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Role of Tree Leaf Loppings and Leachates in Vermicomposting and Earthworm Morphology

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ABSTRACT

Earthworms are very effective in degrading various crop residues and play a vital role in sustainable waste management. The extent of decomposition is dependent on the quality of plant materials used as substrate. An attempt was carried out at Integrated Farming Research Station, Karamana, Kerala Agricultural University, India to study the effect of 21 different tree leaf loppings on growth of earthworm and vermicompost output. It was noticed that tree leaf loppings of *Bombax, Erythrina, Gliricidia* and *Casuarina* had no adverse effect on earthworms and resulted in better compost output. Leachates obtained from these leaf loppings (@10 % concentration) were applied over cowdung inoculated pseudostem biomass to know their influence on earthworm species, *Eudrillus euginae.* The tree leaf leachates, in general, adversely affected multiplication and growth of earthworms.

Keywords Vermicomposting, Leaf tree loppings, Leaf exudates, Earthworm morphology.

INTRODUCTION

Vermicomposting is a simple biotechnological process of composting, where earthworm species are used to enhance the process of waste conversion and produce a better end product (Gandhi *et al.* 1997). It is much faster than ordinary composting, that the substrates once pass though earthworm gut are subjected to a series of biochemical action inside, leading to nutrient rich manure (Tara 2003). Earthworms consume various organic wastes equivalent to their body weight and produce cast equivalent to 50 % of the waste consumed per day (Nagavellamma *et al.* 2004). Any type of bio wastes viz., agro-wastes, animal manure and domestic refuse can be converted to nutrient rich fertilizer which can be utilized for soil quality improvement and effective plant growth (Gajalakshmi and Abassi 2004). This organic fertilizer rich in NPK, micronutrients and beneficial soil microbes (nitrogen fixing and phosphate solubilizing bacteria and actinomycetes), is a sustainable alternative to chemical fertilizers and an excellent growth promoter and protector for crop plants (Sinha *et al.*2011, Chauhan and Singh 2015, Kaur 2020). It serves as a rapid solution for the huge volume of biowaste generated in agricultural fields.

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The waste to be stabilized should support an adequate biomass needed for effective processing (Haimi and Huhta 1986). Vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage,water holding capacity and large surface area, providing strong capacity to hold and retain plant available nutrients such as nitrates, exchangeable phosphorus, soluble potassium, calcium, magnesium and essential micronutrients (Edwards and Burrows 1988, Orozco *et al*. 1996, Chaudhuri *et al.* 2000). Earthworm species like *Perionyxex cavatus, P. sansibaricus* and *Eudrillus eugeniae* have proved to be very ideal for vermicomposting, especially in tropical and sub-tropical regions (Suthar 2007b,Pattnaik and Reddy 2010).Compared to their parent materials, vermicompost has less soluble salts, greater cation exchange capacity, increased total humic acid, available nutrients and biologically active substances such as plant growth regulators (Kale 2014, Rautela *et al*. 2019).

The gut of earthworm has a big population of microflora that could enhance nutrient availability in the vermicompost. Thus, there is direct as well as indirect influence in the degradation of substrate through interior cellulolytic activity and modulating microbial population structure and dynamics. The success of the composting depends upon the fecundity of the earthworm.The quality and quantity of organic wastes used are very important in determining the rate of growth of earthworms (Edwards 1998). It is a complex biological process involving the joint action of earthworms and microorganisms where, microbes are responsiblefor biochemical degradation of organic matter and earthworms are the important drivers of the process, conditioning the substrate and altering the biological activity (Aira *et al*. 2002). The type of substrate used and species of earthworms introduced plays a significant role in plant growth and yield (Suthar and Ram 2008, Suthar 2009, Joseph 2019). Nutrient quality of vermicompost depends on the type of raw material used for composting (Ramnarain *et al.* 2019).

Information is very scanty on the growth of earthworms and rate of vermicompost production when different tree leaves are used as substrates or crop residues for composting. Hence, an attempt was made in this study to know the extent of degradation and vermicompost output that might occur when different leaf loppings of fruit/ agroforestry trees commonly seen in and around a homestead based farming system were used as substrates for composting. Also, their influence on the morphology of earthworms when used as such or as leaf leachates was also examined.

