



Comparative assessment of *Lampito mauritii* and *Perionyx excavatus* for vermicomposting of cow dung and agricultural residues in semi-arid Rajasthan, India

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Abstract

Agricultural waste valorization through vermicomposting is a biotechnological approach that promotes nutrient cycling, waste reduction, and restoration of soil fertility. This study evaluated the vermicomposting efficiency of two indigenous earthworm species, *Lampito mauritii* and *Perionyx excavatus*, for bio-converting agricultural wastes under semi-arid conditions. In a 60-day laboratory experiment, maize and wheat straw were mixed with cow dung at a 3:1 (w/w) ratio and inoculated with each species. Subsamples were collected at 15-day intervals for pH, organic carbon (OC), total nitrogen, phosphorus, potassium, and C:N ratio. Both species significantly improved substrate quality over the control ($P < 0.05$), decreasing pH, OC and C:N ratio and increasing Nitrogen (N), phosphorus (P), and potassium (K). *P. excavatus* performed best: in maize and wheat straw, respectively, it reduced OC by 13.52% and 13.30%, increased total N by 46.38% and 62.77%, and lowered the C:N ratio by 41.20% and 47.95%. It also showed the highest P and K enrichment in both substrates. *L. mauritii* was slightly less efficient but still effective. These findings show that *P. excavatus* is more efficient at converting maize and wheat straw into mature vermicompost, although both indigenous species are suitable for local agricultural waste management.

Keywords: Agricultural waste, bio-converting, vermicomposting, mineralization, valorization

Introduction

Vermicomposting is the biological conversion of complex organic waste into stabilized, odorless, humus-like material through the combined action of earthworms and microorganisms (Aira *et al.* 2002) ^[1]. Vermicomposting is an environmentally sustainable and economically viable approach to managing and converting agricultural waste into valuable organic resources (Arya *et al.* 2026) ^[4]. Converting agricultural wastes into vermicompost yields a high-quality organic manure that enhances soil fertility alongside conventional compost and chemical fertilizers (Kumar 2018) ^[25]. Recycling organic residue via vermiculture effectively mitigates the accumulation and underutilization of agro waste (Kale 2000) ^[23]. However, the nutrient composition of vermicompost depends on the substrate used, with significant variation reported among vermicomposts prepared from different straw residues (Kumar *et al.* 2017) ^[2]. Earthworms are ecological engineers that turn organic residues including animal and crop residues into compost (Singh and Sinha 2022 ^[41], Kumar *et al.* 2023 ^[24], Lavelle and Spain 2024 ^[27]), lowering the C: N ratio (Enebe and Erasmus 2023) ^[11], loaded with nutrients (Mago *et al.* 2021 ^[29], Shafique *et al.* 2023 ^[39]), which further improves the grain yields (Guo *et al.* 2015 ^[15], Ratsiatosika *et al.* 2024 ^[37]). In Indian agroecosystems, species such as *Lampito mauritii*, *P. excavatus*, *Dichogaster bolaii*, *Amyntas morrisi*, and *Drawida willsi* are commonly distributed, and their composting potential is well recognized (Kale *et al.* 1982 ^[22], Gajalakshmi *et al.* 2002 ^[12], Tripathi and Bhardwaj 2004 ^[46]). Among these, *Perionyx excavatus* is an epigeic, surface-dwelling earthworm that feeds primarily on plant litter, dead organic matter, and animal manure at or near the soil surface, and is characterized by a high reproductive rate and efficient

bioconversion of organic wastes (Kale *et al.* 1982 ^[22], Suthar 2007 ^[43]). *P. excavatus* (Perrier) is indigenous and occurs in most parts of India (Gaur and Singh 1995 ^[14], Ismail 1997 ^[18]). In contrast, *Lampito mauritii* (Kinberg), an indigenous anecic earthworm, is amphimictic, sexual and biparental (Gates 1972) ^[13]. *L. mauritii*, a widely distributed indigenous earthworm, has been reported to successfully survive, reproduce, and emerge as a predominant species in the municipal waste disposal sites of Kolkata (Chowdhury and Hazra 2006) ^[8]. The decomposition efficiency and vermicomposting potential of both *Perionyx excavatus* and *Lampito mauritii* on various organic wastes are well documented in literature (Gajalakshmi *et al.* 2002 ^[12], Tripathi and Bhardwaj 2004 ^[46], Suthar and Singh 2008 ^[42], Joshi and Dabral 2008 ^[20], Chanda *et al.* 2011 ^[6], Parthasarathi *et al.* 2016 ^[32], Paul 2017 ^[34], Prashija and Parthasarathi 2019 ^[36], Huntley and Ansari 2021 ^[17]). Vermicomposting is considered an effective approach for converting organic waste material into a valuable substance. Vermiculture supports the maintenance of soil quality for healthy plant and crop growth (Kumar 2020) ^[26]. Baseline data on the vermicomposting efficiency of these species under Udaipur's semi-arid climate are still scarce, despite the region's marked seasonal temperature variations that influence earthworm survival, fecundity, and organic-matter mineralization. Given that the two species represent different ecological groups with distinct morphological traits and feeding habits, their individual biodegradation patterns on regional agricultural residues require experimental assessment.

