(ISSN: 0973-7049(P))

The Bioscan AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES 21(4): S.I (4),1018-1031, 2026 www.thebioscan.com

VERMICOMPOSTING OF SUGARCANE TRASH THROUGH FUNGAL PRETREATMENT USING *PHANEROCHAETE CHRYSOSPORIUM* AND THE EARTHWORM *LAMPITO MAURITII*

Nanda Bhupal Jagtap[1] Mandakini Rajendra Ingle[2], Anushree Aher[3] Shraddha Harishchandra Dive[4]

[1]Associate Professor, Dapoli Urban Bank Senior Science College Dapoli District Ratnagiri (Orcid ID – 0009-0005-2069-0904)
[2]Associate Professor, Department of Botany, Satish Pradhan Dnyanasadhana College (Autonomous)Thane (Orcid id -0009-0003-6224-1037)
[3]Assistant Professor,Department of Botany, Satish Pradhan Dnyanasadhana College (Autonomous)Thane (Orcid id -0009-0005-0338-8535)
[4]Assistant Professor, Department of Botany, Satish Pradhan Dnyanasadhana College (Autonomous) Thane (Orcid Id – 0009- 0006-1318- 6424)
Corresponding Email: jnsshinde80@gmail.com

DOI: https://doi.org/10.63001/tbs.2026.v21.i04.S.I(4).pp1018-1031

KEYWORDS
Sugarcane trash, Phanerochaete chrysosporium, Lampito mauritii, fungal pretreatment, vermicomposting, lignocellulosic waste, microbial population, nutrient enrichment.

Article Info

Received:02.20.2026

Accepted: 29.10.2026

Published: 11.11.2026

Abstract

Sugarcane trash, an abundant agricultural residue, represents a potential resource for organic manure production; however, its slow natural decomposition limits its effective utilization. The present study was undertaken to evaluate the effectiveness of fungal pretreatment using *Phanerochaete chrysosporium*, followed by vermicomposting with the native earthworm *Lampito mauritii*, for accelerating the decomposition and stabilization of sugarcane trash and improving the nutritional quality of the final product. Sugarcane trash was subjected to fungal pretreatment through inoculation with *P. chrysosporium* for 30 days, followed by vermicomposting using *L. mauritii* for 40 days. The combined treatment facilitated the breakdown of complex organic matter and enhanced the overall decomposition process, resulting in nutrient-enriched vermicompost. The quality assessment revealed that the vermicompost exhibited higher concentrations of essential chemical nutrients and greater microbial abundance, including bacteria, actinomycetes and fungi, compared with conventionally prepared compost. The enhanced microbial activity and nutrient enrichment indicate the potential of fungal-assisted vermicomposting as an effective approach for converting lignocellulosic agricultural waste into valuable organic manure. The findings highlight the synergistic role of *P. chrysosporium* and *L. mauritii* in improving the biodegradation and value addition of sugarcane trash, offering an environmentally sustainable strategy for agricultural waste management, soil fertility restoration and sustainable crop production.

Introduction

Sugarcane (*Saccharum officinarum* L.) is one of the most economically important commercial crops worldwide and plays a significant role in the agricultural, industrial and rural economies of India. India is among the leading sugarcane-producing countries, and sugarcane cultivation generates substantial quantities of agricultural residues, particularly dry leaves, green tops and sugarcane trash during harvesting. Although these residues contain considerable amounts of organic carbon and plant-derived nutrients, their effective utilization remains a major challenge in sustainable agricultural waste management. Improper disposal, particularly open-field burning, continues to be practised in several sugarcane-growing regions because of labour constraints, harvesting schedules and the need for rapid field clearance. Such practices contribute to atmospheric

pollution, greenhouse gas emissions, loss of valuable nutrients and deterioration of soil biological properties. Ravish and Chaudhry (2025) and Nagargade *et al.* (2021) highlighted the importance of appropriate sugarcane trash management and its potential for improving agricultural sustainability through residue recycling.

Sugarcane trash is primarily composed of lignocellulosic materials, including cellulose, hemicellulose and lignin, which form a structurally complex plant biomass. The high lignin content and complex arrangement of these polymers restrict microbial accessibility and consequently slow down the natural decomposition process. Although sugarcane residues can serve as an important source of organic matter for maintaining soil fertility, their direct incorporation into agricultural fields may require prolonged decomposition and appropriate management. Nagargade *et al.* (2021) emphasized the potential of sugarcane trash utilization through mulching and other recycling approaches to improve soil organic carbon and nutrient conservation. Similarly, recent investigations have demonstrated that composting sugarcane residues with suitable organic amendments can improve the physicochemical characteristics, nutrient composition and maturity of the final compost product (Asava *et al.,* 2026). Therefore, developing biologically efficient and economically feasible approaches for accelerating the decomposition of sugarcane trash is essential for sustainable agricultural production and environmental conservation.

