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Vermicomposting in agronomy Research using the leaf litter of Tendu Diospyros

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Abstract

The vermiculture using Tendu (Diospyros melanoxylon) leaf litter is another way of managing and recycling organic matter with improved yield in agricultural production . The work also assesses the ability of Eudrilus eugeniae in recycling Tendu leaf litter into the form of a humus rich compost through four different periods of 60 and 90 days depending on variations in the moisture content, ash content, pH and the electrical conductivity (EC) of the composting material. They also found out that earthworms make compost quality better through increasing the capacity to retain moisture, concentrating inorganic nutrient value and reducing the pH of compost in an orderly manner, which would make it good for the fertility of the soil. High EC means high soluble salts that are needed in cycling of nutrients, but it should be managed carefully as toxicity may occur. Tendu leaves used in making silkworm leaves, these leaves are thrown away as garbage but here they provide substrate to plants and do not pollute the surfaces of land. The author presents and discusses the two-fold goal of the work in terms of proper composting of organic material and the utilization of the valued final product—vermicompost.

Keywords: composting, Tendu leaf, earthworm, soil productivity, eco friendly agricultural practices,

Introduction

Vermicomposting is an eco-friendly technique for organic waste management that employs earthworms, primarily *Eisenia foetida* (often referred to as red wigglers), to decompose organic matter. These materials comprise food scraps, yard debris, and agricultural residues, which are otherwise deemed garbage. Earthworms are crucial to this process, as they ingest organic debris, digest it, and excrete it as a nutrient-rich substance known as vermicast or worm castings. Vermi compost serves as an advantageous organic fertilizer due to its abundance of key elements, including nitrogen, phosphorus, and potassium, which are crucial for plant development and soil vitality. Vermicomposting transforms waste into usable compost, hence decreasing landfill utilization and fostering sustainable agricultural practices (Zafar, 2023).

Vermicomposting Procedure

Vermicomposting entails multiple processes that guarantee the effective and efficient transformation of organic waste into nutrient-dense compost. Establishment of the Vermi Bed: The initial phase of vermicomposting involves creating an appropriate habitat for the worms. This is accomplished by establishing a vermicomposting bed, which often entails layering materials like shredded paper, cardboard, and soil. These elements facilitate the establishment of a moist, aerated, and conducive atmosphere for the flourishing of earthworms. Incorporating Organic Waste: After the vermi bed is prepared, organic waste materials such as vegetable peels, fruit remnants, and other biodegradable kitchen refuse are introduced. This excrement constitutes the principal nutritional source for earthworms. It is imperative to guarantee that the trash is devoid of

chemicals, oils, and non-biodegradable materials to preserve the well-being of the worms.

Worm Activity: Earthworms ingest organic stuff, decomposing it via their digestive mechanisms. As the substance traverses their bodies, it experiences breakdown and is augmented by microbial activity. This leads to the generation of vermicast, a highly fertile byproduct. In this phase, it is essential to sustain optimal moisture and temperature conditions in the vermi bed to facilitate the worms' activities Geeksfor Geeks, 2023).

Vermicompost Harvesting: Following many weeks, the vermicompost is prepared for collection. The final product is a black, granular, and odorless substance that can be extricated from the worms and any residual undigested material. This vermicompost can subsequently be utilized to enhance garden soil, offering a natural and efficient substitute for chemical fertilizers. The remaining worms can be repurposed for future cycles of vermicomposting, so guaranteeing a continuous and sustainable process (Thirunavukkarasu *et al*., 2022)(Gupta *et al*., 2019).

Attributes and Accessibility of Tendu Leaf Litter

Tendu leaves, mostly derived from Diospyros species like *Diospyros crassiflora* and *Diospyros melanoxylon*, has considerable ecological and economic significance. These leaves are predominantly utilized in multiple sectors, particularly in the production of beedis (traditional Indian hand-rolled cigarettes). Litterfall from tendu trees transpires frequently year-round, with notable surges during certain seasons. A study in Nigeria indicated that leaf litter generation from *Diospyros crassiflora* reaches its zenith during the dry season, particularly from November to March. This seasonal rise is mostly ascribed to environmental factors, including insufficient precipitation and heightened temperatures.