Therefore, the present study was undertaken to assess the vermicomposting potential of *P. excavatus* and *L. mauritii* using residues of major regional crops (maize straw and wheat straw) as substrate materials, with specific attention

to the substrate decomposition rate and the resultant physicochemical and nutrient properties of the resulting vermicompost.

Material and Methods

In the experiment, two earthworm species, i.e., *Perionyx excavatus* and *Lampito mauritii*, were used.

Collection and storage of agricultural waste and cow dung

The agricultural waste (wheat straw and maize straw) utilized in the present experiments was collected from farmers' fields after harvest and stored in heaps mainly for use as animal fodder. The straw was transported to the laboratory in gunny bags. Cow dung was obtained from a local dairy farmer in Udaipur district and used as an organic substrate in the present study. After collection, it was shade-dried and stored in large containers before utilization.

Collection of earthworm species

Healthy and mature individuals of earthworms, *L. mauritii* and *P. excavatus*, were collected from the study area (Udaipur district of Rajasthan).

Sample processing (pre-digestion)

The collected crop waste was air-dried separately and spread over a polythene sheet for 48 hours. The air-dried samples were pre-digested by sprinkling water over them for a few days before the experiment, while fresh cow dung was sieved to remove straw and undigested particles. In vermicomposting, pre-digestion involves the partial aerobic microbial decomposition of raw waste, generating heat that raises the substrate temperature to around 60°C before earthworms are introduced. Swati and Reddy (2010) [44] reported that highest temperature generated during the initial stages of decomposition can be lethal to earthworms. Therefore, thermal stabilization of the substrate is essential before introducing earthworms. Earthworms should be added only after the temperature of the pre-digested substrate has fallen to around 25°C.

Preparation of vermibed

For the experiment, bedding was prepared by mixing sieved, partially decomposed cow dung with chopped wheat and maize straw at a 3:1 (w/w) ratio, and 4 kg of this mixture was placed in each plastic container. A 0.5 cm drainage hole was provided at the base of each container and plugged with a cotton wick to allow excess water to drain while preventing earthworms from escaping. The vermibeds were watered daily for 15 days to maintain moisture and reduce substrate temperature, safeguarding the earthworms during the initial thermophilic composting phase.

Experimental design

A total of ten containers were used in the experimental study to evaluate the vermicomposting potential of two earthworm species, *Lampito mauritii* and *Perionyx excavatus*, across two different substrate combinations. For each species, five containers were set up, comprising four experimental treatments and one control. The four

experimental containers per species contained a mixture of cow dung with wheat straw or maize straw, inoculated with the respective earthworm species. Additionally, two control containers comprising the same substrate combination without earthworms were maintained for conventional composting. All containers were prepared uniformly and maintained simultaneously throughout the experimental period.

Earthworm inoculation and maintenance:

Two earthworm species (*P. excavatus*, *L. mauritii*), each of 50 adult individuals, were introduced on the surface of the pre-composted substrate. All containers were covered with plastic mesh (1 mm) for ventilation and to protect the earthworms from predators. Moisture in the control and experimental containers was maintained by sprinkling water at regular intervals to ensure optimal moisture content (50-60%) and temperature (around 25 °C) in the vermibed, facilitating vermicomposting.

Study period

The experiment was conducted for up to 60 days. Bedding material samples were collected from the control container (conventional control) and each experimental container on days 0, 15, 30, 45, and 60 of composting.

Physicochemical and nutrient analysis

Homogenized subsamples of the substrate material were collected at intervals of 0, 15, 30, 45, and 60 days from each experimental and control container. The samples were analyzed for pH (Jackson, 1973) [19], organic carbon (Walkley and Black, 1934) [47], total Kjeldahl nitrogen (TKN) (Jackson, 1973) [19], available P (Anderson and Ingram, 1993) [3], and exchangeable K (Simard, 1993) [40]. The C: N ratio was calculated from measured values of organic carbon and total nitrogen.

Statistical analysis

All experimental setups were carried out in triplicate ($n = 3$), and results were expressed as mean $\pm$ standard error (SE). The data were subject to one-way analysis of variance (ANOVA) using SPSS to test for significant differences between treatments, earthworm species and sampling intervals at a significance threshold of $p < 0.05$.

