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RESEARCH ARTICLE

Vermiconversion of leaf wastes *(Ficus benghalensis and Ficus racemosa)* by employing *Eudrilus eugeniae*

[1]Esaivani C, B. Esakiammal[1], K.*Vasanthi[1] R.Nithya[1], and K. Chairman[2]

1.Department of Zoology, Sri Parasakthi College for Women, Courtallam, M.S.University, Tirunelveli, Tamilnadu, India

2.Department of Microbiology, Kamarajar Arts College, Surandai, M.S.University, Tirunelveli, Tamilnadu, India

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Corresponding Author

vasanthispc@gmail.com

Abstract

At present, one of the most important intimidations for human is the disposal of different organic waste . These wastes include tree leaves, garden wastes, agricultural wastes etc. Leaves are potential sources of valuable nutrients providing a high quality of organic matter, which should be returned to the soil. The leaves of most trees contain twice as many minerals as manure. The nutrient fluxes from the trees to soil via litter. Using this rich natural fertilizer makes less reliance on chemical fertilizers which are major pollutants entering the environment. Leaf litter can be utilized as manure by vermicomposting. This study reports the results of vermicomposting with *Eudrilus eugeniae* of *ficus benghalensis* and *ficus racemosa* mixed with cowdung in different ratios (1:1 and 2:1) in a 90 days experiment. In all the treatments a decrease in p^H ,TOC and C/N ratio , whereas increase in EC, TN, TP, TK, Ca and Mg was recorded. The cocoon production and growth rate (biomass gain worm $^{-1}$ day $^{-1}$) were maximum in T_1 mixture containing leaves of *ficus benghalensis* and cowdung in (1:1) ratio followed by T_2 ,T_4 ,T_3 and T_0 respectively. The results indicate that eventhough both the leaves selected for the study belongs to the same genus ficus with immense medicinal value they differ in their allelochemical composition which greatly influenced the palatability of *E. Eugeniae*. Thus vermicomposting is the sustainable ,low – cost and easy solution for the beneficial utilization of such huge quantities of dry leaves**.**

1. INTRODUCTION

Increasing awareness of people on deforestation, air pollution, global warming, climatic changes, etc. and also the encouragement for a forestation under social forestry programmes of government of India since 1976 have given the opportunity to grow more and more trees along the roads, rail lines, backyards, bunds and wastelands by the local residents. These trees produce a considerable quantity of dry leaves throughout the year. Dry leaves are generally collected by the rural habitants in villages of poor and developing countries to use as biomass fuel for cooking. Dry leaves of avenue and fruits trees are usually burnt in India cities to keep the area clean. Burning of fallen leaves is hazardous to human health since it burns slowly due to the presence of moisture and produces poisonous carbon monoxide, sulphur dioxide, carcinogenic benzo(a)pyrene and large amount of airborne particulates- fine bits of dust, soot and other solid materials. These particulates, after reaching deep into lung diseases, can cause coughing, wheezing, chest pain, shortness of breath and sometimes long-term respiratory problems. Besides irritating the eyes, nose and throat of healthy adults, breathing of leaf smokes can really wreak havoc on small children as well as elderly problems to persons with asthma and other lung or heart diseases.

Leaf litter, if left on the soil, contributes significantly towards protecting and enriching the soil (Dash,1993). But leaf litter accumulating in the urban and suburban locations such as sidewalks, lawns, and playgrounds is not only an unseemly sight but adds to the overall problem of municipal solid waste (MSW) disposal. In India and several other countries in the Southern Hemisphere, leaf litter is often piled-up and set on fire. The resulting ash returns some of the NPK content of the litter to the soil but much of nitrogen, phosphorous, and organic carbon gets lost. Leaf litter can be composted and used as a fertilizer or soil conditioner but the market value of the compost is not high. Due to this factor, few people in urban/suburban localities take the initiative of collecting leaf litter and generating compost from it. On the other hand vermicompost is priced about three times higher than compost and is a favourite soil conditioner of the farmers, especially in developing countries. Apart from providing to the soil organic carbon and NPK, which a compost does, vermicompost is believed to have additional attributes of providing enzymes and hormones which stimulate plant growth (Abbasi and Ramasamy,1999; Atiyeh *et al*., 2001,2002; Doube *et al*., 1997; Chaoui *et al*.,2003). Vermicompost is, also believed to be more pathogen- free than compost (Szczech,1999; Slocum 2002). In view of this we have explored the possibility of producing valuable compost by vermicomposting leaf litters of the genus *ficus.*

2. METHODS

Cow dung(CD), *Eudrilus eugeniae*, *Ficus benghalensis* and *Ficus racemosa.*

2.1 Cow dung

Cow dung was commonly available in this region of Tirunelveli (Tamilnadu) , Urine free cow dung collected separately in quantities enough for experimental use were sun dried and powdered.

