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Vermicomposting of banana agro-waste using an epigeic earthworm *Eudrilus eugeniae* (kinberg)

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Abstract

Banana is a major cash crop in India, generating vast agricultural waste after harvest. The aim of this work was to investigate the potential of banana-agro waste (dried leaves and pseudostem biomass) mixed with cow dung into vermicompost using earthworm *E. eugeniae*. Five treatments containing banana waste (BW) and cow dung (CD) in different ratios, were run under laboratory conditions. The maximum growth and reproduction was obtained in 0.20 kg BW + 0.80 kg CD treatment (T_5), but worms grew and reproduce favourable in 0.20 kg BW + 0.60 kg CD treatment (T_4) also. The earthworm mortality was higher in treatment those contained 1.00 kg BW alone (T_1) and BW proportions ie. 0.80 kg BW + 0.20 kg CD (T_2) and 0.60 kg BW + 0.40 kg CD (T_3), respectively. Study revealed that greater proportion of BW in feed mixtures significantly affected the growth and reproduction during vermicomposting. In all the treatments, a decrease in pH, OC, C:N ratio, but increase in N, P and K was recorded at the end of experiment and comparatively T_4 and T_5 treatments showed great increase (from its initial level) for N, P and K than the other treatments (T_1, T_2 and T_3). This study clearly indicates that BW could be potentitally useful as raw substrate in vermicomposting if mixed with CD in appropriate quantities.

Keywords: Cow dung, banana waste, Eudrilus eugeniae, vermicompost, nutrient content

1. Introduction

Agricultural by-products, e.g. animal dung, farm yard manure and crop residues are potential sources of plant nutrients. According to a conservation estimation, around 600-700 million tonnes (mt) of agricultural waste are available in India every year, but most of it remains unutilized (Suthar, 2008). Banana is an important food crop of the world which is cultivated over an area of more than four million hectares and its annual production is more than seventy million tonnes. India is one of the leading producers of banana, which are mostly grown in Tamil Nadu State. After the harvest of the fruits the whole plant (leaves, stem and rhizome) is left in the agriculture field for natural degradation, which takes several months. Earthworms have been used in the vermiconversion of urban, industrial and agro-industrial wastes to produced biofertilizers (Elvira et al., 1998). It is well established that a large number of organic wastes can be ingested by earthworms and egested as peat like materials termed as vermicompost (Sangwan, 2008). According to Dominquez (2004), during vermicomposting 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 are exposed to microorganisms, and making it much more favourable for microbial activity and further decomposition.

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Several epigeics (Eisenia fetida, Eudrilus eugeniae, Perionyx excavatus) have been identified as a potential candidates to decompose organic waste materials (Sinha, 2002; Garg et al., 2006). Traditionally vermicompost has been generated with animal manure as the substrate and has been recognized as a good soil conditioner and fertilizer (Ismail, 1997). In recent years, other organic substrates have also been vermicomposted and the products have been found to be as good as the manure based vermicompost (Gajalakshmi et al., 2002). Therefore, the objective of this study was to test the efficient composting of banana waste spiked with organic supplement, i.e., cow dung using an epigeic earthworm Eudrilus eugeniae (Kinberg).

2. Materials and methods

2.1. Eudrilus eugeniae, banana waste (BW) and cow dung (CD)

Healthy clitellate specimen of E. eugeniae used in the experiment were picked from stock culture maintained in the laboratory, Department of Zoology and Biotechnology, A.V.V.M. Sripushpam College (Autonomous), Poondi, Thanjavur, India. The Banana agro waste (dried leaves and pseudostem) were collected from local farm following harvest. The main physico-chemical characteristics of BW were pH (1: 10 ratio), 8.1 ± 0.03; OC (%) 10.5 ± 0.04; N (%) 0.16 ± 0.05; P (%) 0.06 ± 0.0; K (%) 0.14 ± 0.02; C:N ratio 31.30 ± 0.08. Fresh CD was procured from an intensively live stocked farm at Poondi, Thanjavur,