MATERIALS AND METHODS

The experiment was carried out at Integrated Farming System Research Station, Karamana, Kerala Agricultural University, located at 8° 28' 25" N latitude and 76° 57' 32" E longitude, at an altitude of 5 m above mean sea level. It was designed to assess the suitability of various leaf loppings/ leaf exudates for vermicomposting and their influence on earthworms and vermicompost output. Fresh leaf loppings from fully grown 21 different test trees viz., *Manilkara zapota* (Sapota), *Ailanthus* sp. (Tree of heaven), *Anacardium occidentale* (Cashew), *Artocarpus heterophyllus* (Jack), *A. hirsutus* (Wild Jack), *Azadirachta indica* (Neem), *Bombax* (cotton tree), *Casuarina equisetifolia* (Australian pine), *Coffea* sp. (Coffee), *Erythrina indica* (Indian coral tree), *Glyricidiasepium* (Glyricidia), *Hevea brasiliensis* (Rubber), *Leucaenaleucocephala* (Subabul), *Mangifera indica* (Mango), *Psidium guajava* (Guava), *Swietenia* sp. (Mahogany), *Tamarindus indica* (Tamarind), *Tectona grandis* (Teak),*Thespesia populnea* (Portia), *Theobroma cacao* (Cocoa) and *Macaranga* sp. (Vatta) were collected. The investigation was done in two parts- i) using leaf loppings as crop residues for vermicomposting and ii) leaf exudates obtained from these tree leaf loppings. Both studies were set up as pot culture experiments.

Use of fresh tree loppings

Leaf loppings collected from the test trees (21 No.) were mixed with cow dung in 1:1 proportion and preliminarily incubated for 15 days by sprinkling water daily to prevent excessive buildup of internal temperature.Uniform sized clay pots of 20 cm diameter and 28 cm depth were placed in thatched sheds having open sides. At the bottom of each pot, a layer of coconut husk was placed with the concave side facing upward to ensure proper aeration and drainage of excess water. The husk was moistened and above this, each pot was filled with 13.5 kg (fresh weight) of the partially decomposed waste upto a height of 20 cm. A separate control was maintained in which equivalent quantity of preliminarily incubated mixture containing banana pseudostem, the most commonly used substrate for vermicomposting, was filled. Earthworm, *Eudrillus euginae* was introduced @10 numbers per pot. All the treatments were replicated thrice.

Use of fresh tree leaf leachates

Leaf leachate was prepared by soaking the fresh leaf tree loppings @ 100 g perlitre of water for 12 h (…………) and strained through a muslin cloth. Banana pseudostem was mixed with cowdung in 1:1 ratio and preliminarily incubated for 15 days as in first experiment. Similar sized clay pots were taken and a layer of coconut husk was arranged at the bottom. All the pots were uniformly filled with 15 kg each of the pre incubated mixture upto 20 cm height. Here also, E. euginaewas used for composting and introduced @10 number per pot.The treatment pots were irrigated with tree leaf leachates (10 % concentration), whereas in control the pots were irrigated with water.

In both the cases, the treatment pots were covered with coconut fronds to provide necessary shade and maintain temperature. Adequate and uniform moisture was maintained in all the pots by sprinkling water once in two days. After 75 days of incubation, the compost was removed from each pot along with the worms and heaped in shade separately. This ensured movement of the worms to the bottom of the heap. Composted material was collected from top layers, sieved, dried under shade and weighed. Earthworms that aggregated at the bottom layers were collected separately. Number of earthworms, increment in size (length and weight) of worms and quantity of vermicompost produced/output (on dry weight basis) were recorded in each treatment (pot).

RESULTS AND DISCUSSION

Effect of tree leaf loppings

The outcome of the influence of various leaf loppings on earthworms and vermicompost production

Table 1. Effect of tree leaf loppings when used as substrate for vermicomposting on earthworms and compost production.

