International Journal of Recycling of Organic Waste in Agriculture (2023)12: 699- 708
Doi: 10.30486/IJROWA.2023.1977455.1580

ORIGINAL RESEARCH

Utilization of *Lagerstroemia speciosa* dry leaf litter combined with cattle dung for the production of enriched vermicompost – A possibility of valorization

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Received: 23 January 2023 / Accepted: 17 July 2023 / Published online: 18 July 2023

Abstract

Purpose: Waste and waste disposal is a universal problem and attention is required in all ways. The plant generated waste (leaf litter) is also a type of organic waste that creates multiple issues in urban areas.

Method: Vermicomposting is a suitable alternative safe, hygienic, and cost-effective disposal of organic solid waste with the help of earthworms. The present study focussed on the conversion of leaf litter of *Lagerstroemia speciosa* trees from the local places to beneficial vermicompost. Vermicompost was prepared using leaf litter (LL) supplemented with cattle dung (CD), food waste, and earthworms. The study also explored the physical factors like temperature, pH, moisture, and biomass reduction of the vermicompost (100% & 50% LL) and CD.

Results: An alkaline pH (8.97±0.04), nominal temperature (22.63±0.26°C) and high moisture content (72±2.75%), as well as increased biomass reduction (7.45±0.69 cm) was observed at the end of the vermicompost process. The study also performed plant growth analysis using vermicompost as manure. Increased growth, germination, and pest resistance were observed in the plants in which compost was utilized.

Conclusion: The current study paves the way to create a green environment by reducing and converting leaf litter into vermicompost which will act as a circular economy.

Keywords: Waste management, Earthworms, Manure, Recycle, Plant growth, Circular economy

Introduction

Reducing and managing waste is a great challenge in today's scenario. Waste causes environmental pollution (Aalok and Tripathi 2010) and such waste generation needs to be managed in urban areas including the litter from trees. The litter which is being generated is a natural process but elimination and management of those leaf litter are quite essential to avoid major problems including water logging and land pollution. The litter production and its decomposition are a complex and time-consuming process. Some conventional methods of eliminating litter from urban places include scorching and dumping. These methods not only make the environment polluted but also affects the health of human beings (Sannigrahi 2009). Hence an efficient and sustainable approach is required for managing these leaf litters (Tripathi and Bhardwaj 2004).

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Vermicomposting is a sustainable bioconversion process that has become a popular solid waste management technique. Vermicomposting is a splendid bioconversion process of converting biological waste into nutrient-rich biofertilizers with the help of earthworms and other microflora such as bacteria, fungi and actinomycetes (Shouche et al. 2011). Vermicomposting is an improved part of composting but it differs from composting in several ways and also, it's a quicker process (Gandhi et al. 1997). It is also a result of the combined activity of microorganisms and earthworms in which primary decomposition takes place outside while secondary decomposition takes place inside the earthworm (Shouche et al. 2014). Different types of waste like sewage sludges, animal wastes, crop and industrial residues have been recycled by different researchers through vermicomposting (Mitchell et al. 1980; Chan and Griaths 1988; Hartenstein and Bisesi 1989; Yvonne et al. 2019).

The vermicomposting process involves various phases as follows (Garg et al. 2006):

i. Initial pre-composting phase: In this phase, the collected organic waste is pre-composted for about 15 days in vermi-reactors before the earthworms are introduced. During this phase, readily decomposable compounds will get degraded and the toxic volatile substances are eliminated.

ii. Mesophilic phase: During this phase, earthworms are introduced into the bins and earthworms with their decomposition activity convert the organic matter combined with soil particles into nutrient enriched organic manure which has enhanced microbial activities. This process will take up to an extra 15-30 days.

iii. Maturing and stabilization phase: In this phase, the obtained organic manure rich in nutrients, minerals, N_2, ammonia can be stored for 5 more days to get its fully matured state. After this state, the vermicompost will be ready to act as a natural biofertilizer.

Benefits of vermicomposting

- Vermicompost contains a high amount of humus which helps soil to create channels for the passage of air and increase water hold capacity.
- It increases the beneficial soil microbes and their activity.
- It also develops biological resistance in the plants which increases the Soil Organic Matter (SOM).
- Vermicompost does also have the ability to suppress soil-borne plant diseases and remove soil salinity and soil sodicity.

Vermicompost has so many advantages to the plants which can be available from the properly handled organic waste. This could serve as a circular economy since waste can be managed as well as nutrient rich compost can be produced (Fig. 1).