Table-1: Physico-chemical characteristics of initial feed mixtures and vermicompost obtained from different treatments

Treatments		pH	OC (%)	N (%)	P (%)	K (%)	C:N (%)
T_1	**Initial**	8.1 ± 0.03	10.5 ± 0.04	0.16 ± 0.05	0.06 ± 0.0	0.14 ± 0.02	10.5 ± 0.14
	Final	7.4 ± 0.01	6.1 ± 0.01	0.30 ± 0.21	0.21 ± 0.03	0.29 ± 0.01	5.0 ± 0.12
T_2	**Initial**	8.2 ± 0.01	10.9 ± 0.03	0.23 ± 0.03	0.09 ± 0.01	0.16 ± 0.02	12.8 ± 0.37
	Final	7.5 ± 0.03	6.3 ± 0.02	0.45 ± 0.27	0.25 ± 0.01	0.31 ± 0.03	7.3 ± 0.29
T_3	**Initial**	8.1 ± 0.02	18.1 ± 0.01	0.36 ± 0.08	0.13 ± 0.02	0.22 ± 0.01	29.6 ± 0.52
	Final	7.4 ± 0.02	10.2 ± 0.21	0.70 ± 0.37	0.29 ± 0.01	0.46 ± 0.01	10.2 ± 0.54
T_4	**Initial**	8.3 ± 0.03	23.4 ± 0.15	0.48 ± 0.12	0.26 ± 0.02	0.30 ± 0.04	51.7 ± 1.16
	Final	6.9 ± 0.01	10.4 ± 0.17	1.21 ± 0.28	0.56 ± 0.02	0.82 ± 0.03	13.1 ± 0.61
T_5	**Initial**	8.2 ± 0.02	25.5 ± 0.17	0.52 ± 0.17	0.29 ± 0.01	0.31 ± 0.01	55.2 ± 1.20
	Final	7.0 ± 0.02	11.6 ± 0.25	1.25 ± 0.78	0.52 ± 0.04	0.81 ± 0.04	14.2 ± 0.27

All values are the mean and standard deviation of three replicates

Table 2:Total number of hatchlings, cocoons and biomass production in different treatments

Treatment	Mean initial biomass (mg worm^{-1})	Mean final biomass (mg worm^{-1})	Net weight gain (mg worm^{-1})	Mean individual growth (mg day^{-1})	Total cocoons production	Total number of hatchlings
T_1 (100%)	718 ± 21.2	842 ± 22.5	124 ± 21.3	2.06	16 ± 7.0	21 ± 1.2
T_2 (80:20)	713 ± 28.3	913 ± 27.6	200 ± 10.7	3.31	43 ± 6.3	96 ± 5.5
T_3 (60:40)	693 ± 20.4	962 ± 34.3	269 ± 13.9	4.48	62 ± 8.1	121 ± 4.3
T_4 (40:60)	706 ± 27.6	1127 ± 24.2	427 ± 23.4	7.12	85 ± 5.0	186 ± 6.9
T_5 (20:80)	729 ± 31.5	1132 ± 34.6	409 ± 11.2	6.91	87 ± 3.7	192 ± 5.3

All values are the mean and standard deviation of three replicates

were pH (1:10 ratio) 8.0 ± 0.03; OC (%) 32.8 ± 0.34; N (%) 0.58 ± 0.21; P (%) 0.37 ± 0.13; K (%) 0.42 ± 0.16; C:N ratio 62.3 ± 3.26. The BW were cut into pieces of 2-3 cm for the present study before mixing with CD.