Treatments (Leaf loppings)	No. of worms at the end of composting	Length increment in earthworms (cm)	Weight increment in earthworms (g)	Compost output (dryweight in g)
M.zapota	12.33	3.267	1.067	1415.00
Ailanthus sp.	20.67	5.133	1.167	1053.33
A.occidentale	19.00	4.000	0.867	1023.33
A.heterophyllus	33.00	4.267	0.633	1125.67
A. hirsutus	30.67	3.267	1.333	1347.00
A.indica	13.33	3.467	0.300	1059.00
Bombax sp.	33.67	2.733	0.333	1460.33
C.equisetifolia	28.00	4.133	1.300	1431.00
Coffea sp.	15.67	4.367	0.500	1346.67
E.indica	46.00	4.533	1.767	1374.33
G.sepium	95.67	4.400	1.367	1387.00
H.brasiliensis	16.33	4.833	0.767	1374.00
L.leucocephala	13.33	2.267	0.300	1379.33
M.indica	15.33	3.267	1.200	1377.33
P.guajava	15.00	1.133	0.400	1445.00
Swietenia sp.	26.00	0.600	1.300	1345.00
T.indica	9.00	2.667	0.500	1304.33
T. grandis	21.67	1.933	1.067	1343.33
T.populnea	19.33	1.333	0.400	1348.67
T. cacao	6.67	1.000	0.567	1379.67
Macaranga sp.	11.67	3.667	0.200	1445.33
Control (Banana pseudostem)	37.33	3.667	0.800	1369.00
CD (0.05)	6.20	2.71	0.53	61.42

is detailed in Table 1. Leaf loppings of all test trees except *A.heterophyllus, Bombax* sp., *E. indica* and *G. sepium* significantly reduced worm multiplication (as indicated by total number of worms) when used as substrate for composting. Maximum inhibition was caused by *T. cacao* (82 %) followed by *T.indica* (76 %). *Erythrina* and *Glyricidia* leaf loppings caused significant increase in number of worms. The increase was about three times in the case of *Glyricidia*. As reported by Kale *et al.* (1982),worm growth, maturation, cocoon production and cocoon viability are affected by the substrate used. Except mahogany, all tree leaf loppings caused increase in length of worms, though not significant. It may be due to the alkaloids and other principal compounds present in these leaves that may affect the survival of earthworms (Nagavellamma *et al.* 2004).

Significant increase in weight of worms (more than double) was caused by *Erythrina* followed by *Glyricidia,* while only *Macaranga* leaf loppings caused significant reduction (75%) in weight of worms. Earthworm biomass and cocoon production rate was directly related to the type of earthworm species as well as nature of worm feedstuff. The growth of earthworm and reproduction rate are related to initial N content of the substrate while there was no clear effect of C:N ratio of the composted material on earthworm cocoon numbers and weight gain (Suthar 2007a). The maximum biomass production and growth rate of earthworms were observed with vegetable waste- leaf litter mixture. According to Suthar and Ram (2008), better biomass and cocoon production rate in composting with earthworms could be related to the physio-chemical characteristics, palatability and microbial composition of the substrate materials.

Final compost output was significantly reduced on using leaf loppings of *Ailanthus, A.occidentale, A.heterophyllus, A. indica* and *T.indica*, of which maximum reduction was noticed in the case of *A.occidentale* (25.25%), followed by *Ailanthus* (23.06%). Leaf loppings of *Bombax, P. guajava, Macaranga* (5.58%) and *Casuarina* when used as composting material, resulted in significantly higher compost output than the control in which banana pseudostem was the substrate. It is inferred that tree leaf loppings of *Bombax, Erythrina, Gliricidia* and *Casuarina* does not adversely affect earthworms and results in good compost output. Earthworms can process organic material equivalent to their body weight with a conversion rate of 40-50 % (Sinha *et al.* 2010, Edwards *et al.* 2011). They accelerate the decomposition of substrates and thereby, reduces the C:N ratio of composting material. The final N content is related to the quality of the substrate used for worm feedingprocess (Ansari and Rajpersaud 2012). A similar report on interaction between quality of feed and earthworm growth efficiency was given by Aalok and Tripathi (2010). Variation in nutrient quality of the derived vermicompost was observed when leaf litters of different forest trees viz., *Eucalyptus,* Pinuxroxburghii, Populus deltoids, *Shorea robusta, Parthenium hysterophorus* were used as substrates. Daniel *et al.* (2010) observed that microbial and nutrient rich vermicompost was obtained with the leaves of *G. sepum* and *L. leucocephala*.

