Composting of Coffee Husk and Pulp with Other Organic Wastes as a means of Solid Waste Management

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Abstract

The windrow composting of coffee husk and pulp with other available organic wastes was studied using six different treatments for over 90 days. Six different treatments using randomized complete block design were conducted. The compost quality (physico-chemical and nutrient composition) of the matured compost indicated that composting of coffee husk and pulp with khat waste and cow dung is the best of all the treatments.

Key Words: coffee residue, composting, compost quality, macronutrient

1. Introduction

Botanically, coffee is belonging to the family Rubiaceae in the genus Coffea. Although the genus Coffea includes four major subsections, 66% of the world production mostly comes from Coffea arabica L. and 34% from Coffea canophora Pierre ex Froehner (robusta type) (Mekuria et al., 2004).

Ethiopia is the home and cradle of biodiversity of Arabica coffee seeds. More genetically diverse strains of C. arabica exist in Ethiopia than anywhere else in the world, which has lead botanists and scientists to agree that Ethiopia is the center for origin, diversification and dissemination of the coffee plant (Mekuria et al., 2004).

About 25% (15 million) of the Ethiopian population depend, directly or indirectly, on coffee production, processing and marketing (Woods, 2003). Currently, Ethiopia is the leading Arabica coffee producer in Africa, the fifth largest worldwide and the tenth in coffee exports worldwide. The average annual production amounts to about 350,000 tons. In Ethiopia, Coffee is produced under four broad production systems, i.e forest coffee (8-10%), semi forest coffee (30-35), cottage or garden coffee (50-57%) and modern coffee plantation (5%) (UNDP, 2012).

Ethiopian Coffee is processed in two different processing methods. The first one is called the dry method where the beans are dried inside the fruit. The second method called the sophisticated large scale wet method employs a more advanced technology in which the fruit is immediately removed from the beans in a serious of complex operations before the beans are dried.

The residue from dry processing is burnt while those from wet processing are dumped into rivers, both being disposed into arable land and surface water which can significantly affects the environment. On the other hand, these wastes contain high concentrations of biodegradable organic and minerals of plant origin, which can better be utilized by composting with other organic materials (additives) (Henok et al., 2011).

2. Materials and Methods

2.1 Description of the study Area

The experiment was conducted at Dale district agricultural research center. Dale district is one of the 19 districts in Sidama Zone and covers a total area of 30,212 ha, located at about 320 km south of Addis Ababa along the main highway to Moyale, about 5km to the left after traveling 40km from the region capital Hawassa. The district shares boarder with Wonsho district in the east, Loka-Abaya district in the west, Aleta Wondo and Chuko districts in the south, and Shebedino district in the north. In addition, the district is located in 6^0 44" latitude to the north and 38^0 28'' longitude to the east. The district is subdivided into 36 Kebeles and all those produces coffee (WoFED, 2013).

2.2.1 Collection of Composting Materials

Coffee husk and coffee pulp was collected from Yirgalem wet and dry coffee processing firms directly from their dumping sites. Cow dung and Khat waste (Garaba) was collected from dairy farms and Khat selling houses in yirgalem respectively. Finally the common bulking agent top soil was taken from the Research Center.

2.2.2 Preparation of Compost

The composts base area was 1m width, 1k2m length and 1m height ($1m^3$ in volume), above 20 cm height of bricks bed. The piles were constructed over a bamboo made kiricho on a brick with the composting material in layers. The composting process carried on under aerobic condition. The heap was shuffled after one week in order to enhance the composting process by blending and breaking up the composting materials (Harold et al., 1994). Top soil was added to each treatment at the top of the pile which will introduce microorganisms to the piles.

2.2.3 Methods and Procedures of Physico-chemical Analysis

Temperature

Temperature was measured using digital thermometer daily for the first 30 days on the site. The frequency of measuring the temperature of the pile reduced then after.

pH and Electrical Conductivity

The pH of compost samples was measured by a pH meter by taking a sub sample (10 g) of air-dried ground compost (<2mm) was transferred into a flask and 25 ml of distilled water for 1:2.5 compost/water suspension.

Moisture Content and Dry Matter

Representative sample was weighed in a clean, dry, pre-weighed and recorded moisture free tin and loaded in an oven at 105^0C up to a constant weight (24 hours). Oven dried samples was cooled in desiccators for 30 minutes and reweighed (Sahlemedhin & Taye 2000).

Organic Matter and Organic Carbon

In an air-dry compost Add 10ml 1 N $K_2Cr_2O_7$ solution with pipette to both samples and blank. Carefully add 20ml concentration H_2SO_4 with measuring cylinder in the fume cupboard and swirled the flask and allowed standing asbestos or corking pad for 30 minutes. Then add 200ml distilled water and allowed it to cool. Add 10ml conc. orthophosphoric acid just before titration, and add 0.5 ml of barium diphenylamine sulphonate indicator. Titrate both samples and blanks with 0.5 N ferrous sulfate solution until the color changed to purple or blue, then added ferrous sulfate solution drop by drop until the color flashes to green then continue to a light green end point (Sahlemedhin& Taye 2000).