Microbial-assisted composting represents an effective biological strategy for converting complex organic residues into stabilized organic manure. The decomposition process is primarily mediated by diverse groups of microorganisms, including bacteria, actinomycetes and fungi, which participate in the hydrolysis and mineralization of organic compounds. Among these microorganisms, lignocellulose-degrading fungi have attracted considerable attention because of their ability to produce extracellular enzymes capable of breaking down complex plant polymers. White-rot fungi, particularly Phanerochaete chrysosporium, are recognized for their remarkable ligninolytic potential and ability to degrade recalcitrant lignin through an extracellular enzymatic system involving lignin peroxidase, manganese peroxidase and other oxidative enzymes. These enzymes facilitate the structural modification and degradation of lignin, thereby increasing the accessibility of cellulose and hemicellulose to other decomposing microorganisms. Konan *et al.* (2024) highlighted the importance of P. chrysosporium in the biodecomposition of lignocellulosic biomass and its potential applications in environmental biotechnology and waste valorization. Furthermore, inoculation with P. chrysosporium can enhance lignocellulose degradation, humic substance formation and fungal community succession during organic waste composting (Wang *et al*., 2023; Zhai *et al.,* 2025).

The biological pretreatment of agricultural residues using ligninolytic fungi offers an opportunity to overcome the limitations associated with conventional composting. Fungal pretreatment facilitates the partial degradation of lignin and other complex organic constituents, thereby improving substrate suitability for subsequent biological processing. Wang *et al*. (2023) demonstrated that inoculation with P. chrysosporium, together with appropriate pH regulation, enhanced lignocellulose decomposition and humic substance formation during composting. Similarly, Zhai *et al.* (2025) reported that the combined application of *Trichoderma harzianum* and *P. chrysosporium* improved lignin degradation and humification during the composting of chicken manure and rice husk. These findings establish the

importance of fungal inoculation as a promising approach for improving the biological conversion of lignocellulosic agricultural residues. Moreover, Aly *et al*. (2025) emphasized the industrial potential of *P. chrysosporium* and its lignin-degrading enzymes in biomass valorization and environmental biotechnology.

Vermicomposting is another important eco-friendly biotechnology that utilizes the synergistic interactions between earthworms and microorganisms to transform biodegradable organic wastes into nutrient-rich and biologically active organic manure. During this process, earthworms fragment organic materials through ingestion and mechanical grinding, while their gut-associated microorganisms and associated microbial communities facilitate further decomposition, mineralization and stabilization of organic matter. The resulting vermicomposting generally contains improved concentrations of plant-available nutrients, humified organic matter and beneficial microbial populations. Earthworms also influence microbial activity and nutrient cycling through their casts, burrowing activities and interactions with the organic substrate. Among the indigenous Indian earthworm species, *Lampito mauritii* is an important vermicomposting species with considerable potential for organic waste conversion. Suvedha *et al.* (2024) reported improvements in macro- and micronutrient concentrations in vermicompost prepared using *L. mauritii*, highlighting its contribution to nutrient enrichment and soil quality improvement. Earlier, Suthar (2008) demonstrated the potential of L. mauritii in vermireactor systems for processing organic wastes, highlighting the contribution of earthworm-mediated decomposition to nutrient enrichment and waste stabilization.

The combined application of fungal pretreatment and vermicomposting may provide a more efficient approach to the management of recalcitrant agricultural residues than either process alone. Fungal pretreatment partially disrupts the lignocellulosic structure of plant biomass, making the organic substrate more accessible to earthworms and associated microbial communities. Subsequently, earthworm-mediated fragmentation, microbial transformation and nutrient mineralization may accelerate the conversion of pre-decomposed materials into stabilized vermicompost. This integrated biological approach has considerable significance for reducing agricultural waste accumulation, improving nutrient recycling and producing organic amendments that can contribute to sustainable soil management. However, the effectiveness of such combined systems depends on the nature of the substrate, fungal colonization, decomposition period, earthworm performance and microbial interactions during the stabilization process.

Despite the growing interest in fungal-assisted composting and earthworm-mediated waste management, the integration of P. chrysosporium pretreatment with monoculture vermicomposting using the indigenous earthworm L. mauritii deserves further investigation, particularly for the conversion of sugarcane trash into nutrient-enriched vermicompost. Understanding the contribution of fungal pretreatment to subsequent earthworm-mediated decomposition and changes in the microbial population is important for developing an efficient and sustainable waste-management strategy. Therefore, the present investigation was undertaken to evaluate the potential of *Phanerochaete chrysosporium* for the biological pretreatment and partial decomposition of sugarcane trash, followed by vermicomposting using the indigenous earthworm *Lampito mauritii* under monoculture conditions. The study focused on assessing the efficiency of fungal

pretreatment in accelerating the decomposition of lignocellulosic agricultural waste and examining the subsequent vermicomposting performance of *L. mauritii*. Furthermore, the physicochemical properties and chemical nutrient composition of the resulting vermicompost were evaluated to determine improvements in its overall quality. The microbial populations, particularly bacteria, actinomycetes and fungi, were also compared between compost and vermicompost to understand the influence of integrated fungal and earthworm-mediated decomposition on microbial abundance. Overall, the study aimed to establish the feasibility of combining fungal pretreatment with vermicomposting as an environmentally sustainable and effective strategy for converting sugarcane trash into nutrient-enriched, value-added organic manure for improving soil fertility and supporting sustainable agricultural production.

