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Research Article

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Banana and Manure Waste on Growth, Reproduction and Vermicompost of *Eisenia foetida*

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Abstract

The most promising earthworm species used for vermicomposting are *Eisenia foetida* due to tolerance to large range of moisture levels and temperature. These earthworms were grown in different ratio of banana and cow manure wastes and number of cocoon, number of adults worms, weight gain, total worm population and vermicompost amount were examined to assess the effect of cow manure and banana pseudo mix on growth, reproduction and vermicomposting ability of E. foetida. Earthworm growth and reproduction showed significant differences in response to feed treatments. In all parameters, the highest record was achieved when the amount of cow dung is 60% or more in the feed mix.

Keywords: Earthworms, Bedding, Cocoon, Growth rate

Introduction

Proper utilization of wastes can enhance soil physical condition and environmental quality as well as provide nutrients and increase different crops yield (Kibatu and Mamo, 2014; Edwards and Bohlen 1996; Edwards, 1998). However, the fertilizer values of plant and animal wastes are not being fully utilized. This results in loss of potential nutrients and environment pollution (Reinecke et al, 1992). Vermicomposting is an earthworm based aerobic process which has been widely recognized as low capital and operational cost, most efficient, sustainable and eco-friendly methods for converting waste materials to safe and valuable products (Dominguez, 2004; Garg et al., 2005; Hand et al., 1988). In vermicomposting process earthworms act as mechanical blenders and by comminuting the organic matter, they modify its biological, physical and chemical status, gradually reducing its C:N ratio, increasing the surface area and making it much more favorable for microbial activity and further decomposition (Dominquez, 2004; Atiyeh et al., 2000).

The most promising earthworm species used for vermicomposting are Eisenia foetida, Eisenia andrei, Eudrilus eugeniae and Perionyx excavatus (Sinha et al, 2002; Garg et al., 2006). E. foetida species distribute worldwide due to tolerance to large range of moisture levels and temperature (Sinha et al, 2002; Reinecke et al., 1992, Aira et al., 2007; Kaplan et al., 1980; Neuhauser et al., 1980). Moreover, E. foetida can be handled easily and it is tolerant to other species (Aira et al., 2002; Loehr et al., 1985). As a result, most studies of vermicomposting focus on the species Eisenia foetida (Reinecke et al., 1992; Tripathi & Bhardwaj, 2004).

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Table 1 Chemical property of cow manure and banana waste

Parameter	Cow manure	Banana waste
Electrical conductivity	7.95 ds/m	20.1 ds/m
Organic carbon	41.02 %	40.07 %
Total nitrogen	1.91 %	0.77 %
pH (H2O)	9.02	10.01
Total Phosphorous	6853 mg/Kg	748.17 mg/kg
Total Potassium	35750 mg/Kg	24.14 %
Available phosphorous	1665.5 mg/Kg	
Available Potassium	5.43 mg/Kg	
Moisture		11.47 %

Table 2 The effect of banana and cow manure waste on growth, reproduction and vermicomposting performance of *E. fetida*

Treatments†	Number of Cocoon (NC)	Number of Adults Worms (NA)	Weight gain (g) (WG)	Total worm Population (WP)	Vermicompost amount (kg) (VA)
T1 (1000g CD)	236[b]	106.3[a]	65.7[a]	260[b]	353.7[a]
T2 (800g CD + 200g BW)	355[a]	46.0[b]	56.0[b]	472[a]	224.6[b]
T3 (600g CD +400g BW)	151[c]	31.3[c]	52.9[b]	241[b]	118.2[c]
T4 (400g CD + 600g BW)	92[d]	25.3[cd]	27.8[c]	184[b]	123.4[c]
T5 (200g CD + 800g BW)	10[e]	20.0[d]	17.5[d]	19[c]	66.0[cd]
T6 (1000g BW)	4[e]	22.0[cd]	8.7[e]	25[c]	12.9[d]
ANOVA††					
Treatments	**	**	**	**	**
Error	208.8	32.3	14.9	2073.5	3.13

†Followed by the same letter within column are not significant using Duncan's test at the $p < 0.05$
†† The asterisks (**) indicate significance at $P<0.01$

The sexual maturity in earthworms has been suggested to be stimulated by quality and intake of feed (Bohlen, 2002). Mostly some types of plant waste are mixed with animal residues. Various organic wastes tested in past as feed material for different species of earthworms such as pig waste, crop residues, cow slurry, cattle manure and textile mill sludge (Chan and Griffiths, 1988; Reeh, 1992; Bansal and Kapoor 2000 ; Hand, et al, 1988 ; Mitchell, 1997). The growth (biomass) and reproduction (cocoons and hatchlings) of earthworm in different culture media such as mixture of animal and vegetable wastes (Loehr et al, 1985), kitchen waste (Chaudhuri et al, 2000); animal wastes (Loh et al, 2005) ; different organic wastes (Aira and Dominguez, 2008); and baggase (sugar industrial waste) (Ananthakrishnasamy et al, 2007) were studied.