The production of vermicompost from different leaf litters such as wheat straw (Indrajeet and Singh 2010), sugarcane leaf (Alagesan and Dheeba 2010), Ashoka tree litter, teak tree leaf litter and Neem tree leaf litter (Jayanthi et al. 2010), Tendu leaf litter (Mushan and Rao 2012), mango and guava leaf litter (Vasanthi and Ranjith 2013), rubber leaf litter (Nath and Chaudhuri 2014), Teak leaf litter (Nagalakshmi and Prakash 2016) and eucalyptus (Nagar et al. 2017), sandalwood (Nagar et al. 2018a) and floral waste (Nagar et al. 2018b) have been reported. Although dry leaf is gradually decomposed, but vermicomposting enhances the nutrient level of the leaf litter.

Fig. 1 Graphical representation of conversion of leaf litter to vermicompost

The *Lagerstroemia speciosa* is a medium-sized evergreen tree that grows up to 25 meters tall. This tree is widely distributed in India, Sri Lanka, Cambodia, Myanmar, Thailand, Vietnam, Indonesia, Malaysia, Philippines, Bangladesh and Japan. *Lagerstroemia speciosa* tree has many medicinal advantageous which includes antidiabetics, anti-inflammatory and anti-depressant properties (Guy et al. 2007). *Lagerstroemia speciosa* named Poomaruthu in Tamil is commonly seen in our college campus and those leaf litters were spread out throughout the campus hence it was decided to utilize *Lagerstroemia speciosa* tree leaf litters for effective conversion of vermicompost. Thus, in the current study the production of vermicompost was carried out using leaf litter of *Lagerstromia speciosa* and food waste along with cow dung. The vermicompost produced have undergone for various physical and chemical analysis. The outcome of the vermicompost have been identified from the efficiency of the plant growth.

Materials and methods

Collection of leaf litter waste

Leaves were collected from our Vel Tech High Tech college campus, Avadi (13.1878° N, 80.1064° E) and were authenticated by the Siddha Central Research Institute, Chennai and to be from the *Lagerstromia speciosa* tree. The collected *Lagerstromia speciosa* LL were cleaned with distilled water cleared of any dust, where after it was dried for a week at room temperature (25°C).

Collection of earthworms

The commonly available earthworms which were highly involved in vermicompost include *Eudrillus eugeniae* and *Eisenia foetida*. These earthworms were collected from vermiculture in cattle farm, Avadi and utilized for further process of vermicompost.

Preparation of vermicompost

The shade dried fallen LL of the *Lagerstromia speciosa* tree were crushed into small pieces of about 10-15 mm in size. The crushed leaves (1.0 kg) were thoroughly mixed with old dung (1.0 kg) in a ratio of 1:1 and distributed into plastic bins. To add nutrition value, a small quantity of vegetable peels was added. Leaf litter was thoroughly mixed with cattle dung and food waste were uniformly distributed into vermi-reactors, including plastic, earthern pots and woodworm bins. After 15 days, when the temperature reaches the ambient level, vermicomposting bin was inoculated with 10 worms of each species (*E. eugeniae and E. foetida*). Throughout the research period, the bins received routine watering to maintain a moisture level of 65±1% and at the end of the 45th day valuable nutrient enriched vermicompost was produced.

Physical and chemical analysis of vermicompost

Vermicompost samples were collected from the initial stage (0th day) and at different stages of the vermicomposting process intermittently. The collected samples were allowed to air dry and stored at 4 to 8 ±1°C temperature, until the end of the experimental procedure was completed. During the process the physical and chemical parameters which include odour, pH, temperature, colour, granule size of the vermicompost were analysed. The odour of the vermicompost was determined by smelling directly. The heat produced during the vermicompost process was felt by physical touch (Rodale 1960). The granule size of the vermicompost was also measured using scale (Rodale 1960) and the colour was visually analysed (Shouche et al. 2011). The pH and temperature variations during the entire vermicompost process was measured using pH meter and mercury thermometer respectively (Taiwo and Oso 2004). The moisture present in the vermicompost was determined by taking the wet weight and dry weight of the composting materials before and after drying in the hot air oven at 105ºC for 24hrs and the moisture percentage was calculated as follows (Alidadi et al. 2005).

$$\text{Moisture Content} = \frac{(\text{Wet Weight} - \text{Dry Weight})}{\text{Wet Weight}} \times 100$$

Plant growth

To estimate the effectiveness of the vermicompost, *Hibiscus* plants were grown in clay pots of size 5x4" (breadth x height) under direct sunlight. Three groups were maintained: 1. Vermicompost prepared from the present study, 2. Regular compost available in the market and 3. Control (without any compost). The growth was monitored and the length of the all planted groups were measured every week for a period of 45 days.

