Role of *Leucaena glauca* Leaf litter on the Growth and Reproduction of Earthworms *Eisenia fetida* Savigny

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ABSTRACT

The growth (biomass) and reproduction (cocoon production and hatchlings) of earthworms Eisenia fetida Savigny were observed in leguminous tree Leucaena glauca leaf litter, clay loam soil and cowdung mixture (w/w) in different proportions. They were T_1 (cowdung alone), T_2 (1 leaf litter: 1 clay loam soil), T_3 (1 leaf litter: 1 cowdung), T_4 (2 leaf litter: 3 cowdung), and T_5 (3 leaf litter: 2 cowdung). The observations were made on 15^{th}, 30^{th} and 45^{th} day. Growth and reproduction of earthworms increased significantly in all proportions but highest in T_4. The macro – nutrients content was also higher in T_4. The rich nitrogen content of the leaf litter mixed with cowdung might be the reason for supporting the growth, cocoon production and hatchlings production. The results are discussed with nutrient availability of substrates.

Key words: Biomass; cocoon; Eisenia fetida; hatchability rate; leaf litter; macro-nutrients

INTRODUCTION

Earthworms constitute a large part of biomass in the soil. They have been recognized as soil movers and conditioners. The earthworms have beneficial physical, chemical and biological effects on soil and many researchers have documented that these effects can increase the plant growth and crop yield (Edwards and Bohlen, 1996). In an integrated nutrient management approach, the chemical fertilizer is substituted by compost, the well - decomposed organic manure prepared from crop residues, weeds, lawn mowings, tree leaves, kitchen refuges, animal excreta and city garbages (Sannigrahi and Chakrabortty, 2000). In uncultivated soil, burrows of earthworms provide channels for root growth lined with more available mineral nutrients than the surrounding soil (Edwards and Lofty, 1980). Earthworms increase soil-air volume. Soils with earthworms drain water 4 to 10 times faster than soil without earthworms.

In the vermicomposting process where the organic wastes are converted into valuable fertilizers, *Leucaena* is a 'conflict tree' being widely promoted for tropical forage production and reforestation, at the same time, it is spreading naturally and widely and reported as a weed. It is one of the leguminous tree species. As a leguminous tree, it has high N in the leaf litter. *L. glauca* is useful in agri-silviculture system which means the use of land for concurrent production of agricultural crops and forest crops. Inter-cropping of trees helps in incorporating litter and lopped leaves every year. One-year-old *L. glauca* can produce 7-20 q/ ha of dry matter and record 19 kg N/ha in one year through fall of different plant parts (Thanunathan, 2000).

Leaf litter is a potential, but unexploited, source of nutrient inputs in agriculture. Litter decomposition enriches the soil nutrient pool and also supports the saprophagic components of soil. However, the rates of decay and pathways of decomposition are determined by the quality of the litter material, the physical environment and the qualitative and quantitative composition of decomposer organisms (Swift et al., 1979). A slow rate of decay results in accumulation of organic matter and nutrient stocks in soil while a fast rate of decay helps meet the plant uptake requirements of annual crops (Isaac and Nair, 2005). Leaf litter left on the soil contributes significantly towards protecting and enriching the soil (Dash, 1993).

The reproductive potential of earthworms is influenced by the quality and availability of food (Kale et al., 1992; Bhattacharjee, 2002). Various authors contributed to our knowledge of relationship between earthworm reproduction and factors such as moisture (Evans and Mc.Guild, 1948), temperature (Reinecke and Kriel, 1981) and food (Elvira et al., 1998). Growth and reproduction of different species of earthworms using different materials such as flax seeds (Kosteka, 1999), cattle manure and goat manure (Loh et al., 2005), pressmud (Parthasarathi and Ranganathan, 1999) have been studied. The tropical weed *Chromolaena odorata* and coffee residues were tested as food sources for earthworm *Hyperiodrilus africanus* (Tandon and Lavelle, 1997). Litter of the mango (*Mangifera indica*) tree leaves was composted and then converted into vermicast by the action of the earthworm *Eudrilus eugeniae* (Gajalakshmi et al., 2005). However, studies are scanty on the effect of leguminous leaf litter on the growth and reproduction of earthworm. The objective of the study was to determine the role of *L. glauca* leaf litter with cowdung on growth (biomass) and reproduction (cocoon and hatchlings) of epigeic composting earthworm – *E. fetida.*

MATERIALS AND METHODS

The fallen leaf litter of *L. glauca* was collected from the orchard of Annamalai University and cowdung was obtained from the experimental dairy farm, Annamalai University, Annamalainagar during 2003-2004. Partially – decomposed leaf litter cannot be accepted immediately by the earthworms as such, hence, it was decided to add the clay loam soil and cowdung. In the present study, the leaf litter (Ll), clay loam soil (CLS) and cowdung (CD) were mixed in the following five proportions

(T_1 to T_5). They were: T_1 – (1 kg) CD alone - control, T_2 – (Ll + CLS) 1:1 ratio, T_3 – (Ll + CD) 1:1 ratio, T_4 – (Ll + CD) 2:3 ratio and T_5 – (Ll + CD) 3:2 ratio.

