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Evaluation of Earthworm Species and Bedding Material Collected from Tea Plantations for Vermicomposting in Sri Lanka

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Abstract—*Earthworms has the ability to convert organic waste into compost and this process is known as vermicomposting. This study was conducted to evaluate the suitability of three common earthworm species and four waste material collected from tea plantations as bedding material for earthworms in producing vermicompost. Three experiments were conducted and the experimental design was a Complete Randomized Design with three replicates.*

In the first experiment, four bedding materials that is leaves of Gliricidia (Gliricidia sepium) and Mana (Cymbopogon confertiflorus), tea prunings and refuse tea were composted using earthworm species Eudrilus euginea. Each waste material was mixed with cow dung and poultry manure, separately before using them as bedding material. The results showed that these material can be used for producing high quality vermicompost. In the second experiment three earthworm species Eisenia foetida, Periyonix excavator and Eudrilus euginea which were commonly recorded from Sri Lankan soils were evaluated for vermicomposting. Vermicomposting has increased the quality of organic material but the mean differences in nutrient levels in relation to earthworm species were non-significant (P=0.05). This indicates the suitability of all three species for vermicomposting. In the third experiment three soil amendments, vermicompost produced using Eudrilus euginea, garden compost and inorganic fertilizer were compared using tomato as an indicator crop. Vermicompost applied treatment showed significantly higher (P<0.05) fruit weight and number of branches when compared to other two treatments showing its usefulness as a soil amendment. This study shows that all factors are in place for producing vermicompost successfully in Sri Lanka.

Keywords— Earthworms, Eudrilus euginea, Periyonix excavator, Eisenia foetida, bedding material, vermicompost.

I. INTRODUCTION

In the recent years earthworms have been identified as a major tool for producing high quality compost due to their ability to convert organic waste into valuable plant nutrients and organic matter (Sharma, 2009). In the food web earthworms are regarded as decomposers, detritivores and diggers. They swallow mineral particles and plant debris, partially pushing through the soil and partially eating its way. They are mixed in their gut and pass out as casts on the surface of the soil (Nardi, 2007). Many authors have stated about the process of "feeding high and burrowing low," carried out by the earthworms to physically improve soil structure by enabling pathways for aeration, water infiltration and root penetration. Earthworms are known as "living plow", "best tiller", "farmer's friend", "intestine of earth", "pulse of the soil" as it digest earth and litter leaving behind a rich humus layer, most probably the nature's best fertilizer or known as "black gold" (Ansari and Ismail, 2012; Megraw, 2012; Siddaraju *et* al, 2013; Lorson, 2016). This was also highlighted by the Charles Darwin in his last manuscript written in 1881 titled "The Formation of Vegetable Mould, Through the Action of Worms*"*. Darwin observed and recorded the habits of the earthworms and its effect on soil formation. Darwin learned that worms literally move the earth in the process of their meanderings. Their passage through the earth aerates the soil and the natural chemistry of their guts renders soil and plant matter into fertile pellets. As a by-product of their movements, worms deposit new soil on the surface, causing whatever was on top to slowly submerge" (Megraw, 2012).

About 3,627 species of terrestrial earthworms have been reported from different parts of the world and 63 species of earthworms from Sri Lanka (Reynolds, 1994). A recent study has revealed 22 species of earthworms belonging to 16 genera and 9 families in 17 natural and agricultural sites in the wet and intermediate zones of Sri Lanka

(Samaranayake, 2008). Earthworms categorized into three ecological types, namely epigeic, endogeic and anecic based on morphological features, habits and location in soil (Bouche, 1977). Epigeic earthworms are adapted to living close to the soil surface and are capable of eating and decaying organic material such as garbage and litter. They have a short life cycle and small segmented body. *Eudrilus euginea*, *Periyonix excavator* and *Eisenia foetida* are some common epigeic earthworm species found in Sri Lankan soils (Samaranayake and Wijekoon, 2010).