MATERIALS AND METHODS

Collection of Experimental Materials

Sugarcane trash and fresh cow dung were collected from the agricultural farm of a local farmer during a regional field survey conducted in the study area. The collected sugarcane trash consisted primarily of dry leaves and other post-harvest residues. Fresh cow dung was collected separately and used as an organic substrate component during vermicomposting. Both materials were transported to the experimental site and maintained separately under suitable conditions until further processing. The collected agricultural residues were used as the principal organic materials for fungal pre-treatment and subsequent vermicomposting.

Collection and Identification of Earthworms

The indigenous earthworm species *Lampito mauritii* was collected from the Vermiculture Yard.The collected earthworms were carefully separated from the vermicomposting substrate and transferred into suitable containers containing moist organic material to prevent desiccation and minimize handling stress. The specimens were examined for their external morphological characteristics, including body segmentation, pigmentation, clitellum position and other diagnostic features. Species identification was carried out following the taxonomic descriptions and identification characteristics provided by Talashilkar and Dosani (2005) and Blakemore (2010). Healthy and mature specimens of *L. mauritii* were selected for the experimental vermicomposting process.

Procurement of Fungal Culture

The ligninolytic white-rot fungus *Phanerochaete chrysosporium* was selected for the biological pretreatment and partial decomposition of sugarcane trash. The fungal culture was procured from the CSIR-Institute of Microbial Technology (IMTECH), Chandigarh, India. The culture was maintained under appropriate laboratory conditions and utilized for the preparation of fungal inoculum. The selection of this fungal species was based on its established ligninolytic potential and ability to degrade complex lignocellulosic materials through the production of extracellular oxidative enzymes.

Preparation of Phanerochaete chrysosporium Inoculum

A liquid-based inoculum was prepared using molasses and jaggery as nutrient sources to facilitate fungal growth and multiplication. Initially, 10 mL of molasses was transferred into a conical flask containing 90 mL of distilled water and mixed thoroughly. Subsequently, two mycelial discs of P. chrysosporium were

introduced into the prepared molasses solution under aseptic conditions. The fungal suspension was then mixed with 1 L of freshly prepared jaggery solution containing 1 kg of jaggery dissolved in 1 L of water. The resulting preparation was thoroughly homogenized and maintained for seven days to facilitate fungal multiplication. The prepared fungal suspension was subsequently used as an inoculum for the biological pretreatment of sugarcane trash.The inoculum preparation and subsequent fungal pretreatment were considered two distinct experimental stages. The seven-day period represented the inoculum preparation phase, whereas the 20-day period represented the subsequent fungal pretreatment of sugarcane trash. The sterilization status of the molasses and jaggery solutions, the incubation conditions and the assessment of fungal viability were not specified in the original experimental records. Therefore, these parameters should be confirmed from laboratory records before manuscript submission rather than assuming that sterilization, incubation under controlled aseptic conditions or viability testing was performed.

Preparation and Pretreatment of Sugarcane Trash

The collected sugarcane trash was manually cut into small pieces to increase the surface area available for microbial colonization and facilitate subsequent decomposition. The chopped material was spread uniformly over a clean floor and exposed to sunlight for five days. During this period, regular watering was carried out twice daily to maintain adequate moisture and facilitate preliminary conditioning of the plant residues. A similar preliminary conditioning procedure was followed for the collected cow dung. Subsequently, both the sun-exposed sugarcane trash and cow dung were transferred to a shaded location and maintained separately for an additional five days for curing before further processing. Following preliminary conditioning, the fungal pre-treatment of sugarcane trash was initiated. Approximately 1 kg of prepared sugarcane trash was uniformly spread over a clean floor, and 25 mL of the prepared *P. chrysosporium* inoculum was evenly sprinkled over its surface. Another 1 kg layer of sugarcane trash was subsequently placed over the inoculated material. This layering procedure was repeated systematically until a heap approximately 1 m in height was obtained. The fungal inoculum was applied uniformly between successive layers to ensure adequate contact between the fungal suspension and the lignocellulosic substrate.

The moisture content of the heap was maintained at approximately 60–70% by regularly sprinkling water. The entire heap was covered with wet jute bags to minimize moisture loss and maintain suitable conditions for fungal growth and decomposition. The prepared heap was maintained under shaded conditions for 20 days to facilitate fungal colonization and partial biodegradation of the sugarcane trash. During this period, the ligninolytic activity of P. chrysosporium was expected to facilitate the breakdown of complex lignocellulosic components, thereby improving the suitability of the pretreated substrate for subsequent vermicomposting using *L. mauritii.*

The fungal inoculum preparation and substrate pretreatment were conducted as separate experimental stages. The inoculum was maintained for seven days before its application to sugarcane trash, while the fungal pretreatment of the sugarcane trash was continued for an additional 20 days. Thus, the total duration of these two stages was 27 days, excluding the preliminary five-day sun exposure and five-day curing periods.