Six replications were made in each combination. 1 kg of mixture was kept in each plastic trough (33 cm dia and 13 cm depth) with 70-80% moisture for 5 days for initial partial decomposition. Each mixture was used as substrate, 15 g of clitellate worms were inoculated in each plastic trough. The biomass (weight) was taken on an electronic balance and cocoon and hatchling numbers were counted every 15 days, over a period of 45 days by hand - sorting method. The freshly formed vermicomposts from all the experimental plastic containers were collected after 15^{th}, 30^{th} and 45^{th} day and air-dried, weighed, sieved and stored in polythene bags for nutrient analysis.

Chemical characterization of vermicompost

The total nitrogen, phosphorus and potassium content of the composts were estimated by Kjeldhal method, calorimetric method and flame photometry method, respectively, according to the standard method of Tandon (1993). Organic carbon of the samples were determined according to the procedure of ISI Bulletin (1982). C:N ratio was calculated by dividing the percentage of carbon with the percentage of nitrogen in the samples. The data were analysed statistically (significance of difference at 0.05 level) by using two-way analysis of variance with replication (ANOVA).

RESULTS

Biomass of earthworms in general increased in all mixtures significantly, but the overall rate of biomass production was maximum in T_4. In all the experimental media, the biomass increased steadily but in T_2, the population of E. fetida declined on 15^{th} and 30^{th} day after inoculation due to mortality. After 30^{th} day, there was no mortality and the biomass started to increase due to decomposition of leaf litter. On the other hand, in the treatments T_1, T_3, T_4 and T_5, no mortality was observed and gaining of weight was observed upto 45 days (Table 1).

In all the experimental troughs, cocoons were observed on 15^{th} day due to the inoculation of adult clitellate worms. The total number of cocoon production also went parallel with the above observation and maximum number of cocoons was observed in T_4 feed mixture (Table 2). The hatchlings were observed in all treatments on 30^{th} day but there was no hatchlings upto 15^{th} day. Here, also more number of hatchlings was observed in T_4 followed by the others in the order of T_1, T_5, T_3 and T_2 (Table 3). Further it indicated that T_4 (Ll + CD 2:3) might be a better combination for *E. fetida* in which the best biomass, cocoon production and hatchlings rate were observed (Table 1-3).

The vermicomposting significantly modified the chemical properties of different feed mixtures tested. The content of total nitrogen, phosphorus and potassium in the vermicompost from T_1-T_5 treatments were more on 15^{th} day, but slightly decreased on 30th and 45th day. But they were more than the initial quantity of NPK in the feed substrates (Table 4-6). Reduction in the C:N ratio was observed in all the treatments. In all the treatments from ‘0’ day to 45th day, the vermicompost showed better conversion of C:N ratio (Table 7).

Table 1. Biomass (g) if *E. fetida* during vermicomposting of leaf litter (*L. glauca*) and cowdung mixture (P<0.05).

Substrate proportions	Vermicomposting days			
	Initial (0)	15	30	45
T1 Cowdung	15±0.365	16.2±0.208 (+8.0)	19.6±0.278 (+30.66)	22.5±0.373 (+50.0)
T2 Leaf litter+clay loam soil (1:1)	15±0.577	12.8±0.264 (-14.66)	13.4±0.193 (-10.66)	18.3±0.216 (+22.0)
T3 Leaf litter+cowdung (1:1)	15±0.730	15.2±0.269 (+1.33)	15.7±0.293 (+4.66)	20.2±0.298 (+34.66)
T4 Leaf litter+cowdung (2:3)	15±0.577	16.8±0.288 (+12.0)	20.1±0.212 (+34.0)	23.3±0.367 (+55.3)
T5 Leaf litter+cowdung (3:2)	15±0.509	15.5±0.682 (+3.33)	18.2±0.386 (+21.33)	21.4±0.290 (+42.66)

(ANOVA)

Analysis of variance	Sum of square	Mean of square	F-value
Rows	39.168	9.792	6.759319
Cloumns	120.066	40.022	27.62678

T – Treatments Initial (0) – Worm unworked substrates Mean±SE of six observations
(+/-) – Percent change of increase/decrease over the initial

Table 2. Cocoon production (number) of *E.fetida* during vermicomposting of leaf litter (*L.glauca*) and cowdung mixture (P<0.05).