Crop residues from farm activities and similar derivatives could be mixed with animal slurries which have a high N amount to make a favorable feed for earthworms (Bansal and Kapoor, 2000). Yadav and Garg (2009) made a summary of suitable waste materials which could be mixed with some industrial wastes as a pre-treatment before using them as feed materials for vermicomposting by several earthworm species. Considerable work has been carried out on vermicomposting of various organic materials such as animal dung, agricultural waste, forestry wastes, leaf litter and food wastes (Hand et al., 1988; Singh and Sharma, 2002).

All aspects of the worm biology such as feeding habits, reproduction and biomass production potential must be known in order to utilize the earthworms successfully in vermiculture (Prabha et al., 2007). Different type of bedding give different kind of result on selected biological parameters and amount of vermicompost. Each of bedding material has its own characteristic that differ from one another and can influence the parameter that been studied (Garg et al, 2005). Eisenia foetida, like other earth worm species, requires different ecological and physico-chemical conditions for its optimal development, growth and re-production (Domínguez and Edwards, 2004). In order to utilize this species effectively for vermicomposting of different crop and animal wastes, its vermicomposting ability and response to growth and reproduction should be known. Therefore, the objective of this study was to investigate the effect of cow manure mixed with coffee husk, and banana pseudo stem on growth, reproduction and vermicomposting ability of E. foetida.

Materials and methods

Preparation of Earthworms*:* Eisenia foetida were brought from Adet Agricultural Research Institute. They were raised in College of Agriculture and Natural Resources, Department of Horticulture, Dilla University in wooden worm bin until the required amounts of healthy earthworms were achieved for the experiment.

Preparation of cow manure*:* Fresh waste of cow manure was collected in advance of other wastes from dairy farm at College of Agriculture and Natural Resources, Dilla University. It was air dried, powdered and stored in sack until other experimental materials were ready for the experiment.

Preparation of banana pseudo-stem: Banana pseudo-stems were collected from the nearby local farmers immediately after harvesting. Then it was pre-composted in cement tank (1m x 1m x 1m) for 20 days to eliminate produced toxic gases and to avoid the mortality of worms.

Experimental setup: The experiment was performed in laboratory and all the containers were kept in darkness under identical ambient room temperature (24 - 28°C). The moisture content was maintained at 65-70% of water holding capacity by periodic sprinkling of an adequate quantity of water. No additional feed was added at any stage during the study periods. Banana pseudostem waste (BW) was mixed with the dry cow dung (CD) in six proportions: 1000g CD (T1), 800g CD + 200g BW (T2), 600g CD +400g BW (T3), 400g CD + 600g BW (T4), 200g CD + 800g BW (T5), and 1000g BW (T6). Then, these 1000g substrates were introduced in to pot in three replicate and left for one day. Hence, earthworms were easily settled themselves in the new habitat. Subsequently, sexually mature and clitilated 10 ± 1.1 grams (mean ± SD) E. foetida in their good health condition were introduced in each of the respective containers and no additional feed was added into the containers at any stage during the study periods.

Parameters measured: At the end of experiment (after 8 weeks), the substrate materials in each treatment was turned out. Biomass of intended worms was determined by measuring the wet weight. To accomplish these, the worms were removed from the bedding by hand, gently removed all of extraneous material and the biomass of total population and adult (clitilated) worms were weighed and counted. Cocoons were counted by hand sorting using electronic balance. Weight gain was taken as the difference between the initial weight of worms stocked and final weight of worms produced. Relative growth rate (RGR) was calculated as follows:

$$RGR = \frac{weight\ gain}{initial\ body\ weight}\ x\ 100 \qquad \text{----------------- (1)}$$

Specific growth rate (SGR) was computed using the formula below:

$$SGR = \frac{Logw_f - Logwi}{t}\ x\ 100 \qquad \text{-------------------------- (2)}$$

Where: logwf = logarithm of final weight; logwi = logarithm of initial weight; t = the experimental period in days.

Chemical analysis: The chemical analysis was made by the standard methods (Table 1). The pH was determined (water extraction, 1:2.5 ratio) by potentiometric method. Organic carbon was measured by loss on ignition at 550oC. Total Kjeldahl nitrogen was determined by the method of Bremner and Mulvaney (1982). The available phosphorus was determined by colorimetric methods. Total potassium and determined by ammonium acetate extract.

Statistical analysis: Duncan mean separation tests were used to evaluate differences between treatments at a significance level of 95% (P<0.05) using the SPSS 17.0 software package. The data were processed with Microsoft Excel 2007. Figures and graphs were drawn by Sigma Plot 10.0. All the reported data are the arithmetic means of three replicates.