The volume of tendu leaf litter fluctuates monthly, with December frequently exhibiting the peak rates of litter generation. This litter's composition is advantageous to forest ecosystems, as it is essential for nutrient cycling. The decomposition of litter provides the soil with vital nutrients, ultimately improving soil fertility and fostering biodiversity. This natural cycle highlights the ecological significance of tendu leaf litter in addition to its commercial use (I. B. Nsien & Ufia, 2020)(I. B. Nsien *et al*., 2024).

Possibility of Utilizing Leaf Litter as a Vermicomposting Medium

Tendu leaf litter has demonstrated considerable potential as a substrate for vermicomposting, an environmentally sustainable approach to organic waste management. Studies have shown that the organic material from tendu leaves can augment microbial activity in the composting process. The heightened microbial activity enhances the decomposition of organic matter, hence augmenting nutrient accessibility in the resultant compost. The utilization of tendu leaf litter for vermicomposting repurposes this plentiful natural resource and conforms to sustainable agriculture practices(R. & M., 2013).

Principal Advantages of Utilizing Tendu Leaf Litter in Vermicomposting

Vermicompost generated from tendu leaf litter has enhanced nutritional content relative to conventional composted materials. Research demonstrates that this form of vermicompost has elevated electrical conductivity, indicating improved nutrient accessibility. These enhanced nutrients, comprising both macronutrients and micronutrients, facilitate vigorous plant growth.

The efficacy of biodegradation in vermicomposting is significantly improved with the use of particular species of earthworms, notably *Eudrilus eugeniae*. These worms are especially proficient at decomposing tendu leaf litter under ideal conditions of pH, temperature, and moisture. Upholding these conditions is essential for producing superior vermicompost and optimizing the composting process's efficiency (D.G.Kadam, 2015).

The utilization of tendu leaf litter in vermicomposting is a novel approach to addressing the waste management issues related to the disposal of substantial amounts of tendu leaves. Beedi manufacturing industries produce substantial quantities of tendu leaf waste, which may result in environmental pollution if inadequately managed. Repurposing this material by vermicomposting can diminish pollution, efficiently manage organic waste, and foster sustainable agriculture practices (B. I. Nsien et al., 2022).

Research Objectives

1. To evaluate the effects of *Eudrilus eugeniae* on the decomposition and nutrient dynamics of Tendu leaf litter.

2. To assess changes in moisture, ash content, pH, and EC in Tendu leaf litter during vermicomposting.

Literature Review

(Kadam & Pathade, 2014) The leaves of Tendu (*Diospyros melanoxylon RoxB*.) are widely utilized in India as wrapping for producing primitive smoking sticks referred to as "beedis." Solapur city in Maharashtra hosts multiple small-scale beedi manufacturing operations that produce substantial amounts of trimmed leaf waste, which can be efficiently utilized as feedstock for vermicompost production. This research examines the effects of vermicompost sourced from tendu leaf residues on the growth and yield of Phaseolus vulgaris (French bean) in a greenhouse setting. French bean seeds were cultivated in pots filled with soil only (control), soil with different concentrations of vermicompost, soil with variable levels of urea, and combinations of vermicompost and urea. The results demonstrated that seed germination, shoot and root lengths, fresh and dry weights of shoots and roots, thousand-grain weight, and grain production per plant considerably enhanced ($p < 0.05$) with suitable vermicompost application. Treatment T2 (75% nitrogen via vermicompost) exhibited enhanced growth and yield metrics relative to T1 (100% nitrogen via vermicompost) and T3 (50% nitrogen via vermicompost). In contrast, T1 exhibited diminished growth characteristics compared to the control, indicating possible detrimental impacts of elevated vermicompost concentrations. The synergistic application of tendu leaf vermicompost and urea considerably improved growth and yield ($p \leq 0.05$), with the highest grain yield recorded in the treatment utilizing 25% nitrogen from vermicompost and 75% nitrogen from urea. This study demonstrates that the application of chemical fertilizers in French bean agriculture can be lowered by 25–50% by the combined use of vermicompost and fertilizers. Excessive application of vermicompost may adversely affect development and yield, highlighting the necessity for balanced nutrient management measures.

