

Research Article

VERMICOMPOSTING OF *MUSA FLAVIFLORA* SIMMONDS PSEUDOSTEM WITH *EISENIA FETIDA*: A PRELIMINARY STUDY FROM PASIGHAT, ARUNACHAL PRADESH, INDIA

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HIGHLIGHTS

- Locally available wild *Musa flaviflora* pseudostem was evaluated as a vermicomposting feedstock after mixing with cow dung at a 3:1 fresh-weight ratio.
- A single preliminary vermicomposting unit containing *Eisenia fetida* produced a dark-brown, granular material with an earthy odour after 90 days.
- The recovered material contained 1.8% N, 0.9% P, 1.1% K and 18.5% organic carbon, with a C:N ratio of 10:1.
- Eighteen kilograms of final material were recovered from 30 kg of initial wet substrate, corresponding to approximately 60% wet-mass recovery.
- Because the experiment was non-replicated and lacked controls and comprehensive maturity tests, the observations should be validated in replicated controlled trials before agronomic use is recommended.

ABSTRACT

Vermicomposting uses the combined activity of epigeic earthworms and microorganisms to transform biodegradable residues into a more stabilized organic material (Edwards et al., 2010; Domínguez & Edwards, 2011). Banana pseudostems are moisture-rich lignocellulosic residues that may provide a useful local feedstock for this process. This preliminary study examined whether pseudostem of the wild banana *Musa flaviflora* could be vermicomposted under ambient conditions at Jawaharlal Nehru College, Pasighat, Arunachal Pradesh. Fresh pseudostem was chopped, mixed with cow dung at a 3:1 fresh-weight ratio, pre-composted for 7 days and then inoculated with *Eisenia fetida*. Moisture was maintained at approximately 60–70% during a 90-day processing period. At harvest, the material was dark brown, granular and earthy-smelling. Chemical measurements of the

GRAPHICAL ABSTRACT



final product were N 1.8%, available P 0.9%, exchangeable K 1.1%, organic carbon 18.5% and a C:N ratio of 10:1. Approximately 18 kg of material were recovered from an initial 30 kg wet substrate mixture, equivalent to about 60% wet-mass recovery. These observations indicate that *M. flaviflora* pseudostem can serve as a substrate for *E. fetida*-mediated processing when blended with cow dung. However, the study used only one experimental unit and did not include controls, initial substrate chemistry, germination index, pH or electrical conductivity. The findings should therefore be regarded as proof-of-concept observations rather than evidence of agronomic effectiveness. Replicated treatment comparisons and multi-parameter maturity assessment are required in subsequent work.

KEYWORDS: Banana pseudostem *Musa flaviflora* *Eisenia fetida* vermicomposting organic-waste valorization C:N ratio Arunachal Pradesh.

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1. INTRODUCTION

Vermicomposting is a biological stabilization process in which epigeic earthworms and the microorganisms associated with the decomposing substrate jointly fragment, transform and mineralize organic matter. The resulting material is generally more stabilized and nutrient concentrated than the original waste (Domínguez & Edwards, 2011; Edwards et al., 2010). Because the process proceeds under mesophilic rather than thermophilic conditions, it can be adapted to relatively simple, decentralized organic-waste management systems (Khan & Zargar, 2013; Sarma et al., 2014). *Eisenia fetida* is widely used for this purpose because it performs well in organic-rich substrates and can tolerate relatively broad moisture conditions when temperature and food supply remain suitable (Edwards et al., 2010; Aira et al., 2006; Telila & Shifera, 2025).

Crop production generates large amounts of biodegradable residues. When such materials are burned, discarded or left unmanaged, potentially recyclable nutrients are lost and local environmental burdens may increase (Pathma & Sakthivel, 2012; Yadav & Garg, 2011). Vermicomposting provides one route for returning part of this organic matter and nutrient pool to agricultural systems (Suthar, 2007; Pattnaik & Reddy, 2024). Process performance depends strongly on feedstock quality. Mixing carbon-rich plant residues with nitrogen-rich animal manure can improve substrate balance and create more favourable conditions for earthworm and microbial activity (Chauhan & Singh, 2013; Khan & Zargar, 2013).