Effect of tree leaf leachates

With *Ailanthus, Anacardium occidentale* and *C. equisetifolia* leaf leachates, no earthworms were detected at the end of incubation period, but 95, 86 and 97% vermicompost output was noticed compared with the control (banana pseudostem compost) (Table 2). The composition of extracted leaf leachates (both in quantity and quality) vary considerably with particular plant species. Much variation in dissolved organic carbon, total organic carbon and total dissolved nitrogen and phosphorus content were noticed in the extracts obtained from coniferous and deciduous trees (Joly *et al.* 2016). The extent of exudation of leachates is determined by the quality of leaf epidermis and hypodermis (Don and Kalbitz 2005).

Only treatments with *G. sepium, E.indica* and *A. indica* leachates produced comparatively higher earthworm count at the end of composting. Except *G. sepium,* the earthworm mass was adversely affected by the application of leaf leachate spraying. In general, there was a decline in the length of earthworms and was drastically reduced with *H. brasiliensis* and *Bombax.* The leaf litter quality affects the microbial growth and decomposition process (Dilly and Munch 2001, Liu *et al.* 2010). Leaves are composed of or-

Table 2. Effect of tree leaf leachates on earthworms and vermicompost output.

Treatments	Number of worms at the end of composting	Length increment in earthworms (cm)	Weight increment in earthworms (g)	Compost output (dry weight in g)
M. zapota	8.67	11.10	1.10	1110.67
Ailanthus sp.	0.00	0.00	0.00	1489.00
A.occidentale	0.00	0.00	0.00	1344.67
A.heterophyllus	11.00	5.53	0.93	1569.33
A. hirsutus	15.00	4.30	1.50	1401.33
A.indica	22.00	4.70	1.17	1506.33
Bombax sp.	6.33	2.93	1.57	1340.00
C. equisetifolia	0.00	0.00	0.00	1517.33
Coffea sp.	8.67	6.67	1.03	1533.67
E.indica	21.00	4.50	1.17	1424.00
G. sepium	24.67	4.43	2.70	1526.00
H. brasiliensis	3.33	1.93	0.03	1417.67
L.leucocephala	3.67	3.00	0.00	1518.00
M. indica	5.67	6.87	1.23	1490.00
P. guajava	7.33	6.93	0.57	1404.00
Swietenia sp.	12.00	7.53	1.17	1376.67
T.indica	13.33	7.20	1.47	1381.67
T.grandis	11.00	7.67	1.70	1324.00
T.populnea	11.33	7.93	1.73	1456.00
T. cacao	10.00	6.40	1.57	1460.67
Macaranga sp.	10.33	6.90	1.40	1499.33
Control (Banana pseudostem)	32.33	13.47	3.27	1557.00
CD (0.05)	3.06	2.61	0.67	94.55

ganic materials like sugars, phenolics, hydrocarbons and glycerides which vary with the plant species (Swift *et al.* 1979). This variation in composition will definitely affects the quality of leachates produced and thus influences faunal growth and reproduction. According to Manzoni *et al*. (2012), the addition of particular leaf leachate may affect the physiology of associated microbial community.

Leaf leachates of *M.zapota, A .occidentale, A. hirsutus, Erythrina, H.brasiliensis, P.guajava, Swietenia* sp.*,T.indica, T.grandis, T.populnea* and *T. cacao* resulted in significantly less compost output. Using sapota leaf leachate generated least compost output. It is inferred that exposing earthworms to tree leaf leachates adversely affects multiplication and growth of earthworms and a good biomass supporting medium may not be good medium for reproduction in earthworms (Chaudhuri and Bhattacharjee 2002).

CONCLUSION

Vermicompost production and growth of earthworms were found to be dependent on the quality of foodstuff given. Nitrogen rich substrates like *Glyricidia* and *Leucaena* sp. produced comparatively higher compost output. The studies on role of leaf leachates in earthworm morphology is very meager. Hence, extensive studies have to be undertaken to know the actual chemical influence on these leachates on earthworm activity and resultant compost production. Further efforts might be carried out to exploit the full potential of euphorbiaceae species, *Macaranga* in vermicomposting.

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