(Jamil *et al.,* 2020) This study examines the engineering qualities and drying characteristics of ripe and unripe tendu fruits, emphasizing moisture loss during drying at two temperature settings (50°C and 60°C) for slices measuring 1 cm, 2 cm, and 3 cm in thickness, utilizing tray, vacuum, and freeze drying methods. The drying behaviour was examined utilizing the modified Page equation to determine the moisture ratio. The engineering parameters measured for both ripe and unripe tendu fruits included bulk density, true density, Carr's compressibility index, surface area, unit volume, angle of repose, and static friction coefficient, revealing only minor differences between the two. The porosity and Carr's compressibility index for ripe fruits were 26.12% and 6.64, while for unripe fruits, they were 24.89% and 7.67, respectively. Proximate analysis indicated no substantial variations in ash, crude fat, crude fiber, and protein levels between ripe and unripe fruits. The vacuum drying technique outperformed tray drying across all fruit slice thicknesses. Notably, 1 cm thick slices dried at 60°C exhibited superior outcomes with vacuum drying in comparison to tray drying, corroborated by modeling utilizing X^2, R^2, and RMSE metrics. Freeze drying, as a continuous drying method, yielded the highest quality dried slices across all thicknesses, with ultimate moisture content between 7-10%. The findings indicate that vacuum drying, especially at 60°C for 1 cm thick slices, achieves excellent drying efficacy, but freeze drying preserves the highest quality of dried products regardless of slice thickness.

(Mhaskey *et al.*, 2023) Tendu (*Diospyros melanoxylon Roxb*.), part of the Family Ebenaceae, is indigenous to the Indian subcontinent and is commonly referred to as temburini, tendu, kendu, abnus, or bidi. The leaves of this tree are extensively harvested for local use and export, constituting a crucial source of revenue, especially for tribal tribes in India. Tendu leaves are commonly termed "green gold" because of their considerable economic importance in tribal regions. The Forest Rights Act grants tribal individuals the authority to collect, safeguard, and enhance forest resources. The gathering of tendu leaves employs around 7.5 million workers across the nation for about three months annually, according to the Tribal Cooperative Marketing Development Federation of India. The state government establishes collecting fees, while the harvesting process is governed by the Rajasthan Tendu Leaves (Regulation of Trade) Act, 1974, along with its corresponding regulations. Tendu leaves are primarily collected in districts like as Pratapgarh, Banswara, Udaipur, Dungarpur, Pali, Baran,

Bhilwara, Jhalawar, and Dholpur, where local and tribal populations participate in the harvesting, particularly in the summer months. Moreover, more than 3 million individuals depend on the processing of tendu leaves for the production of bidis, a traditional smoking product. During the fiscal year 2021–2022, 317,206 bags of tendu leaves were sold, yielding ₹4069 lakhs in revenue. Notwithstanding the increase in output and revenue, the industry has exhibited slow yet consistent advancement. Establishing reserve prices and awarding bonuses for laborers are anticipated to enhance income generation by providing increased incentives to the workforce engaged in tendu leaf gathering and commerce.

(Mehta *et al.*, 2020) Research was performed on SFD-controlled trimmed tendu bushes and CFR-controlled non-pruned poles in the Gondia and Gadchiroli forest divisions of Maharashtra to assess the effects of pruning on the yield and quality of tendu leaves. Tendu (Diospyros melanoxylon) is a commercially important species, since its leaves serve as wrappers in the bidi (Indian cigarette) industry, generating money in states such as Madhya Pradesh, Maharashtra, Odisha, and Uttar Pradesh. The findings indicated that pruned bushes yielded more than five times the quantity of healthy leaves (60.33%) in contrast to non-pruned poles (11.90%). Moreover, the prevalence of gall infestations, illnesses, and defoliation was markedly reduced in trimmed bushes, with observed rates of 7.98%, 2.47%, and 29.21%, respectively, in contrast to non-pruned poles (15.37%, 4.97%, and 67.76%). The Specific Leaf Area (SLA), a measure of leaf quality, was greater in pruned bushes (7.46 mm^2/mg) compared to non-pruned poles (6.39 mm^2/mg), signifying enhanced leaf quality in the pruned bushes. Leaf galls were induced by the bug Trioza obsolete, leaf blight by Pestalotia diospyri, and defoliation by the insect Hypocala rostrata. Pruned bushes' healthy leaves demonstrated the highest quantities of carbohydrates and phenols, whereas diseased leaves exhibited the highest proline content, and leaves affected by insects contained the highest concentrations of ascorbic acid. The data indicate that pruning markedly improves the output and quality of tendu leaves, rendering it a more efficient and sustainable method for the bidi business.