2.2 Earthworm cultures

Eudrilus eugeniae was obtained from a vermicomposting unit of Killikulam Agricultural College, Tirunelveli. The stock culture of the earthworm was maintained in plastic containers using partially decomposed biowaste and cowdung as growth medium in laboratory condition for further use in the vermicomposting experiment. Vasanthi *et al.* (2014) reported that *E. eugeniae* is a fast-growing and productive earthworm in animal waste that is ideally suited as a source of animal feed protein as well as for rapid organic waste conversion. *Eudrilus eugeniae* ,weighing 300-450 mg live weight were randomly picked up from the stock culture maintained.

2.3 Collection of leaves:

Freshly fallen as well partially dried leaves of *ficus benghalensis* and *ficus racemosa* were collected from the College campus and nearby surrounding areas. After collecting the leaves ,they were cut into small pieces of 4-5 cm before use in the experiments .Smaller size of the feed is favourable to worms growth and also provides more surface area per volume, which facilitates microbial activities as well as moisture availability. The physico-chemical characteristics of CD and leaf wastes are given in Table 2**.**

2.4 Experimental set up:

Five vermicomposting treatments were established having feed mixtures containing CD alone this serves as a control and others mixed with *ficus benghalensis* and *ficus racemosa* in two different proportions (1:1 and 2:1) in circular plastic troughs (Table 1). Each treatment was established in triplicate. The mixtures were turned manually for proper aeration and were left undisturbed for about 15 days in order to semi – compost the feed so that it becomes palatable to worms. After 15 days, 25 unclitellated *Eudrilus eugeniae* were introduced in each vermicomposting treatment . All the treatments were kept in dark at room temperature. The moisture content was maintained at 60 – 70% during the experiment . The zero days refers to the day of inoculation of earthworms after the pre – composting period of 15 days.

2.5 Physico – chemical analyses of vermicompost

Homogenized samples (free from earthworms and cocoons) were drawn at 0 (initial day) and after 90 days (at the end of experiment) from each treatment for analysis of total organic carbon (TOC), total nitrogen (TN) , total phosphorus (TP) , total potassium (TK), and macronutrients (Ca and Mg). The physico – chemical analysis was done on dry weight basis as reported earlier by Gupta *et al*.,(2007). All the samples were analyzed in triplicate and results were averaged.

2.6 Worm growth and Fecundity

Biomass gain, clitellum development and cocoon production by worms in each treatment were recorded periodically for 90 days . The feed in the container was turned out, then earthworms and cocoons were separated from the feed by hand sorting, after which they were counted and weighed after washing with water. Then all the earthworms were returned to their respective container . The earthworms were weighed with full gut . At the end of the experiment, earthworms and cocoons were separated and the final vermicompost from each treatment was air – dried at room temperature and packed in airtight plastic containers for further physico – chemical analysis.

2.7 Statistical analysis

The probability levels used for statistical significance were $p< 0.05$ for the tests. All results reported are the means of three replicate.

3.RESULTS AND DISCUSSION

Table : 1 The Composition of Cow dung (CD) and leaf wastes in different treatments

Treatment No.	Description	CD (kg)	Leaf wastes (kg)
T_0	CD(100%)	1	--
T_1	CD+*Ficus benghalensis* (1:1)	1	1
T_2	CD + *Ficus benghalensis* (2:1)	1	0.5
T3	CD+ *Ficus racemosa* (1:1)	1	1
T4	CD + *Ficus racemosa* (2:1)	1	0.5