Banana residues are relevant in this context because pseudostems and leaves contain abundant water and lignocellulosic material and are generated after harvest or senescence. Previous studies have shown that banana biomass can be vermicomposted, particularly when it is combined with animal manure (Khatua et al., 2018; Mago et al., 2021; Parmar et al., 2019). Reported changes during processing include reductions in organic carbon and C:N ratio together with changes in nutrient concentrations (Khatua et al., 2018; Diarsa & Gupte, 2021). Nevertheless, final-product quality cannot be inferred from nutrient content alone; pH, electrical conductivity, C:N ratio, germination response and phytotoxicity

are among the parameters commonly used to judge compost maturity and safety (Majlessi et al., 2012; Shafique et al., 2023).

Musa flaviflora is a wild banana reported from Northeast India, including Assam, and is of regional botanical interest because of its distribution and habitat associations (Habitat distribution mapping of *Musa flaviflora* Simmonds, 2020). Although banana-waste vermicomposting has been investigated for other *Musa* materials, information specifically concerning *M. flaviflora* pseudostem under Northeast Indian conditions remains limited. The present work was therefore undertaken as a preliminary proof-of-concept experiment to determine whether *M. flaviflora* pseudostem mixed with cow dung could be processed by *E. fetida* under ambient conditions in Pasighat. The study records the processing period, selected chemical characteristics and recovered mass of the final material, while recognizing the limitations of a single non-replicated experimental unit.

2. LITERATURE REVIEW

2.1 Biology and Ecology of *Eisenia fetida*

Eisenia fetida is an epigeic earthworm associated with decomposing organic matter near the soil surface. Its biology, feeding behaviour and reproduction have made it a standard species in vermiculture research (Domínguez & Edwards, 2011). Under suitable food conditions it can remain active across moist organic substrates, and its population response is strongly affected by feedstock composition. Aira et al. (2006), for example, showed that substrate C:N ratio influences population structure and cocoon production. Work with mixed animal dung and agricultural residues likewise indicates that blended substrates can provide a more balanced feeding environment than poorly balanced single feedstocks (Chauhan & Singh, 2013).

2.2 Physicochemical Changes During Vermicomposting

During vermicomposting, microbial respiration and earthworm-mediated fragmentation progressively alter the chemical composition of the feedstock. Organic carbon commonly declines as part of the carbon pool is mineralized to CO₂, whereas nitrogen may become proportionally concentrated as dry

matter is lost (Khatua et al., 2018; Pramanik et al., 2007; Suthar, 2007). A declining C:N ratio is therefore frequently used as one indicator of stabilization, although it should be interpreted together with other maturity measures (Majlessi et al., 2012; Mago et al., 2021). Phosphorus availability can increase through mineralization and microbial solubilization, while potassium is released from decomposing organic matrices (Ghosh et al., 1999; Yadav & Garg, 2011; Pattnaik & Reddy, 2024).

2.3 Banana Biomass as a Vermicomposting Feedstock

Banana pseudostem is a high-moisture lignocellulosic residue that can be combined with nutrient-rich co-substrates for vermicomposting. Khatua et al. (2018) documented progressive changes in carbon and C:N ratio when banana stem waste and cow dung were processed with *E. fetida*. Mago et al. (2021) also reported successful vermiconversion of banana crop residues, while Diarsa and Gupte (2021) observed improved nutrient characteristics in pseudostem–dung mixtures and used germination testing to evaluate the final product. Related work has also demonstrated vermicomposting of banana pseudostem with maize fodder (Parmar et al., 2019), banana leaf biomass (Ashok Kumar et al., 2022) and banana pseudostems and leaves (Zhou, 2008). Collectively, these studies support the suitability of *Musa* biomass as a candidate feedstock, while also showing that outcomes depend on substrate composition and experimental conditions.

2.4 Maturity and Quality Assessment

A mature vermicompost should be sufficiently stabilized and free from phytotoxic effects. No single parameter establishes maturity in all cases. Common assessments include pH, electrical conductivity, C:N ratio and biological tests such as seed germination and root elongation (Majlessi et al., 2012; Shafique et al., 2023; Diarsa & Gupte, 2021). Monitoring moisture, temperature, mass change and earthworm performance can further clarify how the process develops over time (Srivastava et al., 2024; Chauhan & Singh, 2013). Consequently, nutrient concentrations in an end product should be interpreted together with process data and biological safety indicators before field application is

recommended.