(Nair *et al.*, 2021) The Vidarbha Tiger Landscape in Maharashtra is an essential connection link to the Central India Tiger Conservation Landscape, with the Nagzira Nawegaon Brahmapuri landscape functioning as a corridor for tiger populations among the Tadoba, Pench, and Kanha Tiger Reserves. These corridors host numerous settlements that depend on forest resources for sustenance and additional income. The gathering of Non-Timber Forest Products (NTFPs) like Tendu (Diospyros melanoxylon), Mahua (Madhuca longifolia), and additional forest products is crucial for sustaining livelihoods, yet it also incites human-wildlife conflict. Government agencies and Non-Governmental Organizations have instituted diverse projects to diminish reliance on forest resources along these connectivity corridors. This research, undertaken in the Vidarbha Landscape, is the inaugural documentation of the collection and distribution of two prevalent non-timber forest product species and other selective tree species across communal village lands and agricultural zones between the Nagzira Nawegaon Tiger Reserve and the Brahmapuri Forest Division adjacent to the Tadoba Andhari Tiger Reserve. The research indicates that marginal landholders and landless individuals exhibit greater reliance on the procurement of these resources. The results facilitate the creation of an inclusive corridor and conflict management strategy for both regions, seeking to harmonize conservation objectives with the livelihoods of local populations while alleviating human-wildlife conflict.

Methodology

Experimental Configuration

The experiment aimed to evaluate the influence of Eudrilus eugeniae on the decomposition of Tendu leaf litter and the ensuing alterations in its moisture content, ash content, pH, and electrical conductivity (EC). The control sample consisted of decomposed Tendu absent of earthworms, whereas the experimental groups involved vermicomposting using Eudrilus eugeniae at two distinct intervals: 60 days and 90 days. Fresh Tendu leaf litter was gathered for the experiment, and the decomposition process was observed over 60- and 90-day intervals.

Experimental Procedure

The decomposed Tendu was allocated to distinct composting units, with the experimental units incorporating earthworms (Eudrilus eugeniae) to enhance vermicomposting. The composting units were maintained in a regulated environment with stable temperature and humidity levels to facilitate decomposition. The earthworms were introduced at the onset of the experiment, and their activity was observed

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throughout the investigation. The decomposition process was permitted to continue for 60 and 90 days, after which the compost samples were gathered for analysis.

Sample Collection and Analysis

At the conclusion of the 60- and 90-day intervals, compost samples were obtained for laboratory analysis. The moisture content was determined by drying a specified weight of the sample in an oven at 105°C until a consistent weight was achieved. The ash concentration was ascertained by incinerating the sample at 550°C to eliminate the organic material, so retaining the inorganic ash. The pH was assessed utilizing a pH meter subsequent to combining the compost with distilled water in a 1:1 ratio. The electrical conductivity (EC) was measured with an EC meter to evaluate the soluble salts in the compost.

Statistical Analysis

The data derived from the study of moisture content, ash content, pH, and electrical conductivity were compared between the control and experimental samples at both 60 and 90 days. Statistical significance was assessed by suitable procedures to evaluate the variation in these characteristics at various time points.

Result

Table 1. Physico-chemical investigation of E. eugeniae-processed tendu vermicompost in comparison to disintegrated tendu at different intervals.