3.1 Physico -Chemical changes in quality of vermicompost :

The end product (i.e. vermicompost) significantly differs from the initial feed mixtures in p^H , EC,TOC and macronutrients composition. There was a decrease in p^H in all the feed mixtures during vermicomposting (Table 2). The decrease in p^H may be due to mineralization of nitrogen and phosphorus into nitrites / nitrates and orthophosphates and bio-conversion of the organic material into intermediate species of organic acids (Ndegwa and Thompson, 2000). However , p^H shift during vermicomposting is dynamic and substrates specific as different substrates make different intermediate species of the organic acids (Gupta and Garg ,2008). There was a significant increase in Electrical Conductivity (EC) values as compared to the initial level of all the treatments, (Table 2) . The increase in EC could be due to the loss of weight of organic matter and release of different mineral salts in available forms such as phosphate, ammonium and potassium (Garg *et al* .,2006., Yadav and Garg 2011a). Total Organic Carbon (TOC) was lower in all the treatments by the end of vermicomposting. TOC loss was observed highest in treatment T_1 and lowest in control T_0. A large fraction of TOC was lost in all the treatments by the end of experiment. Elvira *et.al* (1998) have reported that 20 – 43% fraction of organic matter present in the initial feed substrates is lost as CO_2 during vermicomposting. The values of TOC obtained from T_1 was significantly different from other treatments ($P < 0.05$). Earthworms modify substrate conditions, which consequently promotes the carbon losses from the substrates through microbial respiration in the form of CO_2 and even through mineralization of organic matter (Kaushik and Garg, 2003), Suthar (2010 a) has reported that the digestion of carbohydrates and other polysaccharides from the substrates by inoculated worms may cause carbon reduction during vermicomposting of organic wastes. Some part of Organic Carbon (OC) may be converted to worm biomass through the assimilation process, which consequently reduces the carbon budget of waste substrate in the treatments.

3.2 Macronutrients composition (N,P,K,Ca and Mg) :-

The macronutrients composition of the initial feed mixture LW + CD and vermicompost are presented in (Table 2). All the macronutrients were significantly enriched in vermicompost sample than the initial feed mixture. The composition of the macronutrients were found significantly higher in vermicompost sample ($P < 0.05$). There was 2 fold increase in TN content in the end products than the initial level of the LW + CD mixture after 90 days of vermicomposting process. Many factors such as N status of the feed miture ; excretory products , mucus, body fluid, enzyme and even decaying tissue of the death earthworms are associated with the higher level of N in vermicompost (Vasanthi *et al*.,, (2013a) ; Deka *et,al*., 2011).Vermicompost recorded 49.2% increase in T_1 containing available P whereas in case of control it was 16.4% over the initial value of the feed mixture. The present findings corroborate the results of the earlier workers (Fernandez – Gomez *et al*.,2010) which reports upto 97.9% increase in available P due to mineralization of phosphorus in biowaste materials. The availability of P in the end product may vary depending upon the earthworms metabolization and it was suggested that the release of phosphorus in available form is contributed partly by earthworm gut phosphatase, and further release of P through P. Solubilizing micro organisms present in worm casts (Vasanthi *et al.*, 2013b ; Suthar, 2009a). Vermicomposting resulted in significant increase in TN in different treatments. The final TN content in vermicompost is dependent on the initial nitrogen present in the feed material and the degree of decomposition (Crawford , 1983). Furthermore , losses in organic carbon , decreases in P^H (Yadav and Garg 2011) mineralization of the organic matter containing proteins (Garg and Gupta 2011) and conversation of ammonium nitrogen into nitrate (Atiyeh *et al*., 2000) may be responsible for nitrogen addition in vermicompost.

There was increase in total K level in T_1 although the control T_o did not show any significant changes over the initial value of the mixture (Table 2). The present finding is in agreement with the earlier work of Deka *et al*., (2011); have reported 4 fold increase in K content in the vermicompost. Tripathi and Bhardwaj ,(2004) have suggested this increase in TK content in earthworm processed material to be due to higher mineralization rate as a result of enhanced microbial and enzyme activities in the gut of earthworms.

The total Ca and Mg increased by 54.19% and 83.3% in T_1 treatment respectively after vermicomposting of LW+CD mixtures. Senthilkumari *et al*., (2013) ; Suthar (2009 b) have stated that the activity of earthworm's drives the mineralization process efficiently and transforms a large proportion of Ca and Mg from bind to free form which results in increased Ca and Mg level in the final product. As a whole, the overall increase in total nutrient contents in the vermicompost as revealed from the present study is mainly due to the earthworms that reduce the waste mass thereby enhancing the organic matter mineralization rate. (Fernandez-Gomez *et al*., 2010). Furthermore, it can also be hypothized that the concentration of the elements like K, Ca , Mg etc may be enhanced in the end product due to dead and decomposition of the old earthworms although a planned experiment is still needed to prove this hypothesis

Table : 2 Comparison of physico- chemical characteristics of initial mixtures and vermicomposts obtained from different treatments (Mean ± SD, n = 3)

