalance and could be used for vermicompost preparation based on the accessibility of materials. Also utilizing the vermicompost for crop production and enhancing soil fertility.

Keywords

Nutrient Quality, Vermicompost, Cow Manure, Substrates

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1. Introduction

Low soil fertility and combined nitrogen (N) and phosphorus (P) deficiencies are widespread problems in tropical soils. In large parts of the world, agricultural production is mainly characterized by excessive application of chemical fertilizers and insufficient application of organic fertilizers. In organic fertilizers in effect, destroy soil properties while organic fertilizers improve and sustain the soil. Excessive and inappropriate use of chemical fertilizers is the major cause of nutrient imbalance and degrading our soil [1]. An increment of crop yield from 30 to 50% has resulted from application of commercial fertilizers [2]. Excessive and inappropriate use of chemical fertilizers is the major cause of nutrient imbalance and degrading our soil [1]. Continuous use of chemical fertilizer creates a potential polluting effect on the environment. Chemical fertilizers in effect destroy soil properties while organic fertilizers improve and sustain the soil [3]. Moreover, mineral fertilizers are not affordable for many small-scale farmers, and therefore, sole dependence on mineral fertilizers is not conceivable for long-lasting, sustainable soil management.

There is no absolute replacement of chemical fertilizers, as the soils of Ethiopia are low in nutrients, and organic matter. Nutrient recycling by use of organic manures is preferred to restore nutrients removed by crops [4]. Vermicompost is particularly good for farmers, consumers, and ultimately for soil, as it can be used as a resource for maximizing crop productivity on a sustainable basis and with more financial safety in comparison to these chemical fertilizers [5]. Vermicompost increases soil organic carbon, nitrates, phosphates, exchangeable calcium, and some other nutrients for plants [6]. Vermicompost is the recent organic fertilizer in supplementing chemical fertilizers for sustainable development of agriculture [7]. Vermicompost would use the best option to minimize the use of chemical fertilizers and maximize the sustainability and farmers income by reducing cost production.

Earthworms play important roles in soil formation and fertility, functioning as an element of a food web and also being responsible for altering dynamics of the ecosystem through the maintenance and modification. Earthworms can live in decaying organic wastes and can degrade different organic materials like green leaves, weeds, cattle dung, digested slurry, crop straws, etc, into fine particulate materials that are rich in nutrients and humus, as reported by [8]. Preparations of vermicompost technology utilizing earthworms, most frequently from the genus *Eisenia fetida* play an essential role in the composition of organic matter and agro-wastes, which supports improving soil fertility, efficient natural recycling, and enhanced plant growth particularly economically affordable for small holder farmers [9].

Vermicompost is one excellent product technology used as plant growth hormones, higher levels of enzymes, greater microbial populations, and tends to hold more nutrients over a longer period without adversely impacting the environment [10, 11].

In different areas of the world commonly traditional management practice of postharvest 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 [12] (Thiruneela Kandan and Subbulakshmi, 2015). According to [13] mixing cow dung crop residues helps to improve their acceptability by *Eisenia fetida* and improve the physicochemical characteristics of vermicompost produced.

In western Oromia, crop residues such as maize straw, haricot bean straw, and coffee husk are the major, easily accessible residues. Mostly the farmers were burned on the field during land preparation. However, soil fertility declines as a result of nutrient leaching loss through soil erosion, due to limited inputs of organic fertilizer sources are major problems for sustainable crop productions and agricultural productivity. Therefore, mixed use of these locally available crop residues with cow manure have crucial role to improve crop productions and agricultural productivity in sustainable ways. Vermicompost is environmentally sound and economically affordable particularly for small holder farmers in the area. Therefore, this study was initiated with the objectives to evaluate the quality of vermicompost made from different locally available crop residue materials to explore the possibility of using organic fertilizers for sustainable agriculture and minimize the use of chemical fertilizers in crop production and reduce soil pollution.

2. Materials and Methods

2.1. Description of Study Area

The study was conducted at the experimental farm of Haro Sabu Agricultural Research Centre, Dale Sadi District, which is one of the districts in Kellem Wollega Zone of Oromia located 548 km from Addis Ababa on Dembi Dollo main road. Geographyically, it is located at 8.9030 °N, 35.2267 °E and altitude of 1526 m.a.s.l. Agro-climatically, it is located in sub-humid tropical zone. The rainfall pattern of the district is characterized by bimodal distribution with small rainy season *belg* (March-June) and main rainy seasons *Meher* (July-November). The annual rainfall is 1020 mm and annual average temperature of 25.07 °C. The dominant soil type of the district is Nitisol.