Statistical analysis

The obtained results were analysed using one-way analysis of variance (ANOVA) followed by Duncan's multiple range test. The values were denoted as mean ± SD.

Results and discussion

Physical analysis of vermicompost

When produced the odour and colour of vermicompost was observed as well as heat generated during the process. During the first day of the composting, the odour was quite unpleasant and it was gradually changed and finally on the 45th day the compost turned into earthen smell. It was also found that the mixture of leaf litter and cattle dung had a foul odour than 100% cattle dung. The colour of the composting mixture was observed to be light greenish yellow colour at the initial phase but at the maturing phase the mixture turned into dark brown colour. The odour and colour change of the vermicompost observed can be attributed to the decomposition reaction happening during the breakdown process of the LL and cattle dung mixture (Hanumantappa and Sivagamsundari 2021).

The heat generated during the process was sensed with bare hands. It was found that the mixture of LL and cattle dung generated more heat than cattle dung. But at the final stage the heat was reduced and room temperature was achieved in the vermicompost. The increased heat generated during the initial phase of the mixture was due to the decomposition and exothermic reaction happening in the compost (Eduardo et al. 2021). But as the decomposition ends the heat generation also reduced.The grain size of the composting mixture was also noticed and a large sized clump was found at the early phase but at the end of the phase it turned to be smaller granules similar to size of tea leaves.

Chemical analysis of vermicompost

In the present investigation, the pH was found to be acidic in both 100% and 50% leaf litter of *Lagerstroemia speciosa*, while an alkaline pH was observed in 100% cattle dung. The pH of 100% and 50% leaf litter of *Lagerstroemia speciosa* tree was found to increase at the 10th week of vermicomposting later attained stable alkaline pH while in case of 100% cattle dung the pH level declined gradually and reached a stable pH at the 10th week. The final pH of all combinations was estimated to be 8.5 ± 0.5 (Table 1). The variations in the pH noticed during the vermicomposting process was due to the presence of nitrogen and phosphorus minerals in the compost and also as a result of humic and fluvic acid production during the organic matter degradation process (Irsa et al. 2021). A study also reported decline in pH during vermicomposting process using different organic waste including cow dung, horse dung, sheep dung and cashew leaf litter (Parthasarathi et al. 2007). In another research, pH 7.49 was observed in mango leaf litter vermicompost of *Lampito mauritii* while in control the pH was 7.41. Higher pH reduction (2.1) was found in cattle dung with teak leaf litter along with waste cotton and *Lampito mauritii* in the ratio 1:1 than the pH reduction in the ratio of 1:2 of mixture (Sundaravadivelan et al. 2011). Also, a report stated that maximum pH was recorded in the final teak leaf litter vermicompost (7.32) and lower pH in control (7.10) (Prakash and Karmegam 2010). Similarly, another study stated a decrease in pH during the process of vermicomposting of mixture of bagasse and cattle dung (Bhat et al. 2014).

The temperature variations during the process were measured and was found that during the 1st week, the average temperature of leaf litters as well as cattle dung and their mixture were high. It was observed that the temperature declined until the 10th week of vermicomposting period and later stability was achieved. It also revealed that at 1st week, the temperature of leaf litters and cattle dung mixture (36.5ºC±1ºC) was higher than 100% leaf litters (35.9ºC ± 1ºC) but lower than 100% cattle dung (38.5ºC ± 1ºC) (Table 1). Due to the presence of microbes and the aerobic breakdown of the undigested organic carbons present in the mixture the temperature of the 100% LL compost found to be have higher. In case of 100% leaf litters although ample quantity of organic carbon was available but due to the lack of microbial source the temperature was not as high as 100 % cattle dung. The temperature raise in initial phase was caused by the biochemical processes and the breakdown of organic waste components, but as the organic waste began to diminish, the temperature also gradually began to drip (Lefebvre et al. 2000). According to numerous studies, employing organic waste such as cardboard, newsprint, paper towels, municipal sewage, floral waste the increased temperature was observed in the initial phase of the vermicompost.