For methodological transparency and reproducibility, the sterilization status of

the nutrient solutions, incubation temperature, pH, aeration conditions and fungal viability assessment should be documented wherever such information is available in the original laboratory records. In the absence of these observations, no assumptions regarding sterilization or quantified fungal viability have been made in the present description.

Preparation of Experimental Trays and Vermicomposting

Plastic experimental trays measuring 45 × 15 × 30 cm were procured and perforated at the bottom to facilitate the drainage of excess water and prevent waterlogging within the experimental substrate. The vermibedding material was prepared by thoroughly mixing the fungal-pretreated sugarcane trash with partially cured cow dung in a 1:1 ratio (50:50, w/w). The prepared substrate was subsequently transferred into six experimental trays, with an equal quantity of substrate maintained in each tray. Of these, three trays were designated as experimental treatments for vermicomposting using Lampito mauritii, while the remaining three trays were maintained without earthworm inoculation and served as compost controls for comparative evaluation.

Healthy, mature and clitellate individuals of L. mauritii were collected from the vermiculture unit. A total of 100 adult earthworms were introduced into each of the three designated experimental trays, maintaining monoculture conditions. Immediately following inoculation, the earthworms were observed to penetrate the substrate, indicating their initial acceptance of the prepared vermibed. All experimental and control trays were maintained in a shaded, undisturbed location under similar environmental conditions throughout the experimental period. Watering was carried out regularly twice daily to maintain adequate moisture and prevent excessive drying of the substrate, thereby providing suitable conditions for earthworm survival and microbial decomposition.

The experimental process was continued until the pre-decomposed sugarcane trash and cow dung mixture was converted into vermicompost. The resulting vermicompost was carefully harvested and passed through a 3-mm mesh sieve to obtain a relatively uniform and fine-textured product, following the methodology described by Murali and Neelanarayanan (2011). Samples were collected separately from each experimental tray to maintain replicate-wise observations. Similarly, samples from the three control trays were collected for comparative analysis. The harvested compost and vermicompost samples were air-dried at room temperature (approximately 28°C), packed separately in labelled zip-lock polythene bags and stored under suitable conditions until further physicochemical, chemical nutrient and microbiological analyses.

Physicochemical and Biological Analysis of Compost and Vermicompost

The harvested compost and vermicompost samples were subjected to physicochemical, chemical and microbiological analyses to evaluate the effects of fungal pretreatment and earthworm-mediated decomposition on the quality of the final organic manure. The analytical parameters included relevant physicochemical characteristics, nutrient composition and microbial population density. Comparative assessment of the compost and vermicompost samples was undertaken to determine the influence of L. mauritii on substrate transformation, nutrient enrichment and microbial abundance.

Estimation of Microbial Population

The microbial population of the prepared compost and vermicompost samples was determined using the serial dilution and standard plate count techniques. The enumeration of major microbial groups, including bacteria, fungi and actinomycetes, was carried out using appropriate culture media. Nutrient Agar (NA) was employed for bacterial enumeration, Potato Dextrose Agar (PDA) for fungal enumeration and Soil Extract Agar (SEA) for actinomycete enumeration, following the methodology described by Tandon (2005).Briefly, a known quantity of compost or vermicompost sample was suspended in sterile distilled water and mixed thoroughly to obtain a uniform microbial suspension. Serial tenfold dilutions were prepared under aseptic conditions, and suitable dilutions were inoculated onto the respective culture media using an appropriate plating technique. The inoculated plates were incubated under suitable conditions for the development of microbial colonies. Following incubation, visible colonies were counted, and microbial populations were expressed as colony-forming units per gram of sample (CFU g^{-1}). Separate enumeration was performed for bacteria, fungi and actinomycetes to determine their respective population densities in compost and vermicomposting samples. The comparative microbial assessment was used to understand the changes in microbial abundance associated with earthworm-mediated decomposition and the conversion of fungal-pre-treated sugarcane trash into nutrient-enriched vermicomposting.

Result and Discussion

Physicochemical Characteristics of Compost and Vermicompost

The integrated biological treatment involving fungal pretreatment with Phanerochaete chrysosporium followed by vermicomposting using the indigenous earthworm Lampito mauritii resulted in substantial changes in the physicochemical characteristics and nutrient composition of sugarcane trash. After 35 days of earthworm activity, the vermicompost exhibited a distinctly darker appearance than the compost control, indicating progressive decomposition and transformation of the organic substrate. The darker colour may be associated with microbial degradation, earthworm-mediated fragmentation and the formation of humified organic compounds. The combined action of ligninolytic fungi and earthworms potentially enhanced the biological transformation of recalcitrant lignocellulosic materials into relatively stabilized organic manure. The physicochemical and chemical characteristics of the resulting vermicompost and compost are presented in Table 1.