Total Kjeldahl nitrogen

The total nitrogen was determined following the Macro Kjeldahl method Total Kjeldahl Nitrogen (TKN) as described by Bremner (1965).

Available Phosphorus

Available Phosphorus was determined by spectrophotometer model 6400 using olsen method (Olsen et al., 1954).

Exchangeable potassium

Exchangeable potassium was determined by using flame photo meter (Chapman, 1965; FAO, 1993).

ElectricalConductivity(EC)

The electrical conductivity was measured using 1:5 (compost: water) water suspension. Then, electrical conductivity was measured using conductivity meter model Hanna HI 8733 as described by (FAO, 1993).

2.3 Statistical Analysis

Statistical analysis of selected physico-chemical parameters were analyzed by using excel software.

Experimental Design, Treatment and Layout

2.3.1 Experimental Setup

Six different treatments each having three replicates in Randomized complete block design with the total of 18 piles (heaps) were prepared with different composition of coffee residue, cow dung, and khat waste (Garaba).

Treatment 1: (T1) coffee processing wastes (coffee husk and pulp)

Treatment 2: (T2) coffee processing wastes plus cow dung

Treatment 3: (T3) coffee processing wastes plus Khat waste (Garaba)

Treatment 4: (T4) coffee processing wastes plus cow dung plus Khat wastes (Garaba)

Treatment 5: (T5) coffee pulp plus cow dung and Treatment 6: (T6) coffee husk plus cow dung

Table 2.1: Proportion of coffee wastes and each organic residue (top soil, cow dung, Khat waste (Garaba)) in each treatment on dry weight basis.

S.no	Pile Type	Treatments					
		T1	T2	T3	T4	T5	T6
	Coffee pulp	350 Kg	315 Kg	286 Kg	224 Kg	780 Kg	------
	Coffee husk	80 Kg	66 Kg	57 Kg	45 Kg	------	325 Kg
	Cow dung	-----	------	68 Kg	60Kg	125 Kg	92 Kg
	Khat waste	-----	39 Kg	------	31 Kg	…….	…….
	Top soil	23 Kg	19 Kg	14 Kg	11 Kg	49 Kg	36 Kg

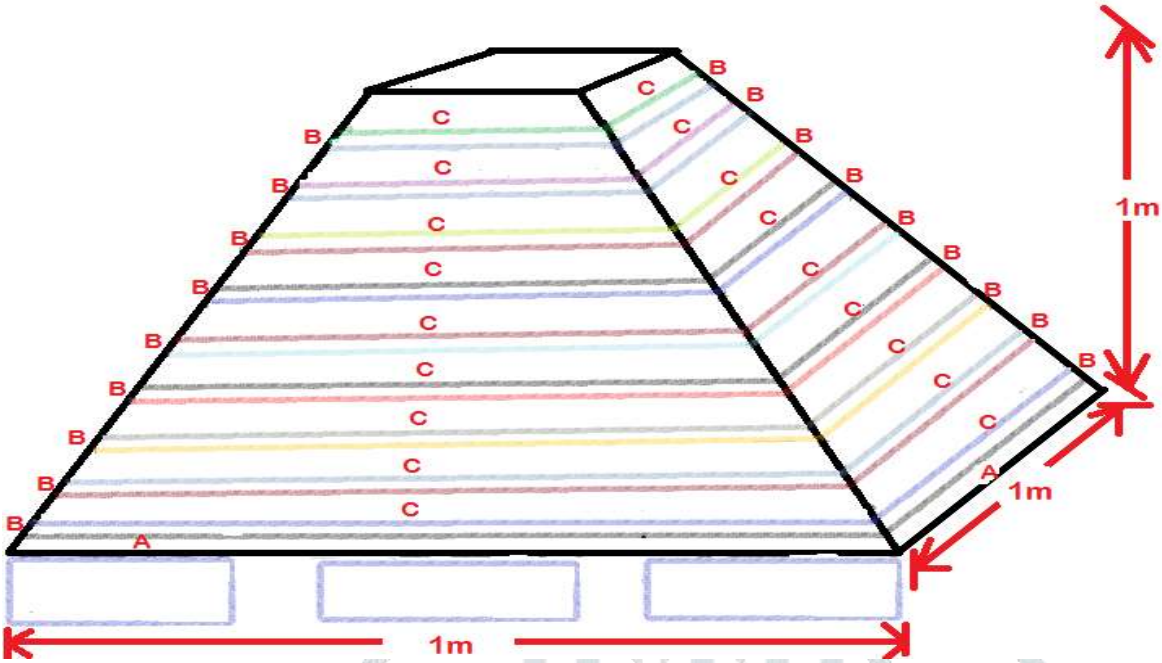

Fig 1. Layout of composting

Layer A: This layer was prepared from locally available material which made from dry bamboo stem called-kircho. This is difficult to decompose and allows ventilation which is important for the survival of microorganisms.

Layer B: This layer consists of coffee by-products (coffee husk and pulp).

Layer C: Varies with the treatment i.e cow dung / and khat waste, in order to reduce the C:N ratio of the coffee husk and pulp for rapid decomposition

These layers were repeated (except layer A) until the heap reaches 1m long.