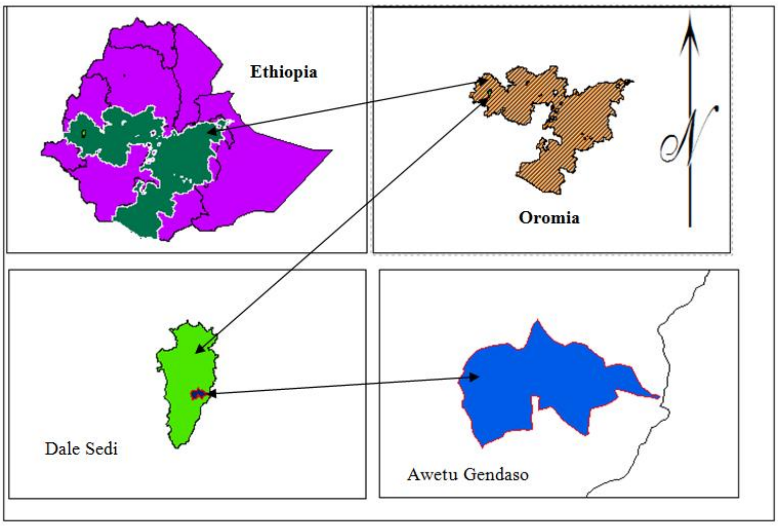

Figure 1. *Map of Study Area.*

2.2. Experimental Materials and Vermicompost Preparation

The experiment was conducted under a production house with a size of 0.4m height, 0.6m width and 1m length. 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). Vermicompost was prepared from different treatments in the ratio of 1:1 cattle manure to crop residues in weight basis viz., T1- Cow manure + maize straw, T2- Cow manure + haricot bean straw, T3- Cow manure + coffee husk/pulp, T4- Cow manure + green leaf, T5- Cow manure + haricot bean straw + maize straw, T6 - Cow manure + coffee husk/pulp + maize straw, T7- Cow manure + green leaf + maize straw, T8- Cow manure + haricot bean straw+ coffee husk/pulp, T9- Cow manure + haricot bean straw + green leaf, T10- Cow manure + maize straw + haricot bean straw + coffee husk/pulp + green leaf. Cattle manure was added to all substrates in equal amount. The substrates or crop residue were chopped manually then finally mixed with cow manure in a ratio of 1:1. Using water cane water was added to maintain optimum moisture for worms as it needed and facilitated decompositions as suitable for worms. A red worm (*Eisenia fetida*) were introduced in to each treatment.

Figure 2. *Vermicompost and Treatments Setup.*

2.3. Methods of Vermicompost Samples Analysis

The collected vermicompost samples were analyzed for the parameters stated in the table below.

Table 1. *Different parameters analysed for vermicompost samples and analysis methods.*

Parameter	Unit	Method
pH (H_2O)	w/v	Potentiometric water extract
Electrical Conductivity	mS/cm	Conductivity Cell Potentiometric
Available Phosphorous	ppm	Olsen *et al*., 1981
Organic carbon	%	Walklay Black
Total nitrogen	%	Kjeldehal
Cation exchangeable capacity	meq/100gm	Ammonium Acetate

2.4. Method of Data Collection

The vermicompost in each container was harvested by removing the earthworms and sieving the vermicompost. The vermicompost samples were weighed and chemical characteristics of vermicompost was analyzed in the soil laboratory of Nekemte Soil research center.

2.5. Method of Data Analysis

The experiment was a laboratory analytical procedure on the different materials where values recorded values recorded and interpreted.

3. Result and Discussion

Table 2. Selected Chemical Properties of Vermicompost from different materials.

Treatments	pH (H_2O)	OC (%)	E.C (µs/Cm)	TN (%)	C:N	Av.P (ppm)	CEC (Cmol (+)/Kg)
T1	7.57	11.70	0.215	1.01	11.58	24.80	35.60
T2	7.42	11.05	0.392	0.95	11.63	30.84	42.00
T3	7.54	10.08	0.137	0.87	11.58	28.40	30.00
T4	7.63	10.53	0.153	0.91	11.57	22.70	8.00
T5	7.58	11.05	0.218	0.95	11.63	23.50	41.00
T6	7.42	10.40	0.271	0.90	11.55	24.40	45.00
T7	7.41	11.05	0.278	0.95	11.63	24.20	39.00
T8	7.49	11.83	0.118	1.02	11.59	21.70	30.00
T9	7.46	9.75	0.158	0.84	11.61	21.10	31.00
T10	7.35	10.40	0.211	0.90	11.55	22.00	42.60

T1- Cow manure + maize straw, T2- Cow manure + haricot bean straw, T3- Cow manure + coffe ehusk, T4- Cow manure + green leaf, T5- Cow manure + haricot bean straw + maize straw, T6- Cow manure + coffee husk + maize straw, T7- Cow manure + green leaf + maize straw, T8- Cow manure + haricot bean straw + coffee husk, T9- Cow manure + haricot bean straw + green leaf, T10- Cow manure + maize straw+haricot bean straw + coffee husk + green leaf.

3.1. Selected Chemical Properties of Vermicompost The pH (H_2O) and Electrical Conductivity (EC)

According to the laboratory analysis result, the pH value of vermicompost ranged from 7.35 to 7.63 (Table 2). The pH values of all types of vermicompost are found in suitable range for plant growth. This finding agreement with finding of [14] who stated that the values of pH was ranged from 6.8 to 8.41 for vermicompost. Additionally, [15] reported that the pH values of all types of vermicompost are found in a suitable range for the survival of earthworms since pH values greater than 8.5 are harmful to microorganisms.