The pH of the final vermicompost approached near-neutral conditions, suggesting that the decomposition process promoted a relatively balanced chemical environment. Variations in pH during vermicomposting are primarily governed by the nature of the organic substrate, microbial mineralization, ammonification, nitrification and the formation of intermediate organic acids. Haimi and Huhta (1987) suggested that earthworm activity and associated nitrogen transformations influence pH during organic matter decomposition. Similarly, Ndegwa and Thompson (2000) reported that changes in substrate composition and nitrogen transformations can influence the pH of vermicomposting systems. Ammonification may temporarily increase pH, whereas nitrification and the accumulation of organic acids can promote acidification. Thus, the final pH reflects the balance among several simultaneous biochemical processes rather than the action of a single nitrogenous compound.

Selvamuthukumaran and Neelanarayanan (2012a, 2012b) and Viji and Neelanarayanan (2013) also reported changes in pH during the vermicomposting of different agricultural and organic wastes. Sarkar et al. (2020) further emphasized that the biological conversion of heterogeneous organic substrates generates intermediate compounds capable of producing either acidic or alkaline shifts. In the present investigation, fungal pretreatment may have facilitated the initial breakdown of lignocellulosic materials, while subsequent earthworm activity and microbial transformations contributed to the final pH characteristics of the vermicompost.

Table 1. Comparative physicochemical and chemical characteristics of vermicompost produced by *Lampito mauritii* using sugarcane trash pretreated with *Phanerochaete chrysosporium* and compost control.

Parameters	Vermicompost	Compost control	Change (%)
pH	Near-neutral	-	—
Electrical conductivity (dS m^{-1})	1.21 ± 0.03	1.98 ± 0.05	−38.89
Moisture (%)	25.18 ± 0.09	32.18 ± 0.03	−21.75
Organic carbon (%)	21.09 ± 0.10	31.05 ± 0.02	−32.08
Total nitrogen (%)	1.91 ± 0.12	0.41 ± 0.01	+365.85
Total phosphorus (%)	2.45 ± 0.05	0.21 ± 0.02	+1066.67
Total potassium (%)	1.67 ± 0.01	0.34 ± 0.01	+391.18
C:N ratio	11:1	75:1	−85.33

The electrical conductivity (EC) of vermicompost prepared from fungal-pretreated sugarcane trash was 1.21 ± 0.03 dS m^{-1}, which was lower than the 1.98 ± 0.05 dS m^{-1} recorded in the compost control. This corresponds to an approximately 38.89% reduction in EC following earthworm-mediated processing. Electrical conductivity is an important indicator of soluble salt concentrations in organic amendments and may influence their suitability for agricultural application. Excessive soluble salts can adversely affect seed germination, root development, water absorption and nutrient uptake. Hoekstra et al. (2002) and Ofosu-Budu et al. (2010) discussed the significance of soluble salts in compost quality and agricultural utilization. Although EC values below approximately 2 dS m^{-1} are often considered favourable for many compost applications, their suitability depends on the extraction method, crop sensitivity and soil conditions. The comparatively lower EC recorded in the vermicompost suggests a reduced soluble salt concentration relative to the compost control.

Moisture Content and Organic Carbon Dynamics

The moisture content of vermicompost was 25.18 ± 0.09%, compared with 32.18 ± 0.03% in the compost control, representing an approximately 21.75% reduction. Moisture content plays an essential role in regulating microbial metabolism, earthworm activity and organic matter decomposition. The observed difference may reflect changes in substrate structure, decomposition characteristics and water retention during biological processing. However, final moisture content is also influenced by drying and sampling

conditions, and therefore cannot independently establish a higher degree of stabilization.

The organic carbon content of vermicompost was 21.09 ± 0.10%, whereas the compost control contained 31.05 ± 0.02%, indicating an approximately 32.08% reduction in organic carbon concentration. This decline is consistent with the progressive mineralization of carbon-rich organic compounds during fungal-assisted vermicomposting. Sugarcane trash contains substantial quantities of cellulose, hemicellulose and lignin, which are progressively degraded by lignocellulolytic microorganisms. The white-rot fungus *P. chrysosporium* is particularly important in the degradation of lignin-containing substrates through extracellular oxidative enzymes, including lignin peroxidase and manganese peroxidase. Konan et al. (2024) highlighted the potential of P. chrysosporium for lignocellulosic biomass degradation, while Wang *et al.* (2023) demonstrated its contribution to organic matter transformation and humification during composting.

During vermicomposting, the partially degraded organic materials are further fragmented and processed by earthworms and associated microbial communities. Carbon is utilized as an energy source by decomposing microorganisms, and a proportion is released into the atmosphere as carbon dioxide through microbial respiration. Consequently, a reduction in organic carbon concentration may accompany the progressive stabilization of the substrate. The lower organic carbon content recorded in the vermicompost, together with its reduced C:N ratio, is consistent with more advanced organic matter transformation than in the compost control. Nevertheless, direct measurement of carbon loss would require a mass balance incorporating initial and final dry weights.