Upper layer: Covered with grass or leaves to prevent water loss.

3. Results and Discussions

Physico-chemical characterization of feedstock and compost

Table 3.1: physico-chemical properties of raw feedstock and compost

	Parameters									
	MC %	DM%	pH	EC (dS/m)	OM%	OC%	TN%	TP (%)	TK (%)	C:N ratio
	Raw feedstock									
CH	11.86	88.14	5.6	1.96	87.9	50.98	1.25	-	-	40.8:1
CP	82.11	17.89	8.7	4.2	70.5	40.89	2.38	-	-	17.2:1

CD	64	36	8.1	4.2	40.3	27.37	1.69	-	-	16.2:1
Khat	60	40	8.1	3.6	45.9	26.63	2.27	-	-	11.7:1
TS	7.9	92.1	7.9	0.14	12.5	7.25	0.25	-	-	29.1
	Processing compost after 45 days									
T1	68.2	31.8	8	2.4	51.5	29.87	1.09	0.09	1.3	27.4
T2	65.5	34.5	8.2	1.83	45.7	26.56	1.23	0.17	0.78	21.59
T3	69.6	30.4	7.96	2.67	48.3	28	1.45	0.1	0.81	19.3
T4	64.2	35.8	7.93	2.07	47.9	27.8	1.36	0.14	0.69	20.44
T5	67.6	32.4	8.1	1.81	45.34	26.3	1.21	0.12	0.63	21.7
T6	68.3	31.7	7.89	2.29	46.55	27	1.22	0.13	0.74	22
	Matured compost after 90 days									
T1	49.6	50.4	7.85	2.66	42.7	26.68	1.28	0.25	0.25	20.8
T2	39	61	8.05	4.3	39.76	23.49	1.76	0.87	1.26	13.34
T3	40.5	59.5	8.2	3.19	39.5	22.32	1.97	1.02	0.74	11.32
T4	38.4	61.6	8.1	4.4	39	22.3	2.06	0.9	1.48	11
T5	40	60	7.9	3.96	40.9	24.36	1.45	0.53	0.91	16.8
T6	39	61	8.0	4.15	41.6	25.3	1.71	0.49	0.85	14

Temperature

The temperature of the compost began to rise soon after the establishment of composting conditions within 24-72 hours of composting period except T1 which remains for almost 5 days at mesophilic phase.

Moisture content

The moisture content dropped gradually throughout the composting time except T1. In the co-composted piles, highest moisture levels were seen in the active phase with high moisture losses occurring afterwards. Finally the moisture content of the piles become 38.4-49.6% which is recommended by California integrated waste management board compost quality standards for finished compost.

pH Change

The pH of all treatments was found to be within 7.85-8.25. This result is in agreement with the compost quality standards for compost used in agriculture in Switzerland (pH < 8.2) and Great Britain (7.5-8.5) (OVAM, 1999).

Electrical conductivity

The mean EC values of all the treatments of matured composts were found to be between 2.66-4.4 dS/m, in which the highest value of EC was recorded at T4. This result is in agreement with the quality compost used by the countries such as Dutch, Belgium and Italy that is < 5 dS/m (OVAM, 1999).

Organic matter content

The initial organic content of the compost was 46%, 40.5%, 39.5%, 39%, 42% and 43.6% in trial 1, 2, 3, 4, 5 and 6 respectively. The lower organic matter content was recorded in T4. The result obtained in all treatments is in agreement with the quality compost criteria, which is used by the countries such as Dutch, Belgium and Italy that is >20%.

Change in C/N ratio

The final value for C:N was 20.8, 13.34, 11.32, 11, 16.8, 14 in trial 1, 2, 3, 4, 5 and 6 respectively. The C/N ratio of the studied compost samples are in agreement with the compost quality standards used by the countries such as Dutch, Belgium and Italy that is less than 18.

Total Kjeldahl Nitrogen (TKN, %)

The recorded total nitrogen content of the trials was 1.28%, 1.76%, 1.97%, 2.06%, 1.45% and 1.71% for trial 1, 2, 3, 4, 5 and 6 respectively. This result is in agreement with the quality compost criteria, which is used by the counties such as Dutch, Belgium and Italy that is >0.7%. **Total phosphorus**

The Total P % content of the matured composts for all the treatments were found to be in between 0.25 – 1.02 %. The result obtained in this study is in conformity with the recommendations of Ontario ministry of the environment (2004) that recommended the typical minimum concentration (percentage dry weight) of total P as 0.25.

Total potassium

The value of potassium for the studied compost ranges from 0.25-1.48 in percent. The results obtained in this study is in conformity with the quality compost criteria, which is used by the counties such as Dutch, Belgium and Italy that is >0.75%, except T1 which is out of the recommended range of most countries.

Conclusions

Treatment 4(coffee residue, cow dung and Khat waste) is the best of all the treatments because of its maximum contents in macronutrients as well as organic matter, organic carbon and all the necessary requirements of compost quality at the end of the composting process. Thus it is recommended that the application of coffee residue with other organic wastes can be considered as a good compost.

Acknowledgments

We would like to thank those who helped us during this research work.

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