2.5 Organic-Waste Management in Northeast India

Northeast India combines high biological diversity with farming systems that generate banana, bamboo and other horticultural residues. Low-cost vermicomposting has been proposed as a decentralized option suitable for the region (Sarma et al., 2014). Wild *Musa* resources, including *M. flaviflora*, add a locally available biomass stream that may be explored for small-scale organic-waste conversion. Using such residues could support local recycling of organic matter, but species-specific feedstocks require experimental evaluation before their performance or agronomic value can be established.

3. MATERIALS AND METHODS

3.1 Study Site and Experimental Period

The experiment was carried out from September to December 2025 in the Department of Botany, Jawaharlal Nehru College, Pasighat, East Siang District, Arunachal Pradesh, India (27.9260° N, 95.3266° E; approximately 155 m a.s.l.). Plant material was obtained from the wild *Musa* collection maintained in the college botanical garden.

3.2 Feedstock and Earthworm Species

Fresh pseudostem of locally maintained *M. flaviflora* was used as the principal plant residue. The material was identified by the first author. Cow dung approximately 14 days old was obtained locally and used as the nitrogen-rich co-substrate. Adult *E. fetida* were obtained from an established vermiculture culture in Pasighat.

3.3 Substrate Preparation and Vermicomposting

The pseudostem was cut into pieces of approximately 2–5 cm to increase the exposed surface area. Pseudostem and cow dung were combined at a 3:1 fresh-weight ratio, comparable with mixtures used in earlier banana-biomass studies (Khatua et al., 2018; Diarsa & Gupte, 2021). Before earthworms were added, the mixture was allowed to pre-decompose for 7 days. This step was intended to initiate microbial breakdown and reduce potentially unfavourable conditions associated with fresh

manure (Chauhan & Singh, 2013; Khan & Zargar, 2013). A total of 30 kg fresh substrate was placed in an approximately 60-L vermicomposting chamber. Adult *E. fetida* were introduced at about 50 individuals kg⁻¹ substrate. The unit was maintained for 90 days, with moisture kept near 60–70% by periodic watering and aeration. A breathable cover was used to maintain ventilation while reducing excessive moisture loss.

3.4 Sampling and Physicochemical Analysis

At 90 days, earthworms were separated manually and the recovered material was weighed. Subsamples were analysed using the methods reported for the original experiment. Total N was determined by macro-Kjeldahl digestion, distillation and titration (AOAC, 2000). Available P was extracted with 0.5 M NaHCO₃ at pH 8.5 and measured colorimetrically using the molybdate–ascorbic acid procedure at 882 nm (as cited in Pramanik et al., 2007). Exchangeable K was extracted with 1 M ammonium acetate at pH 7.0 and measured by flame photometry at 766 nm (Yadav & Garg, 2011). Organic carbon was measured by Walkley–Black wet oxidation using acidic K₂Cr₂O₇ and back-titration with ferrous ammonium sulphate, applying a recovery factor of 0.77 (as cited in Ghosh et al., 1999). The C:N ratio was calculated from measured organic carbon and total nitrogen. Wet-mass recovery was calculated from the final recovered mass relative to the initial 30 kg substrate.

3.5 Data Treatment and Study Design

This work was designed as a preliminary single-unit trial. Because there were no independent replicates or control treatments, inferential statistics were not applied. The measurements are presented descriptively. The absence of baseline substrate chemistry also prevents attribution of final chemical values specifically to earthworm activity or to the chosen feedstock mixture.

4. RESULTS

After 90 days, the original pseudostem–cow dung mixture had changed into a dark-brown, granular material with an earthy odour. These macroscopic features were consistent with the appearance commonly reported for substantially decomposed

vermicompost (Khatua et al., 2018; Mago et al., 2021). The final material contained 1.8% N, 0.9% P, 1.1% K and 18.5% organic carbon, giving a calculated C:N ratio of 10:1. Eighteen kilograms were recovered from the initial 30 kg wet mixture, corresponding to approximately 60% wet-mass recovery. As the trial lacked replication and controls, these values represent observations from the experimental unit rather than estimates of treatment effects.

Table 1. Selected characteristics and mass-recovery observations from the preliminary single-unit trial.