Total Nitrogen Enrichment

The total nitrogen content of vermicompost was 1.91 ± 0.12%, considerably higher than the 0.41 ± 0.01% recorded in the compost control. The observed values represent an approximately 4.66-fold higher nitrogen concentration, equivalent to a 365.85% increase relative to the control. This substantial difference indicates pronounced nitrogen enrichment in the final vermicompost.

Pramanik et al. (2007) suggested that nitrogen enrichment during vermicomposting may result from organic carbon mineralization, decomposition of nitrogen-containing compounds and changes in the relative concentration of nutrients. Tripathi and Bhardwaj (2004) also highlighted the contribution of earthworm-associated biological activities, including mucus secretion, nitrogenous excretory products and microbial interactions, to nutrient transformations during vermicomposting.

The elevated nitrogen concentration observed in the present investigation may be associated with the combined effects of fungal pretreatment, earthworm-mediated decomposition and microbial mineralization of organic matter. The reduction in organic carbon concentration may also have contributed to the relative enrichment of nitrogen in the final product. However, the higher nitrogen percentage does not necessarily indicate an equivalent increase in the absolute quantity of nitrogen, because total substrate mass and nitrogen losses were not determined. Nevertheless, the comparatively high nitrogen concentration suggests that the vermicompost may serve as a useful nitrogen-containing organic amendment for agricultural soils.

Total Phosphorus Enrichment

The total phosphorus concentration increased markedly in the vermicompost, reaching 2.45 ± 0.05%, compared with 0.21 ± 0.02% in the compost control. This represents an approximately 11.67-fold higher phosphorus concentration, corresponding to a 1066.67% increase relative to the control.Phosphorus transformation during vermicomposting is influenced by the decomposition of organic phosphorus-containing compounds, microbial mineralization and interactions between earthworms and phosphorus-solubilizing microorganisms. Ghosh et al. (1999) suggested that phosphatase activity associated with earthworm casts may contribute to phosphorus transformation during organic waste decomposition. Similarly, Kumar and Prasad (2022) discussed the role of earthworm-associated microorganisms and phosphatase enzymes in converting organically bound phosphorus into more accessible forms.

In the present study, the comparatively high total phosphorus concentration in vermicompost may reflect enhanced decomposition and nutrient concentration during the integrated fungal–earthworm treatment. Fungal pretreatment may have increased the accessibility of organic constituents to subsequent microbial and earthworm-mediated processing. However, because total phosphorus rather than plant-available phosphorus was measured, the results establish phosphorus enrichment in the final product but do not directly quantify the proportion available for immediate plant uptake.

Total Potassium Enrichment

The total potassium concentration of vermicompost was 1.67 ± 0.01%, compared with 0.34 ± 0.01% in the compost control. This corresponds to an approximately 4.91-fold higher potassium concentration, representing a 391.18% increase relative to the control.

Potassium is an essential macronutrient involved in enzyme activation, osmotic regulation, stomatal functioning and several physiological processes associated with plant growth. Garg et al. (2006) reported that biological decomposition and earthworm-associated microbial activities can influence nutrient concentrations in vermicompost. Unlike nitrogen and phosphorus, potassium is largely present in plant tissues as a soluble inorganic ion rather than as a structural component of complex organic molecules. Therefore, the decomposition of sugarcane trash may facilitate potassium release from plant residues.

The higher potassium concentration recorded in the vermicompost suggests that the integrated biological treatment improved the nutrient composition of the final organic amendment. Nevertheless, potassium enrichment expressed on a percentage basis may also reflect the reduction in total organic matter and dry mass during decomposition. The actual extent of potassium retention or loss would require measurements of initial and final substrate mass.

Carbon-to-Nitrogen Ratio and Vermicompost Stabilization

The carbon-to-nitrogen ratio is widely regarded as an important indicator of organic matter decomposition and compost stabilization. In the present investigation, the C:N ratio declined substantially from approximately 75:1 in the compost control to 11:1 in the vermicompost. This represents an approximately 85.33% reduction in the C:N ratio.

The pronounced decline in the C:N ratio reflects the combined effects of reduced organic carbon concentration and increased relative nitrogen concentration in the final vermicompost. During biological decomposition, carbon-rich organic compounds are utilized by microorganisms

as energy sources, while nitrogen is retained or transformed into different organic and inorganic forms. The integrated action of P. chrysosporium and L. mauritii may have facilitated these processes through lignocellulose degradation, fragmentation of organic residues and stimulation of microbial activity.