This burrowing and feeding activity of earthworms have numerous beneficial effects on overall soil quality for crop production. Typical earthworm populations can easily consume 5 tons of dry matter per ha per year, partly digesting and mixing it with soil. It is also estimated that for a single acre of cultivated land, earthworms move 8 tons of earth in a year, enough to form a new layer of earth 2 inches thick, rich in nitrogen, phosphorus and calcium (Megrow, 2012). Earthworm casts have higher available N, P, K and Ca contents than surrounding soil, as well as a higher cation-exchange capacity (Jones, 2013; Aladesida *et al*, 2014; Sherman, 2017). The excrement of earthworms are rich in micronutrients, such as Zn and B through chelation. Earthworms also excrete material that has high concentrations of beneficial microbes that help decompose crop residue. The increase in porosity created by earthworms facilitating quick water infiltration into the soil and reduce the effects of compaction is highly advantageous in the no-till systems of farming. pH buffering action of organic molecules produced in the gut of worms is another advantage of earthworms (Jones, 2013; Aladesida *et al*, 2014; Sherman, 2017).

Decomposition of waste materials using earthworms is known as vermicomposting (Sharma, 2009; Ansari and Ismail, 2012). Vermicmpost is accepted as humus, bio fertilizer, 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.

Tea industry provides several biodegradable waste or by-products during field operations as well as during tea manufacturing. They include refuse tea, instant tea wastes, shade tree loppings, tea prunings and weeds. In Sri Lanka about 4-6 percent of the total product of made tea goes as refuse tea (Rupasinghe, 2006).

The past research has reported that quality of vermicompost is influenced by the earthworm species and the bedding material (Manaf *et al*, 2009; Bisen *et al*, 2011; Yadav *et al*, 2013). *Eudrilus euginea*, *Periyonix excavator* and *Eisenia foetida* are three common earthworm species recorded in Sri Lanka and are being been used for composting worldwide especially in India (Suthar and Singh, 2008; Manaf *et al*, 2009; Bisen *et al*, 2011; Anandharaj *et al*, 2013; Siddaraju *et* al, 2013; Perera and Nanthakumaran, 2015). The objective of this study was to examine the suitability of three common earthworm species and some waste materials generated in tea estates as bedding material for earthworms for producing vermicompost.

II. MATERIALS AND METHODS

Experimental site

Three experiments were conducted during this study to achieve objectives. First and second experiments were conducted at the Erin Tea Estate, Galaha during August to September, 2016. The estate is located in the mid country wet zone (agro-ecological region WM_2). The Mean minimum and maximum temperature during the research time period was 17^0C and 27^0C, respectively. The third experiment was conducted at the University Experimental Station, Dodangolla, Kundasale during September to November, 2016. It is located in the mid country intermediate zone (agro-ecological region IM3a). The soil group of this area is Immature Brown Loam and Reddish Brown Latasolic. The Mean minimum and maximum temperature during the research period was 20.6^0C and 29^0C, respectively.

Multiplication of Earthworms

Earthworm species *Eudrilus euginea* and *Periyonix excavator* were collected from cow dung heaps in Erin Tea Estate, Galaha. *Eisenia foetida* were collected from partly decomposed vegetable refuse from the Nuwara Eliya area. Multiplication of earthworms were done using a mother compost media stored in a 30cm x 25cm x 45cm plastic pots. Plastic pots were filled with 3cm layer of stones, 3cm layer of brick pieces, 5cm layer of soil and 20 cm layer of bedding material kept from bottom to top and placed under closed room conditions. Mixture of vegetable refuse, gliricidia leaf, wild sunflower leaf, banana stem and cow dung were used as the bedding material. After filling the pots with bedding material they were kept for two weeks to allow partial decomposition before introducing the earthworms. Top of the Plastic pots were covered with one layer of newspaper. Watering was done on a need basis and kept for one month for multiplication.

Experiment 1: Evaluation of bedding material for Vermicompost production

In the first experiment four waste materials commonly occur in tea plantations, the leaves of *Gliricidia sepium* and Mana (*Cymbopogon confertiflorus*), tea prunings and one month old refuse tea was composted using earthworm species *Eudrilus euginea*. Each bedding material were mixed either with one week old cow dung or one year old

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poultry manure at 1: 2 ratio to have eight treatment combinations. The experimental design was a Complete Randomized Design with eight treatment combinations and three replicates. Watering was done on a need basis and kept for two months for vermicompost production.