The laboratory analysis result of electrical conductivity of vermicompost ranged from 0.118 to 0.392 mS cm^{-1} (Table 2). The highest and the lowest mean value of EC was recorded from mixed *Cow manure + haricotbean straw* and *Cow manure + haricotbean straw + coffee husk* respectively. Salinity which has the value of EC greater than 8 mS cm^{-1} is harmful to microorganisms [16]. Similarly, [15] found that EC values of both conventional and vermicompost were free from salinity. Therefore, the values of EC of vermicompost made from all materials are suitable for the survival of earthworms and applicable for crop production.

3.2. Total Nitrogen and Available Phosphorus

Total nitrogen ranges from 0.84 to 1.02% in vermicompost prepared from different organic materials. The highest (1.02%) and the lowest (0.84%) total nitrogen content was recorded from vermicompost made from mixed cow manure, haricot bean straw, coffee husk and cow manure, haricot bean straw, and green leaf respectively (Table 2). The variation of total nitrogen content among the treatments may be attributed to the type of substrates used in the feeds. A compost has been fertilizing capabilities and for it to be used in agriculture the total nitrogen content must be over 1% [17].

The result indicated that the available phosphorus was influenced by variation in feeding materials of vermiworms (Table 2). As the result indicates that the highest (30.84 ppm) was recorded by feeding of mixed *cow manure* + *haricot bean straw* while the lowest value of (21.10 ppm) was recorded by feeding of mixed *cow manure* + *haricot bean straw* + *green leaf* respectively. 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. This might be the reason for releasing and increasing the content of phosphorus in the vermicompost. The enhanced phosphorous level in vermicompost suggests phosphorous mineralization during the process. The worms during vermicomposting converted the insoluble Phosphorous into soluble forms with the help of Phosphorous-solubilizing microorganisms through phosphatases present in the gut, making it more available to plants [18].

3.3. Carbon to Nitrogen Ratio (C:N)

The calculated carbon to nitrogen ratio (C:N) varied from 11.58 to 11.63% (Table 2). The vermicompost prepared using different mixed feed sources had the lowest C:N ratio. This result is consistent with the result of [18] who reported that a C:N ratio < 20 indicated advance in organic matter stabilization and reflects a satisfactory degree of maturity of organic wastes. The C:N ratio is one of the most widely used indicators of vermicompost maturation, decreasing sharply during the vermicompost process. According to [19], higher nitrogen levels and lower C:N ratio in vermicompost could be attributed to alteration of the microbial nutrient spectrum in earthworm casts due to the increased presence of nitrogen-fixing microbes, which in turn enhance total nitrogen concentration in vermicompost.

3.4. Cation Exchangeable Capacity (CEC)

Cation exchangeable capacity (CEC) values of vermicompost prepared using different mixed feed sources were varied from 8 to 45 cmol+/kg (Table 2). As the results revealed that the highest (45 cmol+/kg) and the lowest (8 cmol+/kg) were obtained from vermicompost prepared using mixed *Cow manure* + *coffee husk* + *maize straw and Cow manure* + *green leaf* 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 similar to the finding of [18] who reported that CEC in vermicompost ranges from 57 to 68.70 mg/kg.

4. Conclusion and Recommendation

Previously, conventional compost and farmyard manure have been used as sources of organic fertilizer. Recently, vermicompost technology has been widely disseminated through extension and non-governmental organization in the region in most of the districts and kebeles on the assumption that vermicompost can be an alternative source of chemical fertilizers.

Vermicomposting is a promising technology where various organic materials are converted into processed compost by earth worms. However, no studies have been undertaken in the study area on the nutrient quality of vermicompost prepared from different materials. Hence, this experiment was carried out under mini shade to determine different feeding materials on the nutrient quality of vermicomposts in Haro Sabu research onstation of Dalle Sadi district, during *2021 - 2022* fiscal year.

According to the result of this study the highest values of Total Nitrogen were recorded by mixed feeding materials of Cow manure, haricot bean straw, coffee husk followed by Cow manure with maize straw using the earthworm *(Eisenia foetida)*. Therefore, it is concluded that among the raw material used Cow manure, haricot bean straw, coffee husk followed by Cow manure with maize straw in the ratio of 1:1 (50:50) was found best due to its higher total nitrogen nutrient contents for farmers in Dalle Sadi districts.

Therefore, based on the results of the study and the above conclusion, it can be recommended that; Cow manure, haricot bean straw, coffee husk followed by Cow manure with maize straw in the ratio of 1:1 (50:50) could be recommended for farmers in then study area to produce organic fertilizer for crop production and agricultural productivity in sustainable ways. Future research should focus on the rate of vermicompost application and their effects on crop yields and soil physicochemical properties.

Abbreviations

EC	Electrical Conductivity
C:N	Carbon to Nitrogen
IQQO	Oromia Agricultural Research Institute
m.a.s.l	meter above sea level
T	Treatment

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Conflicts of Interest

The authors declare no conflicts of interest.

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