Lim and Wu (2016) reported a C:N ratio below 12 during the vermicomposting of palm oil by-products, indicating substantial stabilization of the organic substrate. A C:N ratio below 20 is commonly used as one indicator of compost maturity, although maturity assessment should also consider phytotoxicity, respiration, ammonium-to-nitrate ratio and other stability indicators. The C:N ratio of approximately 11:1 recorded in the present investigation is therefore consistent with a comparatively stabilized vermicompost and suggests its potential suitability as an organic soil amendment.

Microbial Population and Biological Activity

The biological quality of vermicompost is strongly influenced by the abundance and activity of microorganisms involved in organic matter decomposition, nutrient mineralization and humification. In the present investigation, the vermicompost was reported to exhibit higher microbial populations, particularly bacteria, fungi and actinomycetes, than the compost control. This observation suggests that earthworm-mediated processing may have created favourable conditions for microbial proliferation and organic substrate transformation.

The partial decomposition of sugarcane trash by P. chrysosporium may have increased the accessibility of organic compounds to subsequent microbial utilization. Following fungal pretreatment, the introduction of L. mauritii could further influence microbial communities through fragmentation, ingestion, cast production and modification of substrate microhabitats. Earthworm activity can stimulate certain groups of heterotrophic microorganisms by increasing substrate accessibility and altering the physicochemical characteristics of organic residues.

Kale et al. (1992) reported elevated populations of bacteria and actinomycetes in organic wastes processed by earthworms, including Eudrilus eugeniae and Perionyx excavatus. Similarly, Parthasarathi and Ranganathan (2000) observed changes in bacterial populations in vermicompost processed by L. mauritii and E. eugeniae compared with untreated controls. These findings support the potential role of earthworm-associated microbial activity in the biological transformation of organic wastes.

The increased microbial abundance reported in the present investigation may have contributed to the observed nutrient enrichment and reduction in the C:N ratio. However, quantitative microbial population data expressed as colony-forming units per gram (CFU g^{-1}) are required to establish the magnitude of these differences and assess their statistical significance.

Conclusion:

The findings of the present investigation demonstrate that fungal-assisted vermicomposting represents an effective biological approach for converting lignocellulosic agricultural residues into nutrient-enriched organic manure. The pretreatment of sugarcane trash with the ligninolytic fungus *Phanerochaete chrysosporium*, followed by vermicomposting using the indigenous earthworm *Lampito mauritii*, resulted in substantial improvements in the physicochemical and chemical characteristics of the final product compared with conventional composting.

The vermicompost exhibited a lower electrical conductivity (1.21 ± 0.03 dS m^{-1}), reduced organic carbon content (21.09 ± 0.10%) and a markedly improved carbon-to-nitrogen ratio (11:1), indicating enhanced organic matter transformation and stabilization. Furthermore, considerable enrichment of total nitrogen (1.91 ± 0.12%), phosphorus (2.45 ± 0.05%) and potassium (1.67 ± 0.01%) was observed in the vermicompost compared with the compost control. The higher microbial abundance of bacteria, fungi and actinomycetes further indicates the biological potential of the resulting organic amendment. The darker appearance and improved nutrient composition of the vermicompost also support the effectiveness of the integrated fungal and earthworm-mediated decomposition process. Overall, the study establishes the potential of *P. chrysosporium* pretreatment combined with *L. mauritii* vermicomposting as a promising strategy for the sustainable management and value addition of sugarcane trash. This approach may contribute to agricultural waste recycling, nutrient conservation, improvement of soil fertility and environmentally sustainable crop production. Further field-based investigations are recommended to evaluate its effects on crop growth, soil health and long-term agricultural productivity.

References:

1. Aly, A. B. A., Shanmugaraj, B., & Ramalingam, S. (2025). Industrial applications of Phanerochaete chrysosporium lignin-degrading enzymes: Current status, production challenges, and future directions. World Journal of Microbiology and Biotechnology, 41(5), 171.
2. Asava, S., Sharma, D., Yadav, K. D., Bansal, T., Kamyab, H., & Haq, M. (2026). Evaluation of sugarcane residues and organic waste combinations in sustainable bin composting. Biomass and Bioenergy, 206, 108662.
3. Garg, P., Gupta, A. and Satya, S., 2006. Vermicomposting of Different Types of Waste Using Eiseniafoetida: A Comparative Study. Bioresource Technology. 97(3), 391–395. doi: 10.1016/ j.biortech.2005.03.009
4. Ghosh, M., Chattopadhyay, G. N., & Baral, K. (1999). Transformation of phosphorus during vermicomposting. Bioresource Technology, 69(2), 149–154. https://doi.org/10.1016/S0960-8524(99)80001-7
5. Haimi, J., & Huhta, V. (1987). Comparison of composts produced from identical wastes by "vermistabilization" and conventional composting. Pedobiologia, 30(2), 137–144.
6. Hoekstra, N. J., et al. (2002). Bibliographic details require verification. The specific publication cited for the electrical conductivity threshold could not be confidently identified.
7. Kale, R. D., Mallesh, B. C., Bano, K., & Bagyaraj, D. J. (1992). Influence of vermicompost application on the available macronutrients and selected microbial populations in a paddy field. Soil Biology and Biochemistry, 24(12), 1317–1320. https://doi.org/10.1016/0038-0717(92)90111-A.
8. Konan, D., Ndao, A., Koffi, E., Elkoun, S., Robert, M., Rodrigue, D., & Adjallé, K. (2024). Biodecomposition with Phanerochaete chrysosporium: A review. AIMS Microbiology, 10(4), 1068–1101.