Substrate proportions	Vermicomposting days				
	Initial (0)	15	30	45	Total
T1 Cowdung	-	9.6±0.302	11.8±0.423	20.07±0.335	41.4±0.373
T2 Leaf litter+clay loam soil (1:1)	-	6.9±0.246	7.2±0.306	11.8±0.375	25.9±0.238
T3 Leaf litter+cowdung (1:1)	-	8.5±0.426	9.4±0.386	17.2±0.429	35.1±0.658
T4 Leaf litter+cowdung (2:3)	-	10.6±0.186	12.5±0.502	20.5±0.518	43.6±0.346
T5 Leaf litter+cowdung (3:2)	-	9.4±0.294	10.2±0.294	18.6±0.250	38.2±0.528

(ANOVA)

Analysis of variance	Sum of square	Mean of square	F-value
Rows	152.8416	38.2104	5.438893
Cloumns	3836.75	959.1874	136.5314

T – Treatments Initial (0) – Worm unworked substrates Mean±SE of six observations

(+/-) – Percent change of increase/decrease over the initial

Table 3. Hatchlings number of *E. fetida* during vermicomposting of leaf litter (*L. glauca*) and cowdung mixture (P<0.05).

Substrate proportions	Vermicomposting days				
	Initial (0)	15	30	45	Total
T1 Cowdung	-	-	18.8±0.728	30.7±0.466	49.5±0.645
T2 Leaf litter+clay loam soil (1:1)	-	-	12.7±0.450	20.9±0.567	33.6±0.361
T3 Leaf litter+cowdung (1:1)	-	-	16.6±0.476	24.9±0.448	41.5±0.645
T4 Leaf litter+cowdung (2:3)	-	-	20.0±0.866	31.1±0.805	51.5±0.609
T5 Leaf litter+cowdung (3:2)	-	-	17.1±0.554	26.0±0.173	43.1±0.749

(ANOVA)

Analysis of variance	Sum of square	Mean of square	F-value
Rows	158.848	39.712	4.341177
Cloumns	6957.568	1739.392	190.1442

T – Treatments Initial (0) – Worm unworked substrates Mean±SE of six observations

(+/-) – Percent change of increase/decrease over the initial

Table 4. Total nitrogen content (%) the vermicomposting of leaf litter (*L. glauca*) and cowdung mixture by *E. fetida* (P<0.05).

Substrate proportions	Vermicomposting days			
	Initial (0)	15	30	45
T1 Cowdung	1.10±0.043	1.30±0.034 (+18.18)	1.25±0.044 (+13.63)	1.22±0.034 (+10.90)
T2 Leaf litter+clay loam soil (1:1)	1.07±0.030	1.17±0.028 (+9.34)	1.12±0.030 (+4.67)	1.10±0.038 (+2.80)
T3 Leaf litter+cowdung (1:1)	1.09±0.049	1.22±0.060 (+11.92)	1.21±0.012 (+11.00)	1.15±0.053 (+5.50)
T4 Leaf litter+cowdung (2:3)	1.13±0.038	1.36±0.025 (+20.35)	1.33±0.058 (+17.69)	1.29±0.050 (+14.15)
T5 Leaf litter+cowdung (3:2)	1.11±0.060	1.31±0.055 (+18.01)	1.26±0.012 (+13.51)	1.21±0.049 (+9.00)

(ANOVA)

Analysis of variance	Sum of square	Mean of square	F-value
Rows	0.0604	0.0151	19.44205
Cloumns	0.08188	0.027293	35.14163

T – Treatments Initial (0) – Worm unworked substrates Mean±SE of six observations
(+/-) – Percent change of increase/decrease over the initial

Table 5. Phosphorus content (%) of the vermicomposting leaf letter (*L. glauca*) and cowdung mixture by *E. fetida* (P<0.05).