Parameters	Control (T_0)		T_1		T_2		T_3		T_4	
	Initial	final	Initial	Final	Initial	final	Initial	Final	Initial	final
P^H	7.35±.01	7.26±.02	7.27±.01	6.38±.01	7.23±.02	6.48±.02	7.64±0.02	7.97±0.01	7.34±0.01	7.09±0.01
Electrical conductivity (ms/cm)	1.09±.17*	1.44±.03	2.59±.01	3.74±.01	1.22±.02	2.69±.02	1.33±0.03	1.67±0.03	1.79.±0.01	2.42±0.03
Organic carbon	31.97±.02	30.89±.02	28.66±.01	20.90±.02	30.55±.02	26.59±.01	29.71±0.08	28.88±0.02	28.38±0.46	27.97±0.18
Total Nitrogen	0.34±.01	0.96±.01	0.95±.01	1.74±.02	0.96±.01	1.54±.02	0.81±0.02	1.11±0.03	0.92±0.01	1.39±0.02
Total Phosphorus	1.40±.01	1.63±.02	2.59±.02	3.66±.03	1.77±.02	2.84±.01	1.59±0.03	1.88±0.02	1.81±0.01	2.78±0.01
Total Potassium	.63±.01	1.23±.02	1.64±.01	2.72±.02	1.76±.03	1.98±.01	1.33±0.02	1.56±0.02	0.67±0.01	1.95±0.01
Total Calcium	2.73±.01	3.12±.01	3.74±.03	4.81±.02	3.46±.03	4.66±.02	2.99±0.01	3.22±0.01	2.97±0.01	3.51±0.03
Total Magnesium	1.13±.01	2.10±.01	1.98±.01	3.85±.03	1.56±.01	3.74±.03	1.53±0.02	2.48±0.01	1.67±0.02	2.76±0.03
C/N	34.08±0.04	32.17±0.03	28.48±0.03	12.01±0.01	29.96±0.03	17.27±0.02	31.45±0.03	26.01±0.02	29.54±0.04	20.12±0.02

* non-significant

Mean values are statistically significant (P< 0.05)

3.3 C/N ratio

The results of the present findings clearly shows that there were significant decrease in the C/N value at the end of the vermicomposting process. The decrease in C/N ratio was 12.01 % in T_1 as against 32.17% in T_0 from the initial level of the LW + CD mixture. The present findings corroborated with the previous worker (Vasanthi *et al*.,2011) reported upto 82.9% decrease in C/N value during vermicomposting of citronella waste material and cow dung (CWM + CD). The C/N ratio below 20 is indicative of an advanced degree of stabilization and acceptable maturity, while a ratio of 15 or less being preferable for agronomic use of compost (Morais and Queda ,2003). Likewise , in the present study the vermicompost sample was found to meet this requirement thereby indicating high degree of organic matter stabilization and agronomic potentiality.

3.4 Earthworm population and biomass

Table : 3 Summarizes the weight gain biomass of *E.eugeniae* in leaf wastes of *ficus benghalensis and ficus racemosa* mixed with cowdung in different ratios 1:1 and 2:1. Maximum weight gain was observed in T_1 followed by T_2 ,T_4 ,T_3 and T_0 . No mortality was observed during the first two weeks in any of the treatment. From the 30th day onwards mortality was noticed in T_3 whereas after 45th day dead worms were found in T_4 and no mortality was observed in T_1 and T_2 throughout the study period. But the rate of mortality was not found to be significant. From the study , the maximum biomass gain was recorded in T_1 (1756.3 ± 3.21 mg/worm) and T_2 (1498 ± 1.82 mg/worm) treatments. Similarly, the maximum growth rate was achieved in T_1 (41.83 ± 0.10 mg/worm/day) and T_2 (38.51 ± 0.01 mg/worm/day) than the other treatments. There was no statistical significant difference among T_1 and T_2 treatments for biomass gained per worm ($P < 0.05$). The growth rate has been considered as a good comparative index to compare the growth of earthworms in different feeds. (Edwards *et al*, 1998; Vasanthi *et al.*, 2013 c).

Growth and reproduction in earthworms require OC, N and P which are obtained from litter,grit and microbes (Edwards *et al*., 1985).It has been reported earlier that the decomposition rate of tree leaves is slow compared to other crop wastes which was obvious due to hard and hydrophobic nature of dry leaves. The presence of different allelochemicals in leaves of different trees may be the reason for their slow rate of microbial decomposition. The size of the leaves as well the presence of toxic chemicals is another reason influencing the palatable characters of both the earthworm and microorganism.Thus from the present study it is clear that *E.eugeniae* preferred litters of *ficus benghalensis* than that of *ficus racemosa* which resulted in increased biomass of the worms throughout the study period with no mortality.