9. Lim, S. L., & Wu, T. Y. (2016). Characterization of matured vermicompost derived from valorization of palm oil mill byproduct. Journal of Agricultural and Food Chemistry, 64(8). https://doi.org/10.1021/acs.jafc.6b00531
10. Murali, M., & Neelanarayanan, P. (2011). Determination of mesh size for sieving of vermicompost without cocoons and incubation medium for cocoons produced by three species of earthworms. Electronic Journal of Environmental Sciences, 4, 25–30.
11. Nagargade, M., Shukla, S. K., & Pathak, A. D. (2021). Cash the trash. Indian Farming, 71(6).
12. Ndegwa, P. M., & Thompson, S. A. (2000). Effects of C-to-N ratio on vermicomposting of biosolids. Bioresource Technology, 75(1), 7–12. https://doi.org/10.1016/S0960-8524(00)00038-9
13. Ofosu-Budu, G. K., et al. (2010). Complete bibliographic details require verification before using this citation for the EC threshold.
14. Parthasarathi, K., & Ranganathan, L. S. (2000). Aging effect on enzyme activities in pressmud vermicasts of Lampito mauritii (Kinberg) and Eudrilus eugeniae (Kinberg). Biology and Fertility of Soils, 30, 347–350. https://doi.org/10.1007/s003740050014
15. Pramanik, P., Ghosh, G. K., Ghosal, P. K., & Banik, P. (2007). Changes in organic-C, N, P and K and enzyme activities in vermicompost of biodegradable organic wastes under liming and microbial inoculants. Bioresource Technology, 98(13), 2485–2494. https://doi.org/10.1016/j.biortech.2006.09.017
16. Ravish, P., & Chaudhry, S. (2025). Evaluation of the impact of sugarcane trash in situ incorporation on soil health in North Haryana. Environmental Monitoring and Assessment, 197, 1089.
17. Sarkar, et al. (2020). Full bibliographic details require verification.
18. Selvamuthukumaran, D., & Neelanarayanan, P. (2012a). Bioconversion of leaf litter into vermicompost by indigenous earthworm, Perionyx excavatus. Electronic Journal of Environmental Sciences, 5, 55–60.
19. Selvamuthukumaran, D., & Neelanarayanan, P. (2012b). Bio-transformation of poultry waste into vermicompost by using an epigeic earthworm, Eudrilus eugeniae. Electronic Journal of Environmental Sciences, 5, 61–65.
20. Suthar, S. (2008). Development of a novel epigeic-anecic-based polyculture vermireactor for efficient treatment of municipal sewage water sludge. International Journal of Environment and Waste Management, 2(1/2), 84–101.
21. Suvedha, A., BrindhaDevi, G. B., Logeswari, E., & Revathi, K. (2024). Micro and macro nutrient analysis on vermicomposting properties of native Indian Lampito mauritii. Uttar Pradesh Journal of Zoology, 45(19), 408–418.
22. Tandon, H. L. S. (2005). Methods of Analysis of Soils, Plants, Waters, Fertilizers and Organic Manures. Fertiliser Development and Consultation Organisation, New Delhi.
23. Tripathi, G., & Bhardwaj, P. (2004). Decomposition of kitchen waste

amended with cow manure using an epigeic species (Eisenia fetida) and an anecic species (Lampito mauritii). Full journal and page details should be checked against the original publication.

24. Viji, J. and Neelanarayanan, P. 2013. Production of vermicompost by utilizing paddy Oryza sativa) straw (pre-digested with Trichoderma viride) and Eudrilus eugeniae, Perionyx excavatus and Lampito mauritii. International Journal of Pharma and Bio Sciences. 4(4): 986- 995.
25. Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science, 37(1), 29–38.
26. Wang, Y., Wei, Y., Zhou, K., Gao, X., Chang, Y., Zhang, K., Deng, J., Zhan, Y., Li, J., Li, R., Li, J., & Xu, Z. (2023). Regulating pH and Phanerochaete chrysosporium inoculation improved the humification and succession of fungal community at the cooling stage of composting. Bioresource Technology, 384, 129291.
27. Zhai, et al. (2025). Effects of Trichoderma harzianum combined with Phanerochaete chrysosporium on lignin degradation and humification during chicken manure and rice husk composting. Frontiers in Microbiology, 16, 1515931.Garg, P., Gupta, A., & Satya, S. (2006). Vermicomposting of different types of waste using Eisenia foetida: A comparative study. Bioresource Technology, 97(3), 391–395. https://doi.org/10.1016/j.biortech.2005.03.009