Parameters		Moisture (%)	Ash (%)	pH	EC (mS/cm)
Decomposed Tendu		46.02 ± 5.73	52.66 ± 4.97	7.10 ± 0.82	0.42 ± 0.03
Vermicompost	**E.eugeniae 60 days**	52.4 ± 6.02 (13.87%)	54.92 ± 5.01 (4.3%)	7.00 ± 0.62 (5.7 %)	0.67± 0.08 (59.6 %)
	E.eugeniae 90 days	48.7 ± 5.91 (4.46%)	50.47 ±5.03 (4.2%)	6.93 ± 0.67(1.5%)	0.69 ±0.08 (64.3 %)

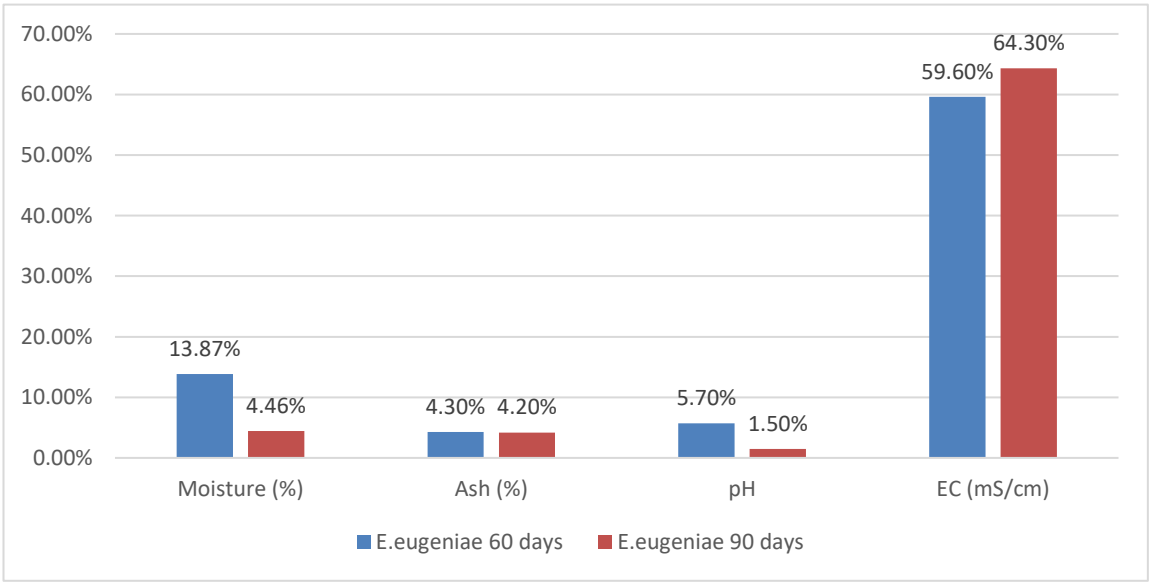

Figure 2: Physico-Chemical Analysis of Tendu leaf litter Vermicompost processed by *E.eugeniae* at various time periods.

On average, 100g of decomposed tendu which was used as a control in this experiment, was found to possess 46.02± 5.73% moisture content. The moisture content on the other hand risen to 52.4 ± 6.02% after 60 days of composting with earthworm species Eudrilus eugeniae. This is supposed to have been caused by the actions of the earthworms in the decomposition of organic matter hence leading to an increase in the amount of moisture which is retained in the compost. However, after 90 days the percentage of moisture content reduced to 48.7 ± 5.91%. This decline might be due to the reduction of drying effects over time or a change in the degradation process, however, the fluctuation from the control was not significant.

In as far as ash content is concerned, there was an increase after 60 days of composting the values being at 54.92 ± 5.01 % which was 5.8% higher than the control. This increase may be attributed to higher variability and leaching of the organic matter as well as accu-mulation of minerals and inorganic compounds during the decomposition stage. But at the end of the 90 day period, the ash content marginally reduced to 50.47 ± 5.03%, which was 8.2 % lesser than that of the control. This decline continues to support the notion that the material is even more decomposed, and the minerals may have been used or washed away.