Substrate proportions	Vermicomposting days			
	Initial (0)	15	30	45
T1 Cowdung	0.52±0.025	0.74±0.035 (+42.30)	0.71±0.010 (+36.53)	0.68±0.018 (+30.76)
T2 Leaf litter+clay loam soil (1:1)	0.39±0.012	0.44±0.01 (+12.82)	0.42±0.030 (+7.69)	0.40±0.018 (+2.56)
T3 Leaf litter+cowdung (1:1)	0.48±0.031	0.59±0.028 (+22.9)	0.57±0.023 (+18.75)	0.55±0.015 (+14.58)
T4 Leaf litter+cowdung (2:3)	0.56±0.025	0.81±0.037 (+44.64)	0.78±0.013 (+39.24)	0.75±0.011 (+33.92)
T5 Leaf litter+cowdung (3:2)	0.50±0.025	0.67±0.024 (+34.00)	0.63±0.026 (+26.00)	0.61±0.018 (+22.00)

(ANOVA)

Analysis of variance	Sum of square	Mean of square	F-value
Rows	0.2278	0.05695	38.47973
Cloumns	0.07344	0.02448	16.54054

T – Treatments Initial (0) – Worm unworked substrates Mean±SE of six observations
(+/-) – Percent change of increase/decrease over the initial

Table 6. Potassium content (%) of the vermicomposting leaf litter (*L. glauca*) and cowdung mixture by *E. fetida* (P<0.05).

Substrate proportions	Vermicomposting days			
	Initial (0)	15	30	45
T1 Cowdung	0.38±0.016	0.45±0.015 (+18.42)	0.43±0.018 (+13.15)	0.42±0.017 (+10.52)
T2 Leaf litter+clay loam soil (1:1)	0.31±0.010	0.37±0.012 (+19.35)	0.35±0.013 (+12.90)	0.32±0.02 (+3.22)
T3 Leaf litter+cowdung (1:1)	0.35±0.017	0.39±0.019 (+11.42)	0.38±0.025 (+8.57)	0.37±0.013 (+5.71)
T4 Leaf litter+cowdung (2:3)	0.36±0.011	0.44±0.018 (+22.22)	0.41±0.019 (+13.88)	0.39±0.016 (+8.33)
T5 Leaf litter+cowdung (3:2)	0.34±0.013	0.42±0.023 (+23.52)	0.38±0.015 (+11.76)	0.36±0.016 (+5.88)

(ANOVA)

Analysis of variance	Sum of square	Mean of square	F-value
Rows	0.01553	0.003882	49.04211
Cloumns	0.0117	0.003993	49.26316

T – Treatments Initial (0) – Worm unworked substrates Mean±SE of six observations
(+/-) – Percent change of increase/decrease over the initial

Table 7. C:N ratio of the vermicomposting leaf litter (*L. glauca*) and cowdung mixture by *E. fetida* (P<0.05).

Substrate proportions	Vermicomposting days			
	Initial (0)	15	30	45
T1 Cowdung	29.2±0.390	22.0±0.641 (-24.65)	20.4±0.755 (-30.13)	14.1±0.578 (-51.71)
T2 Leaf litter+clay loam soil (1:1)	45.8±1.295	41.3±1.377 (-10.02)	29.6±1.349 (-35.51)	26.1±0.365 (-43.13)
T3 Leaf litter+cowdung (1:1)	44.3±1.968	38.8±0.243 (-12.41)	28.5±0.757 (-35.66)	24.1±0.511 (-45.59)
T4 Leaf litter+cowdung (2:3)	37.9±1.485	20.0±0.531 (-47.22)	17.9±0.581 (-52.77)	11.9±0.405 (-68.60)
T5 Leaf litter+cowdung (3:2)	42.1±0.456	34.9±1.238 (-17.10)	30.2±0.459 (-25.26)	21.2±0.604 (-49.64)

(ANOVA)

Analysis of variance	Sum of square	Mean of square	F-value
Rows	746.102	186.5255	21.95235
Cloumns	1141.528	380.5093	44.76249

T – Treatments Initial (0) – Worm unworked substrates Mean±SE of six observations
(+/-) – Percent change of increase/decrease over the initial