Experiment 2: Evaluation of Earthworm Species for Vermicompost production

In the second experiment *Eudrilus euginea*, *Periyonix excavator* and *Eisenia foetida* were evaluated for vermicomposting with respect to N, P and K level in the produced compost. The waste material mixture consisting Gliricidia leaf, tea prunings, mana leaf and refuse tea was blended with either cow dung or poultry manure before using as a bedding material. Hence there were six treatment combinations. The experimental design was a Complete Randomized Design with three replicates. Watering was done on a need basis and kept for two months for vermicompost production.

Measurements - Experiments 1 and 2

Total Nitrogen, Phosphorus and Potassium content, Electrical Conductivity and pH values of bedding material were measured before adding earthworms and also after two months of vermicomposting. Total Nitrogen, phosphorus and potassium contents were measured using micro kjeldhal method, spectrophotometer and flame-photometer, respectively. Conductivity meter and pH meter were used to measure EC and pH, respectively. Earthworms weighing fifty grams were added to 100g of mother compost at each of the experimental units during experiment 1 and 2.

Experiment 3: Evaluation of Vermicompost as a soil amendment.

Vermicompost produced from tea waste + poultry manure with *Eudrilus euginea* (T1) was compared with garden compost (T2) and inorganic fertilizer (T3). Twenty one day old same sized tomato plants from *Thilina* variety were used as the indicator crop in the experiment. Plastic pots were used for this experiment and they were filled with soil 5 days prior to planting of tomato plants. Both vermicompost and garden compost were added at the rate of 400g per pot. The fertilizer recommendation of the Department of Agriculture for tomato was applied under the inorganic fertilizer treatment. Application of water was done on a regular basis. Staking was practiced on 14th day after planting. Plant Height, Number of Leaves, Number of Leaflets, Number of Flowers, Number of branches, Number of fruits were measured at 1st, 2nd, 3rd and 4th week after planting. The experimental design was a Complete Randomized Design with three treatments and three replicates.

Data analysis

Data were analyzed using Statistical Analysis System (SAS) software package. Parametric data were analyzed using analysis of variance (ANOVA) and non-parametric data with categorical data analysis procedures. Significant means of treatments were separated using the Least Significant Difference Test (LSD).

III. RESULTS AND DISCUSSION

Experiment 1: Evaluation of bedding material for Vermicompost production

Total Nitrogen, Phosphorus, Potassium, Electrical Conductivity and pH values of bedding materials and vermicompost produced by the earthworm species *Eudrilus euginea* is given in the Table 1. The results indicates that vermicomposting has increased Nitrogen, Phosphorus, and Potassium contents and also the Electrical Conductivity. pH has decreased as a result of earthworm activity. It was also revealed that mean differences in N, P and K contents among different treatments were non-significant (P=0.05). Hence, it can be concluded from this study that the biodegradable waste and by-products generated during field operations and tea manufacturing such as refuse tea, shade tree loppings, tea prunings and weeds can be used as suitable bedding material for earthworms to produce high quality compost.

Table.1: Quality of vermicompost produced using Eudrilus euginea and different bedding materials.

Trt..	N (mg g^{-1})		P (mg g^{-1})		K (mg g^{-1})		PH		EC (mS cm^{-1})	
	BM	VC	BM	VC	BM	VC	BM	VC	BM	VC
T1	7.03	7.40	0.93	0.97	7.69	7.73	8.38	8.06	2.17	2.47
T2	8.90	8.90	0.93	0.96	8.59	8.61	8.06	7.85	3.19	3.77
T3	4.20	4.47	0.50	0.54	7.90	7.92	8.19	7.72	2.48	2.91
T4	6.97	7.30	1.70	1.73	9.10	9.13	8.55	8.23	3.38	3.93
T5	5.00	5.40	0.71	0.74	7.91	7.94	8.95	8.82	2.47	2.87
T6	7.07	7.37	1.31	1.33	7.77	7.79	8.06	7.49	3.51	3.85
T7	4.17	4.43	1.14	1.16	10.69	10.72	8.15	7.12	2.87	3.17
T8	4.47	4.67	0.62	0.65	11.63	11.66	8.22	7.16	3.91	4.18

Key: Trt-Treatments, BM-Bedding material, VC-Vermicompost

Treatments: T1 - Gliricidia + Cow dung, T2 - Tea prunings + Cow dung, T3 - Mana + Cow dung, T4 - Refuse tea + Cow dung, T5 - Gliricidia + Poultry manure, T6 - Tea prunings + Poultry manure, T7 - Mana + Poultry manure, T8 - Refuse tea + Poultry manure.