The moisture content of the Vermicompost mixture with 100% and 50% LL and with 100% cattle dung were gradually increased and high moisture content of about 71.65% was observed in 100% LL Vermicompost than the 50% LL Vermicompost (67.7%) and 100% cattle dung (65.2%). The moisture present in the mixture increased gradually in the LL and cattle dung mixture. This is because of the role of earthworms. The earthworms can greatly influence soil structure by the ingestion of soil which partially breaks down the organic matter causing intimate mixing of the components and ejection of these materials as earthworm casts. Earthworms also burrow through the soil eating and mixing the soil which is egested near the soil surface. Earthworms also play a role in the development of soil aggregates, increased soil aeration, and increased soil porosity during these processes. Their castings include more water-stable aggregates than the surrounding soil, and as a result of their activity, they have an impact on the soil's ability to retain moisture and drain water, both of which are crucial for the productivity of plants (Ansari and Ismail 2012; Ansari and Hanief 2013).

The biomass volume reduction was determined by measuring the height of the Vermicompost in the vermi-reactors. At the beginning of the process, the height of the composting mixture of 100% leaf litter and 50% leaf litter-cattle dung in vermi-reactors without decomposition was found to be 30.30 cm. and 29.15 cm respectively while the height of the cattle dung alone mixture was 15.86 cm. A declination in the height of the mixture was observed during the process and at the end stage the height has reached 6.5±1 cm (Table 1). The loss of water as water vapour and the breakdown of complex organic waste into simpler forms may have been contributed to the decrease in biomass. Biomass reduced quickly in the first two weeks of a study on municipal solid trash before remaining steady (Norbu 2002). In another study, the maximum depth reduction occurs during the first week and it was later determined to occur after 25 days. Similar observation was also observed in 100 % leaf litter (48%) and 50% leaf litter cattle dung mixture (46%) at first week of vermicomposting phase. It was also found that, the moisture level was rapidly increased in the 2nd of vermicomposting process in the mixture of 100% leaf litter and 50% leaf litter cattle dung mixture. As the process progresses, the moisture level was gradually reduced till the 10th week of vermicomposting phase. The results of the current study agreed with those of the composting of food and solid waste carried out by Suler and Finstein (1977) and Moqsud et al. (2012). In these studies, composting was completed in 35–40 days, and the volume of organic waste was decreased by 50–70% of its initial volume. A study stated that due to the abundance of easily degradable organic matter, microorganism reproduced very rapidly at the early stages of composting (Zheng and Chen 2004).

Plant growth

Three *Hibiscus* plants were grown, one as control without any compost, the second plant with Normal compost available in the market and the last plant with vermicompost produced from the current study. It was observed that there was good plant growth in both compost and vermicompost used plants. But comparatively the height of the plant was quite high in prepared vermicompost utilized plant than the commercially available compost (Fig. 2). The flowering and pest resistance was also observed in the plants which utilized the produced vermicompost. Similar study had shown the plant growth is a continuous variable, and they observed increased plant growth height with biofertilizer and its concentration

(Preethee et al. 2022). Also, studies showed when vermicompost has been used as manure, accelerated germination, increased shoot length, induced good rooting and yield has been observed (Vasanthi and Ranjith 2013; Thangaraj 2015; Mehran et al. 2020).

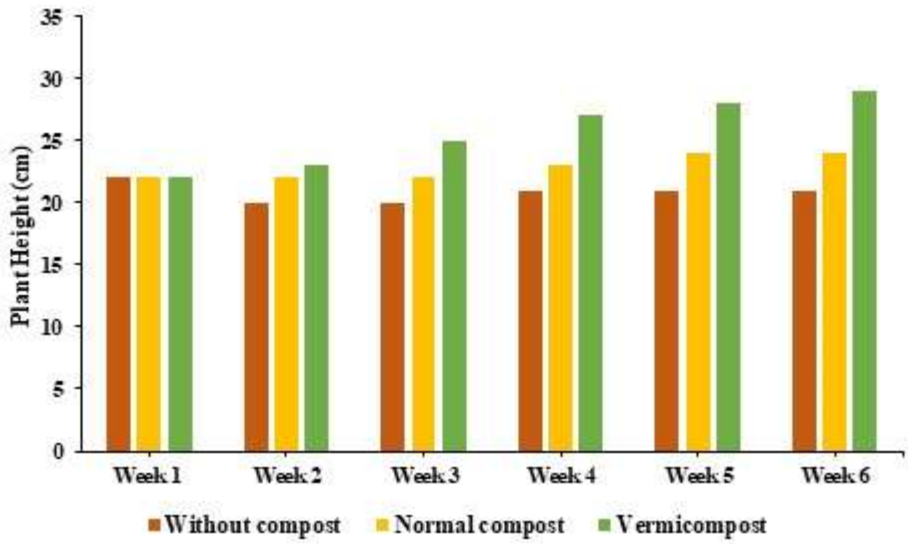

Fig. 2 Determination of plant height of control (without compost), normal compost and vermicompost