Table : 3 Growth of *Eudrilus eugeniae* in different treatments (Mean ± SD,n = 3)

leaf wastes	Mean Initial biomass/earthworm (mg)	Maximum biomass achieved /worm(mg)	Maximum biomass achieved on	Net biomass gain/worm (mg)	Growth rate/worm/day/ (mg)
T_0	250.00±1.00	1390±1.00	8th week	1257±4.73*	22.45±0.09*
T_1	491.33±3.21*	3370±4.73*	6th week	1756.3±3.21*	41.83±0.10*
T_2	392.00±2.04	2750±2.81*	7th week	1498±1.82*	38.51±0.01
T3	278.01±1.01	1500±1.48*	9th week	1282±4.61*	25.39±0.03
T4	380.00±2.00	2269±2.65*	8th week	1379.3±1.53*	32.49±0.05

*non-significant
Mean values are statistically significant ($P< 0.05$)

3.5 Sexual development and cocoon production

Data on the sexual development and cocoon production of *E.eugeniae* in different treatments with and without leaf wastes are presented in(Table 4). All individuals in the feeds developed clitellum in the 4th week after the start of the experiment. The cocoon production started in the 5th week in treatment T_1 and T_2 and in 6th week in T_4 and T_0 and in the 7th week in treatment T_3 .After vermicomposting maximum cocoons were counted in T_1 (1600 ±10.0) and T_2 (

1033.3 ± 15.2) treatment than other treatments. Similarly ,the maximum number of hatchlings were produced in T_1 (69.33 ±1.52) and T_2 (56.33 ± 1.54) treatment but the difference was not statistically significant . The cocoon production by worms ceased after the 8^{th},9^{th},10^{th},11^{th} and 12^{th} week in treatment $T_{3,}$ $T_{0,}$ $T_{4,}$ T_2 and T_1 respectively . It may be due to the exhaustion of food for worms. The difference between the rates of cocoons and hatchlings production in different treatments could be related to the nutrient quality of the feed mixtures , which is one of the important factors in determining the onset of cocoon production (Gupta *et al*.,2007).

Edwards *et al* (1998) have also reported that the important difference among the rates of cocoon production in different organic wastes are related to the quality of the waste material used as feed. Thus in the present study treatment T_1 containing equal proportion of *Ficus benghalensis* and cowdung (1:1) shows enhanced reproduction , cocoon production and hatchability rate revealing the suitability of the substrate supporting the growth and reproduction rate of *E.eugeniae*. The difference between cocoon productions in different treatments could be related to the biochemical quality of the feed mixtures , which is one of the important factors in determining onset of cocoon production. (Flack and Hartenstein,1984).

Table : 4 Fecundity of *Eudrilus eugeniae* in different treatments (Mean ± SD,n = 3)

Leaf wastes	Clitellum development started in	Cocoon production started in	Total no of cocoons produced after 8 weeks	No of cocoons produced /worm	No of cocoons produced /worm/day	Juveniles
T_0	4^{th}week	6^{th} week	731.06±19.10*	30.0±.60	.85±.01	16.70±.10*
T_1	4^{th} week	5^{th} week	1600.0±100.00	64.0±4.00	1.51±.09*	69.33±1.52*
T_2	4^{th} week	5^{th} week	1033.3±15.27*	41.3±6.01	1.16±.18*	56.33±1.54*
T3	4^{th} week	7^{th} week	738.06±16.0*	31.2±3.05	.86±.01	20.3±.04
T4	4^{th} week	6^{th} week	755.00±01	38.2±3.01	0.99±.01	43±0.18*

*non-significant

Mean values are statistically significant ($P< 0.05$)

4. CONCLUSION :

The vermicompost were nutrient rich, odour free ,more mature and stabilized than initial waste mixture. The present study showed that good quality vermicompost could be prepared from dry leaves of trees. When India is facing shortage in supplying chemical fertilizers to all its farmers to increase food production and gradually switching over to evergreen revolution through integrated nutrient management where vermicompost plays an important role, none can afford to destroy these dry leaves by burning. Vermicomposting is the sustainable , low-cost and easy solution for the beneficial utilization of such huge quantities of dry leaves.

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