Experiment 2: Evaluation of Earthworm Species for Vermicompost production

Total Nitrogen, Phosphorus, Potassium, Electrical Conductivity and pH values of bedding materials and vermicompost produced by the earthworm species *Eudrilus euginea*, *Periyonix excavator* and *Eisenia foetida* are given in the Table 2. The results indicates that vermicomposting has increased Nitrogen, Phosphorus, and Potassium contents and also the Electrical Conductivity.

pH has decreased as a result of earthworm activity. It was also revealed that mean differences in N, P and K contents in the vermicompost produced by applying different treatments were non-significant (P=0.05). Hence, the study confirms that all three earthworm species evaluated in this study are suitable for producing high quality vermicompost.

Table.2: Quality of vermicompost produced by the earthworm species Eudrilus euginea, Periyonix excavator and Eisenia foetida.

Trt.	N (mg g^{-1})		P (mg g^{-1})		K (mg g^{-1})		PH		EC (mS cm^{-1})	
	BM	VC	BM	VC	BM	VC	BM	VC	BM	VC
T1	10.16	10.64	0.57	0.87	8.94	9.12	8.67	7.07	0.75	1.85
T2	10.01	10.34	1.62	1.92	12.08	12.33	8.73	6.83	3.20	5.40
T3	10.20	10.52	0.69	0.96	10.08	10.42	8.50	7.00	1.21	3.58
T4	10.84	11.22	1.54	1.95	12.52	12.82	8.73	6.80	2.72	5.61
T5	10.71	11.03	0.33	0.66	8.84	9.18	8.43	7.23	1.42	2.38
T6	9.65	10.06	2.17	2.61	10.57	10.95	8.67	6.93	2.53	4.80

Key: Trt-Treatment, BM-Bedding material, VC-Vermicompost

Treatments: T1 – *E. euginea* + Cowdung, T2 – *P. excavator* + Cowdung, T3 – *E. foetida* + Cowdung, T4 – *E. euginea* + Poultry manure, T5 – *P. excavator* + Poultry manure, T6 – *E. foetida* + Poultry manure

Experiment 3: Evaluation of Vermicompost as a soil amendment.

In this experiment vermicompost produced from tea waste + poultry dung with *Eudrilus euginea* was compared with garden compost and inorganic fertilizer by taking tomato as an indicator crop. Vermicompost applied treatment showed significantly higher (P<0.05) fruit weight (g/plant) and number of branches per plant when compared to other two treatments (Table 3). This shows that vermicompost is a useful soil amendment for producing vegetables such as tomato.

Table.3: Number of branches produced at weekly intervals and mean fruit weight (g/plant) of tomato in relation to three treatments.

Treatment / WAP	Number of branches			Mean fruit weight (g/plant)
	2WAP	3WAP	4WAP	
Vermicompost	5.46^c±0.49	5.77^b±0.70	6.38^b±0.49	363.9^b±52.8
Garden compost	1.27^a±0.12	1.27^a±0.12	1.69^a±0.26	128.3^a±9.48
Inorganic fertilizers	2.68^b ±0.43	2.68^a±0.43	2.99^a±0.38	134.7^a±15.00
LSD	1.32	1.65	1.35	111.3

Key: WAP-Weeks after planting, LSD-Least Significant Difference.

Difference of means denoted by same letter are non-significant.

IV. CONCLUSIONS

The results of the experiment shows that waste material generated from field operations of tea plantations and tea manufacturing such as Gliricidia leaf, tea prunings, mana leaf and refuse tea after mixing with cow dung or poultry manure can be used successfully as bedding material for earthworms for producing vermicompost. The study also shows that *Eudrilus euginea*, *Periyonix excavator* and *Eisenia foetida* are suitable earthworm species for vermicomposting. Further it is observed that vermicompost is a useful soil amendment when compared to garden compost and inorganic fertilizer for the successful culture of tomato. Similar results have been reported by many authors including Chanda *et al*, (2011), Tringovska and Dintcheva, (2012) and Basheer and Agrawal, (2013) when vermicompost was used in the growing media for tomato.

Based on the results of this study it can be concluded that there is a high potential for developing vermitech as a technology for improving soil fertility for crop production systems in Sri Lanka.

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