Conclusion

Managing plant leaf litter waste has become crucial due to it being an additional source of pollution. It poses a big challenge for both the government and private sectors to dispose of and manage this waste. However, converting the waste into vermicompost can serve as a circular economy, reducing the waste content while producing a nutrient-rich biofertilizer. This study focuses on converting the waste leaf litter generated in and around the Vel Tech Campus into valuable vermicompost. The addition of cattle dung in a 1:1 ratio with leaf litter accelerates the rate of decomposition, while the presence of earthworms improves the quality of the final product. Throughout the process, various physical and chemical parameters such as pH, temperature, moisture content, and biomass reduction were analyzed, and they reached optimum levels for plant growth. The results showed a gradual increase in plant growth, pest resistance, and flowering in plants that used vermicompost as manure. Therefore, this study emphasizes the significance of converting leaf litter waste into valuable vermicompost, which can lead to a greener environment when implemented on a large scale.

Compliance with ethical standards

Conflict of interest; The authors declare that there are no conflicts of interest associated with this study.

Table 1 Physical parameters and Biomass reduction of leaf litter (100% & 50%) and cattle dung

S. No	Collected samples	pH			Temperature (ºC)			Moisture (%)			Biomass reduction (cm)		
		100% LL	50% LL	CD	100% LL	50% LL	CD	100% LL	50% LL	CD	100% LL	50% LL	CD
1	1st week	6.7±0.04	6.9±0.10	9.6±0.06	36.9±0.7	37.6±0.87	39.6±0.71	49.3±1.64	47.6±0.69	61.4±0.92	30.3±1.14	29.1±0.81	15.9±0.78
2	2nd week	7.4±0.04	7.5±0.04	9.5±0.04	34.6±1.7	35.7±1.9	36.5±1.7	61.7±0.35	59.8±0.62	62.4±0.31	26.2±0.84	26.6±0.82	13.8±0.88
3	3rd week	7.7±0.10	7.9±0.10	9.4±0.07	33.6±0.2	33.6±0.32	34.9±0.65	63.9±0.26	60.7±0.22	63.9±0.26	23.7±0.64	24.4±0.53	12.1±0.24
4	4th week	8.1±0.10	8.2±0.10	9.3±0.04	31.5±0.71	32.7±0.24	33.6±0.28	64.5±0.41	61.6±0.40	64.8±0.37	19.3±0.82	23.3±0.31	11.7±0.15
5	5th week	8.2±0.04	8.3±0.07	8.2±0.04	29.4±0.63	29.6±1.07	30.9±0.86	66.8±0.5	64.6±0.71	65.7±0.13	17.9±0.23	21.9±0.41	11.3±0.10
6	6th week	8.3±0.10	8.5±0.09	9.1±0.04	28.5±0.75	28.6±0.48	28.5±0.44	68.4±0.37	65.7±0.19	65.9±0.07	15.7±1.01	16.8±1.63	10.7±0.32
7	7th week	8.5±0.11	8.6±0.08	9.1±0.06	26.2±0.69	27.2±0.49	26.5±0.67	69.4±0.24	66.6±0.27	66.7±0.21	13.6±0.33	13.8±0.3	9.7±0.24
8	8th week	8.7±0.10	8.8±0.06	9.0±0.08	24.6±0.77	25.7±0.56	25.7±0.37	70.2±0.2	66.9±0.04	67.3±0.17	11.9±0.44	11.4±0.92	8.9±0.26
9	9th week	8.8±0.04	8.9±0.07	9.0±0.04	23.3±0.58	23.8±0.59	23.9±0.70	71.3±0.31	66.9±0.04	65.4±0.62	10.6±0.47	10.5±0.04	7.2±0.56
10	10thweek	8.9±0.06	9.0±0.07	9.0±0.10	23.1±0.27	23.7±0.24	22.5±0.47	71.7±0.22	67.7±0.24	65.2±0.29	9.3±0.42	9.1±0.70	6.9±0.11
11	11thweek	9.0±0.06	8.9±0.07	9.0±0.08	22.4±0.46	22.5±0.52	23±0.11	72.3±018	67.2±0.44	66±0.22	8.1±0.34	7.7±0.23	6.5±0.2

Values are means ± SD (n=5)

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