2.2. Experimental setup

Five feed mixtures having different ratios of BW and CD, including BW alone was established. One kg of feed mixtures (on dry weight basis) was put in each circular plastic container (vol 10 L, diameter 40 cm, depth 12 cm). The composition of the BW and CD in different treatments is given below:

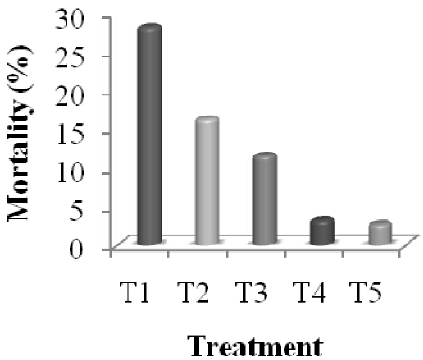
Treatment 1 (T1)	:	1.00 kg BW
Treatment 2 (T2)	:	0.80 kg BW + 0.20 kg CD
Treatment 3 (T3)	:	0.60 kg BW + 0.40 kg CD
Treatment 4 (T4)	:	0.40 kg BW + 0.60 kg CD
Treatment 5 (T5)	:	0.20 kg BW + 0.80 kg CD

The moisture content of the feed in each treatment was maintained at 60-80% by periodic sprinkling of adequate qualities of water. All the containers were kept in darkness under identical ambient room temperature (24 - 28°C). The experiments were replicated thrice for each treatment. At the end of experiment (after 60 days), the substrate material in each treatment was turned out. The earthworms, hatchlings and cocoons were separated from the feed by hand sorting, after which they were counted and weighed after washing with water and dried by paper towels. The worms were weighed with full gut content.

2.3. Physico-chemical analysis

The pH was measured using digital pH meter in 1/10 (w/v) aqueous solution. The nutrient parameters of vermicompost produced after experiments were analysed by using standard methods. Organic carbon (OC) was determined by the partially oxidation method (Walkley and Black, 1934). Nitrogen content (N) was estimated by Kjeldahl method (Bremner and Mulvaney, 1982). Phosphorus (P) was analysed using the colorimetric method (John, 1970). Potassium (K) was determined (acid digest) by flame photometer. C:N ratio was calculated from the measured value of C and N.

Fig 1: Mortality rate of *Eudrilus eugeniae* in different treatment



2.4. *Statistical analysis*

All the reported data are the arithmetic means of three replicates. Two-way analysis of variance (ANOVA) was done to determine any significant difference among the treatments analysed during vermicomposting at 0.05% level of significance.

3. Results and discussion

3.1. Physico-chemical changes during vermicomposting

Physico-chemical properties of vermicompost for five different treatments are presented in Table 1. A decrease in pH was recorded in all treatments during vermocomposting. pH ranged between 6.9 ± 0.01 (T4) and 7.5 ± 0.03 (T2) in feed materials, lower than initial levels (Table 1). The shift in pH during the study could be due to microbial decomposition during the process of vermicomposting (Elvira et al., 1998). All the treatments showed a similar pattern of change in OC, which reduced from the initial value in the range of 10.5 ± 0.04 – 25.5 ± 0.17. The maximum reduction was observed in T4 (10.4 ± 0.17) and T5 (11.6 ± 0.25) treatments. In the present study, reduction of OC in all the treatments after vermicomposting indicates net organic matter stabilization in the substrate due to joint action of earthworms and microorganisms (Elvira et al., 1996). In the experiments N content was significantly higher in the vermicompost than initial substrate material. N concentration in the vermicompost of different treatments was in the order T5 (1.25 ± 0.78) > T4 (1.21 ± 0.28) > T3 (0.70 ± 0.37) > T2 (0.45 ± 0.27) > T1 (0.30 ± 0.21). Results clearly suggested that N increase in vermicomposted materials was directly related to the physico-chemical properties of the initial substrates. Most other reports on vermicomposting (Benitez et al., 1999; Elvira et al., 1996; Suthar, 2007) have reported a higher N increase at the end. The P content in vermicomposted materials was higher in all the treatments at the end. The highest increase in P content was in T4 (0.56 ± 0.02) followed by T5 (0.52 ± 0.04), T3 (0.29 ± 0.01), T2 (0.25 ± 0.01) and T1 (0.21 ± 0.03). Increase in P content during vermicomposting is probably through mineralization and mobilization of phosphorus by bacterial and faecal phosphatase activity of earthworms (Khwairakpam, 2009). Similarly, there was about 2-fold increase in K content of the final vermicompost in all the treatments compared with K content in initial feed mixtures (Table 1). Suthar (2007) have reported that earthworm processed waste material contains higher concentration of exchangeable K due to enhanced microbial activity during the vermicomposting process, which consequently enhances the rate of mineralization. The C:N ratio traditionally considered as a parameter to determine the degree of maturity of compost. C:N ratio below 20 is indicative of acceptable maturity, while a ratio of 15 or lower being preferable. In this study, vermicompost from all treatments is preferable as C:N ratio stated 5.0 ± 0.12 – 14.2 ± 0.27 (Table 1).