Results and discussion

Cocoon number, weight gain and growth rate: The analysis of variance test shows a significant difference (P<0.01) among the different treatments in influencing these parameters. The difference in cocoon number could be related to quality of the food as biochemical quality is an important factor in determining onset of reproduction (Edwards et al., 1998; Flack and Hartenstein, 1984). The difference in weight gain in earthworms related to chemical quality and decomposition activities as easily metabolize organic matter and non-assimilated carbohydrates favor growth of earthworms (Lazcano et al., 2008; Jesikh and Lekeshmanaswamy, 2013; Latifah et al 2009; Suthar, 2007).

The relative and specific growth rates: These parameters were showed increasing trend as ratio of cow manure increased and reached 60% in the treatments. Then they showed almost similar and constant growth rate (Figure 1, Figure 2).

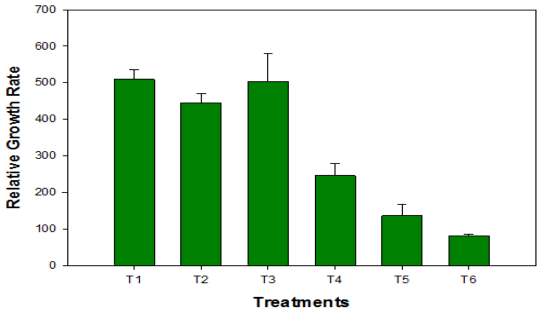

Figure 1: The effect of banana and animal waste in specific growth rates

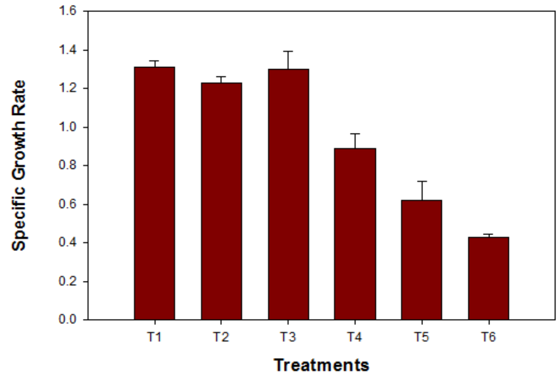

Figure 2: The effect of banana and animal waste in specific growth rates

Similar observations have been reported by Latifah et al (2009), Garg et al (2005) and Chaudhuri & Bhattacharjee (2002). Kavitha, et al (2010) suggested addition of 20-40% banana waste to the cow dung as a raw material in the vermicomposting.

Growth and reproduction in earthworms require organic carbon, nitrogen and phosphorus (Edwards and Bohlen, 1996) which, in this study, expected to come more from cow manure than banana pseudo-stem (Table 1).

The analysis of variance test shows a significant difference among the different treatments in influencing the number of worms. The maximum worm population and number of adult worms were gain in T2 (472) and T1 (106.3) respectively. In both case the minimum was recorded in T5 and T6, which were statistically at par. In case of number of adult worms, no significant difference was shown among T4 (25), T5 (20) and T6 (22), and between T3 (31) and T4 (25). In case of total number of worm population did not vary significantly between T3 (241) and T4 (184) treatments and between T5 (19) and T6 (25) treatments (Table 2). The factor that influences the number of worm is related to the cocoons production (Latifah et al, 2009). As the number of cocoon increases, the total worm population increases. This strong correlation (0.941) is also confirmed by Pearson correlation analysis of means (Table 3).

Table 3: Pearson correlation coefficients between the different biological parameters†

Parameters	Number of Adults	weight gain (g)	Total worm population	Vermicompost (kg)
NC	0.578*	0.192	0.941**	0.738**
NA	1	0.660**	0.414	0.857**
WG		1	0.120	0.522*
WP			1	0.597**

†CN: number of cocoons; AW: number of adult worms; WG: weight gain (g); TWP: worm population; VA: vermicompost amount (g), * Significant at $p<0.05$, ** Significant at $P<0.01$

Vermicompost amounts were significantly ($p<0.01$) affected by the different waste treatments (Table 2). However, no significant difference was shown among the T3 (118g) T4 (123g) and T5 (66g), and between T5 (66g) and T6 (12g). The maximum vermicompost amount was recorded in treatment T1 (354g). The minimum amount of vermicompost was recorded in T6 (12g), which had only banana pseudo stem (Table 2). This might show the great influence of cow manure on the production of vermicompost. In the other hand, Pearson correlation analysis of means showed a strong positive correlation of number of cocoon and number of adults with vermicompost amount (Table 3). This might be due to high utilization of energy for mating and other reproduction purpose, which results more feed taking and more excreta (Jesikha and Lekeshmanaswamy, 2013).

Conclusion

Earthworm showed significant differences in response to feed treatments which illustrated that each of the treatment has its own advantages and disadvantages that might come from difference in palatability and chemical contents. In this study, the number of adult worms, number of cocoon, weight gain, worm population and vermicompost amount varied among the treatments. In all parameters, the highest record was achieved when the amount of cow dung is 60% or more to the banana waste in the feed mix.

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