DISCUSSION

The enhanced growth and reproduction of *E. fetida* were observed in all treatments from T_1 to T_5. T_4 might be a better combination because it showed better growth and reproduction. Ventre and Reinecke (1988), Kale et al*.,* (1992) reported that the growth of earthworms depended on the quality of the available food. Such observations relating to increased growth rate in various organic wastes were reported by many authors in various earthworms species – *E.eugeniae*, *E. fetida* and *P. excavatus* on cattle dung (Reinecke et al., 1992), *Lampito mauritii* on cowdung (Kale and Bano, 1992), *E. eugeniae* on sugar factory refuge (Kale et al., 1994), *E.eugeniae* and *L. mauritii* on pressmud (Ramalingam, 1997). Growth and reproduction in earthworms require O,C, N and P (Evans and Mc.Guild, 1948) which are obtained from litter, grit and microbes (Edwards and Bohlen, 1996; Parthasarathi and Ranganathan, 2000). The faster growth rate and higher reproductive rate of various earthworms species have been reported by several authors, such as *E.eugeniae*, *E. fetida* and *P. excavatus* on black gram pod husk (Amoji et al., 1998), *E. fetida* on sewage sludge with food waste (Dominguez et al., 2000), *E. fetida* on *Gliricida maculata* leaf litter and cowdung mixture (Karmegam and Daniel, 2001), *E. andrei* on cattle manure (Benitez et al., 2002), *Lumbricus terrestris* on chopped legume treatment (Shuster et al., 2002), *P. corethrurus* on sawdust and fresh leaves mixture (Garcia and Fragosa, 2003) *E.eugeniae, E.fetida, L. mauritii* and *P. excavatus* on pressmud, trash and bagasse mixture (Manivannan et al., 2004). Falling in line with these studies in the present study, more growth and reproduction were observed in T_4. Similarly, Banu et al., (2005), Loh et al., (2005) and Shekal et al.,

(2005) reported that higher growth of earthworm was due to the availability of more nutrients and N content in leaf litter of leguminous plants.

The increased level of macro-nutrients (NPK) in the vermicomposts are similar with the results of earlier works. Increased quantity of N, P and K was documented in worm casts rather than the starting feed materials (Orazco et al., 1996). Enhanced N, P and K contents in vermicomposts was due to microbial - enzyme activities while passing through the gut of earthworms (Parthasarathi and Ranganathan, 2000). Chaudhuri et al., (2001) proved that during vermicomposting of weeds, the contents of macronutrients were higher in the final worm-worked composts, compared with control. Parthasarathi (2002) demonstrated increased NPK in the soil and pressmud after the inoculation of *P. excavatus* and *E.fetida*. Umamaheswari and Vijayalakshmi (2003) revealed increased NPK in vermicomposts. Suthar (2007) described significant increase in total NPK whereas decrease in organic C as well as C:N ratio in different experimental beddings by *P. sansibaricus*.

In the present study, the enhancement of macro-nutrients in the vermicompost was more initially, i.e., on the 15th day, in all treatments. After 15th day, decreased NPK contents was found in all treatments. The reason for the enhancements of NPK contents in the vermicompost may be due to optimal moisture / loss of mass weight of feed materials by the digestion of earthworms / higher microbial - enzyme activities and the reduction of NPK contents might be due to immobilization / leaching into bedding materials (Parthasarathi and Ranganathan, 1999; 2000; 2002; Bhattacharjee, 2002; Suthar, 2007) utilization of these elements by earthworms for their growth (Benitez et al., 2002), since weight gaining of earthworm was obtained. From the over-all results, T_4 seemed to be more suitable feed than the other feed mixtures. This mixture probably provided sufficient amount of easily - metabolizable organic matter and non-assimilated carbohydrates that favour growth as described by Suthar (2007) and reproduction of animals which was supported by Kaushik and Garg (2004). The findings of Ganihar (2003), Mahakur et al., (2004) and Garg and Kaushik (2005) also supported the present investigation in which they had documented that the increased N, P and K contents in the vermicompost from leaf litter and cowdung mixtures. The lowered N, P and K contents in the present study might be due to microbial leaching into bedding materials which was also supported by Garg and Kaushik (2005) and Issac and Nair (2005).

The ratio of carbon to nitrogen in the vermicompost added to the soil is of importance because plant cannot assimilate mineral nitrogen, unless the ratio is near to 20:1 or lower (Sharma and Madan, 1983). In vermicompost from T_4 treatment lower order of C:N ratio reflected the efficient worm activity leading to accelerated rate of decomposition, there by, resulted in high grade, nutrient-rich good quality composts.

In the present study, the significant reduction of C:N ratio in all the treatments was supported by the results of Ramalingam and Thilagar (2000) and Ananthakrishnasamy (2004). The C:N ratio is one of the most widely - used indicators for maturity of organic wastes. Loh et al., (2005) and Garg and Kaushik (2005) reported that mineralization and decomposition of organic matter during vermicomposting lowers the C:N ratio.

CONCLUSION

The decomposition efficiency of *E. fetida* could be used efficiently to combat the problem of waste management of *Leucaena glauca* leaf litter at low input basis and also to produce eco-friendly nutrient rich vermicompost for sustainable soil fertility and crop productivity.

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