Parameter	Recorded value
Nitrogen (N)	1.8%
Phosphorus (P)	0.9%
Potassium (K)	1.1%
Organic carbon	18.5%
C:N ratio	10:1
Initial substrate mixture	30 kg
Recovered vermicompost	18 kg
Approximate wet-mass recovery	~60%
Observed processing period	90 days

5. DISCUSSION

The experiment shows that a mixture of *M. flaviflora* pseudostem and cow dung can undergo *E. fetida*-mediated processing under the ambient conditions used in Pasighat. The final C:N ratio of 10:1, together with the dark granular appearance and earthy odour, is compatible with substantial decomposition. Previous studies have treated relatively low C:N ratios as evidence of advanced stabilization (Majlessi et al., 2012; Mago et al., 2021). Nevertheless, C:N ratio and appearance by themselves do not demonstrate complete maturity, particularly in the absence of pH, EC, germination and phytotoxicity measurements.

The measured N, P and K concentrations fall within the broad range reported in studies using banana biomass or mixed organic wastes (Parmar et al., 2019; Ashok Kumar et al., 2022; Yattoo et al., 2022). Earlier work indicates that nutrient patterns during vermicomposting reflect both microbial transformations and earthworm-associated processing, as well as the original elemental composition of the feedstock (Ghosh et al., 1999;

Pramanik et al., 2007; Yadav & Garg, 2011). In the present experiment, however, there was no cow-dung-only treatment, pseudostem treatment without earthworms, or analysis of the initial mixture. It is therefore not possible to separate the contribution of the earthworms from the effect of feedstock composition.

The recovery of about 18 kg from 30 kg initial wet substrate represents an approximate wet-mass recovery of 60%. Mass reduction during biological stabilization can arise from carbon mineralization as well as changes in water content (Srivastava et al., 2024; Mago et al., 2021). Because dry mass and moisture were not measured at successive intervals, the observed loss cannot be partitioned between these processes.

The study has regional relevance because *M. flaviflora* occurs in Northeast India and represents a locally available wild *Musa* biomass resource (Habitat distribution mapping of *Musa flaviflora* Simmonds, 2020). Exploring such materials is consistent with decentralized, low-cost approaches to organic-waste management proposed for the region (Sarma et al., 2014). Even so, the present findings should not be interpreted as demonstrating field performance of the product.

Before agronomic recommendation, the material should be evaluated using several complementary maturity and safety criteria. These should include pH, electrical conductivity, germination index, phytotoxicity testing and, where feasible, humification-related indicators (Majlessi et al., 2012; Shafique et al., 2023; Ashok Kumar et al., 2022). Replicated pot and field studies would then be needed to test effects on soil properties, nutrient availability and plant growth.

6. STUDY LIMITATIONS AND PRIORITIES FOR FURTHER RESEARCH

- Use independently replicated vermicomposting units and include relevant controls, such as cow dung alone, pseudostem without earthworms and alternative mixing ratios.
- Characterize the starting feedstocks and mixtures for pH, EC, organic carbon, N, P and K, and apply analytical replication and appropriate quality-control procedures.

- Record earthworm survival, biomass and reproduction, together with substrate temperature and moisture, throughout the experiment.
- Measure substrate properties and dry mass at defined intervals so that decomposition, nutrient dynamics and true dry-matter loss can be followed over time.
- Assess final-product maturity and safety with multiple indicators, including germination index, phytotoxicity, pH, EC and C:N ratio.
- Conduct replicated pot or field trials before making claims about agronomic effectiveness.

7. CONCLUSION

This preliminary experiment indicates that *M. flaviflora* pseudostem mixed with cow dung at a 3:1 fresh-weight ratio can be processed by *E. fetida* under the local conditions used in Pasighat. After 90 days, the recovered material was dark brown and granular and contained 1.8% N, 0.9% P, 1.1% K and 18.5% organic carbon, with a calculated C:N ratio of 10:1. Approximately 18 kg of material were recovered from 30 kg of initial wet substrate. These results provide a basis for designing a more rigorous study, but they do not establish treatment superiority, complete maturity or agronomic effectiveness because the experiment lacked replication, controls, baseline chemistry and several standard maturity tests. Future work should therefore combine replicated treatment comparisons with validated chemical analyses, biological maturity tests and plant-response experiments.

DECLARATIONS

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Conflict of Interest. The authors declare no conflict of interest.

Data Availability. Raw data and experimental records are maintained in the laboratory notebook of the Department of Botany, Jawaharlal Nehru College,

Pasighat, and are available upon reasonable request to the corresponding author.

Author Contributions. T.P. conceived the study, supervised all experimental activities, and drafted the manuscript. Fifth-semester students of 2025 batch conducted the hands-on experimental work and assisted in data collection under supervision.

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