3.2. Growth and reproduction by E. eugeniae in different treatments

The growth, number of cocoon and hatchlings production varied among different treatments. Statistically, growth and reproduction of E. eugeniae showed significant different patterns of means individual growth rate (mg day-1), mean individual weight gain (mg wt. worm-1), total cocoon number, hatchlings production and mortality. However, growth and reproduction of earthworm did not show any significant different among T4 and T5 treatments (Table 2). Suthar (2009) have reported proportion and quality of bulking material in the treatments not only influenced the mineralization rate but also altered the earthworm biomass production rate. In the present study maximum individual net weight gain for E. eugeniae was in T4 (427 ± 3.4 mg) treatment followed by T5 (409 ± 11.2), T3 (269 ± 13.9), T2 (200 ± 10.7) and T1 (124 ± 21.3 mg) treatments. The individual growth rate (mg wt. day-1) in different treatments ranged between 2.06 (T1) and 7.12 (T4). The difference in growth rate among different treatments seems to be closely related to feed quality. Crop residues have different palatability, particle size, protein and crude fiber contents and even some concentration of special plant metabolities and related substances (Suthar, 2008). The excellent growth rate in T4 and T5 treatments could be due to its palatability and more acceptability as food by worms. Total cocoon numbers were significantly different among different treatments. But cocoon numbers did not vary significantly between T4 (85 ± 5.0) and T5 (87 ± 3.7) treatment (Table 2). The maximum and minimum hatchlings number was recorded in T5 (192 ± 5.3) and T1 (21 ± 1.2). The greater percentage of BW in the feed mixture significantly affected cocoon and hatchlings production. Edwards et al. (1998) concluded that the important difference between the rates of cocoon production in the different organic wastes must be related to the quality of the wastes. Recently, Lazcano et al. (2008) summarized that except to the quality and chemical properties of waste, the microbial biomass and decomposition activities during vermicomposting were also important. The difference between biomass and cocoon production in different treatments could be related to the biochemical quality of the feed, which was one of the important factors in determining onset of cocoon production (Flack and Hartenstein, 1984). Earthworm mortality was between the ranges of 2.7 ± 0.62 (T5) and 28.2 ± 4.27 (T1), among treatments. However, earthworm mortality did not show significant difference between T4 and T5 treatments (Fig. 1). It suggest that the higher content of BW affects the survival rate of earthworms in waste decomposing system. Garg and Kaushik (2005) reported that E. foetida showed more mortality in beddings, which contained lower amounts of organic supplements in textile mill sludge vermibeds. Finally the results suggest that the addition of 20-40% BW to the CD, it can be used as a raw material in the vermicomposting.

References

Benitez, E., Nagales, R., Elvira, C., Masciandaro, G. and Ceccanti, B. (1999). Enzyme activities as indicators of the stabilization of sewage sludge composting with *Eisenia foetida*. Biores. Technol. 67: 297-303.

Bremmer, J.M. and Mulvaney, R.G. (1982) 'Nitrogen Total', In: Page A.L. Miller, R.H., Keeney, D.R., *Method of Soil Analysis*, edn., American Society of Agronomy, Madison, pp. 575-624.