As for the pH value, control sample had pH 7,10 ± 0,82. According to the results, it became 7.00 ± 0.62 after 60 days of vermicomposting which is 5.7% reduction. These small changes in pH can therefore be attributed to microbial and earthworm activity given that organic acids are produced during decomposition. After 90 days, the pH reduced to 6.93 ± 0.67, quite a substantial inhibition of 14 % as compared the initial control. The further decrease in pH over time could be because the compost had progressed through the advanced stage of decomposition stage as well as the escalating microbial function in the compost.

Electrical conductivity (EC) was also experiences changes during the study and there were significant difference. To begin with the EC of the decomposed tendu was determined at 0.42 ± 0.03 mS/cm. At the end of the 60 days of process of vermicomposting the EC was raised to 0.67 ± 08 mS/cm compared to the control, with an increase of 59.6%. Hence, this rise in EC could be attributed to the build up of soluble salts from microbial action or the leach out of minerals in the organic matter that defines the compost characteristics on the ion value. This rise in EC was statistically significant at $P < 0.01$. After 90 days, the EC rises further to 0.69 ± 0.08 mS/cm, which is a 64.3% increase, more pronounced at $P < 0.001$. This raises an implication that extended duration in the decomposition of these compounds and earth worm invasion results in accumulation of soluble salts, which is typically linked with nutrient cycling in compost materials.The outcomes from the experiments in this study uts the importance of earthworms in composting in as a dynamic process in that every period of composting Dry weight, ash content, pH and EC values demonstrate physical and chemical composition of compost subjected to the earthworms show how composting is a dynamic process over time.

Discussion

This study's findings illustrate the substantial influence of Eudrilus eugeniae on the composting process, specifically on moisture content, ash content, pH, and electrical conductivity (EC). The rise in moisture content from 46.02% in the decomposed tendu to 52.4% after 60 days indicates that earthworm activity contributes to improved moisture retention in the compost. Earthworms facilitate the decomposition of organic materials, enhancing its water retention capacity. The reduction in moisture content to 48.7% after 90 days may suggest that the compost material experiences desiccation over time due to natural processes like evaporation, or that the earthworms may have ingested the moisture-rich material more rapidly than it could be supplied.

The ash content exhibited a comparable trend, with a notable rise of 5.8% relative to the control after 60 days. This may indicate the concentration of inorganic constituents, including minerals and trace elements, when organic matter decomposes. The following reduction in ash concentration after 90 days, by 8.2% relative to the control, may indicate that certain minerals and inorganic compounds were either assimilated into microbial biomass, leached out, or consumed by the earthworms. This signifies an intricate interplay between biological and chemical processes throughout degradation.

The pH of the compost progressively declined, signifying a trend of acidification. The reduction in pH from 7.10 to 6.93 after 90 days aligns with the typical observations in organic decomposition processes, wherein microbial activity and the generation of organic acids progressively decrease the pH. This reduction may be advantageous for specific plant growth, as

mildly acidic environments frequently enhance nutrient availability.

The significant rise in EC, particularly the 59.6% increase after 60 days and the 64.3% increase after 90 days, signifies an accumulation of soluble salts resulting from breakdown. Elevated EC values indicate that the compost may be nutrient-dense, advantageous for plant development, yet necessitate monitoring to prevent salt toxicity.

Conclusion

This research also shows that Tendu leaf litter could be a good substrate for vermicomposting and it may be a cost effective and efficient way to manage organic waste. These enhanced features of compost quality include: increased moisture holding capacity, nutrient concentration, and fertilising capacity followed by increased EC and reduced pH, all of which are beneficial to soil growth when Eudrilus eugeniae is included in a compost mix. The work suggests that Tendu leaf based vermicompost is rich in available nutrients and can reduce or replace chemical fertilizers in sustainable agriculture. The following ban has ensured that environmental pollution is not realized and that proper waste management is boosted in line with the circular economy objectives: With the verified capacity of the concept to turn agricultural waste into valuable compost, this type of practice addresses vicious interdependence between waste handling and agriculture and can open up for further experimentations in regards to more efficient and ecological types of agronomic practices.

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