Dominguez, J. (2004). State of the art and new perspectives on vermicomposting research. In: Edwards, C.A. (Ed.), Earthworm Ecology, Second ed. CRC Press, pp. 401-424.

Edwards, C.A., Dominguez, J. and Neuhauser, E.F. (1998) 'Growth and reproduction of *Perionyx excavatus* (Perr.) (Megascolecidae) as factors in organic waste management', *Biol. Fertil. Soils*, Vol. 27, pp. 155-161.

Elvira, C., Sampeelro, L., Benitez, E. and Nagales, R. (1998) 'Vermicomposting of sludges from paper mill and dairy industries with *Eisenia andrei*: a plot scale study', *Bioresour. Technol.*, Vol 62, pp. 205-211.

Flack, F.M. and Hartenstein, R. (1984). Growth of earthworm *Eisenia foetida* on microorganisms and cellulose. Soil. Biol. Biochem., 16, 491-495.

Gajalakshmi, S., Ramasamy, E.V. and Abbasi, S.A. (2002) 'Vermicomposting of paper waste with the anecic earthworm *Lampito mauritii* Kinberg', *Indian J. Chem. Technol.*, Vol. 9, pp. 306-311.

Garg, V.K. and Kaushik, P. (2005) 'Vermistabilization of textile mill sludge spiked with poultry droppings by an epigeic earthworm *Eisenia fetida*', *Bioresour. Technol.*, Vol. 96, pp. 1063-1071.

Garg, V.K., Kaushik, P. and Dilbagi, N. (2006). Vermiconversion of wastewater sludge from textile mill mixed with an aerobically digested biogas plant slurry employing *Eisenia foetida*. Ecotoxicol. and Environ. Safety, 65: 412-419.

Ismail, S.A. (1997). Vermitechnology: The biology of earthworms. Orient Longman Limited, Chennai.

John, M.K. (1970). Colorimetric determination of phosphorus in soil and plant material with ascorbic acid. Soil Science. 109, 214-220.

Khawairakpam, M. and Bhargava, R. (2009) 'Vermitechnology for sewage sludge recycling', *J. Hazard. Mater.*, Vol. 161, pp. 948-954.

Lazcano, C., Brandon, M.G. and Dominguez, J. (2008) 'Comparison of the effectiveness of composting and vermicomposting for the biological stabilization of cattle manure', *Chemosphere*, Vol. 72, pp. 1013-1019.

Manivannan, S., Ramamoorthy, P., Parthasarathi, K. and Ranganathan, L.S. (2004) 'Effect of sugar industrial waste on the growth and reproduction of earthworms', *J. Exp. Zool. India*, Vol. 7, pp. 29-37.

Sangwan, P., Kaushik, K. and Garg, V.K. (2008) 'Vermiconversion of industrial sludge for recycling the nutrients', *Bioresour. Technol.*, Vol. 99, pp. 8699-8704.

Sinha, R.K., Heart, S., Agarwal, S., Asadi, R. & Carretero, E. (2002): Vermiculture and waste management: study of action of earthworms *Eisenia foetida*, *Eudrilus eugeniae* and *Perionyx excavates*. On biodegradation of some community wastes in India and Australia. – Environmentalist 22: 261-268.

Suthar, S. (2007) 'Vermicompsting potential of *Perionyx sancibaricus* (Perrier) in different waste material', *Bioresour. Technol.*, Vol. 98(6), pp. 1231-1237.

Suthar, S. (2008). Bioconversion of post harvest crop residues and cattle shed manure into value added products using earthworm *Eudrilus eugeniae* Kinberg. Ecol. Engineer., 32: 206-314.

Suthar, S. (2009) 'Vermistabilization of municipal sewage sludge amended with sugarcane trash using epigeic *Eisenia fetida* (Oligochaeta)', *J. Hazard. Mater.*, Vol. 163, pp. 199-206.

Walkley, A. and Black, I.A. (1934). Chronic acid titration for determination of soil organic matter. Soil. Sci., 63, 251.