Result and Discussion

Vermicomposting maize and wheat straw with *Perionyx excavatus* and *Lampito mauritii* caused substantial physicochemical changes in the substrate over 60 days (Fig. 1, 2). The observed changes included decreases in pH, organic carbon, and the C: N ratio, along with increases in total nitrogen, phosphorus, and potassium. These changes align with the general pattern of biochemical transformation reported during vermicomposting, where earthworms interact with substrate-associated microorganisms and accelerate the breakdown and stabilization of organic residues. Vermicomposting therefore represents not simply a physical conversion of waste, but a biologically mediated process involving fragmentation, digestion, microbial mineralisation, and nutrient transformation (Thirunavukkarasu *et al.* 2023) [45], Raza *et al.* 2022 [38])

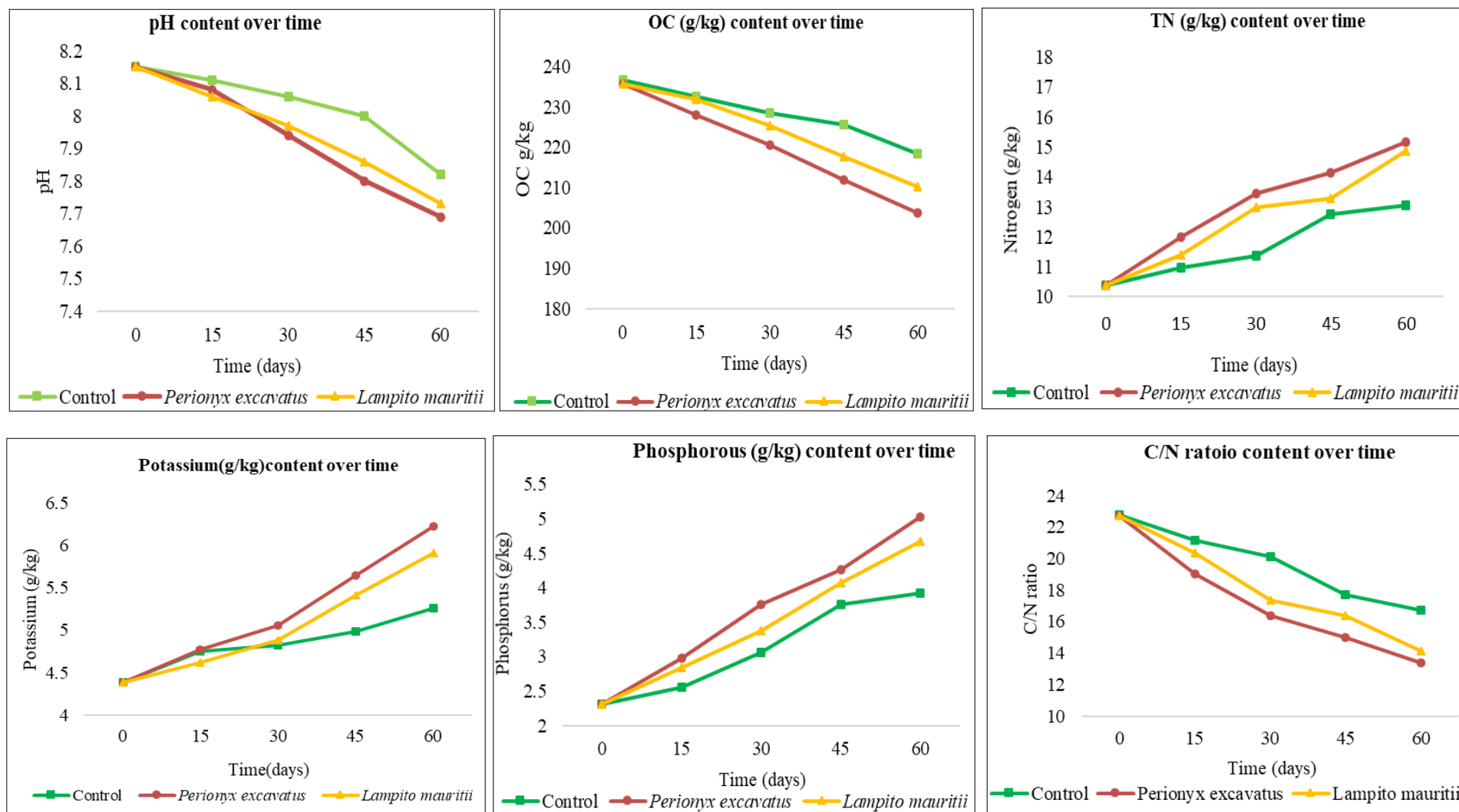


Fig 1: Variation in physicochemical characteristics of the bedding substrate over time during vermicomposting of maize crop residue.

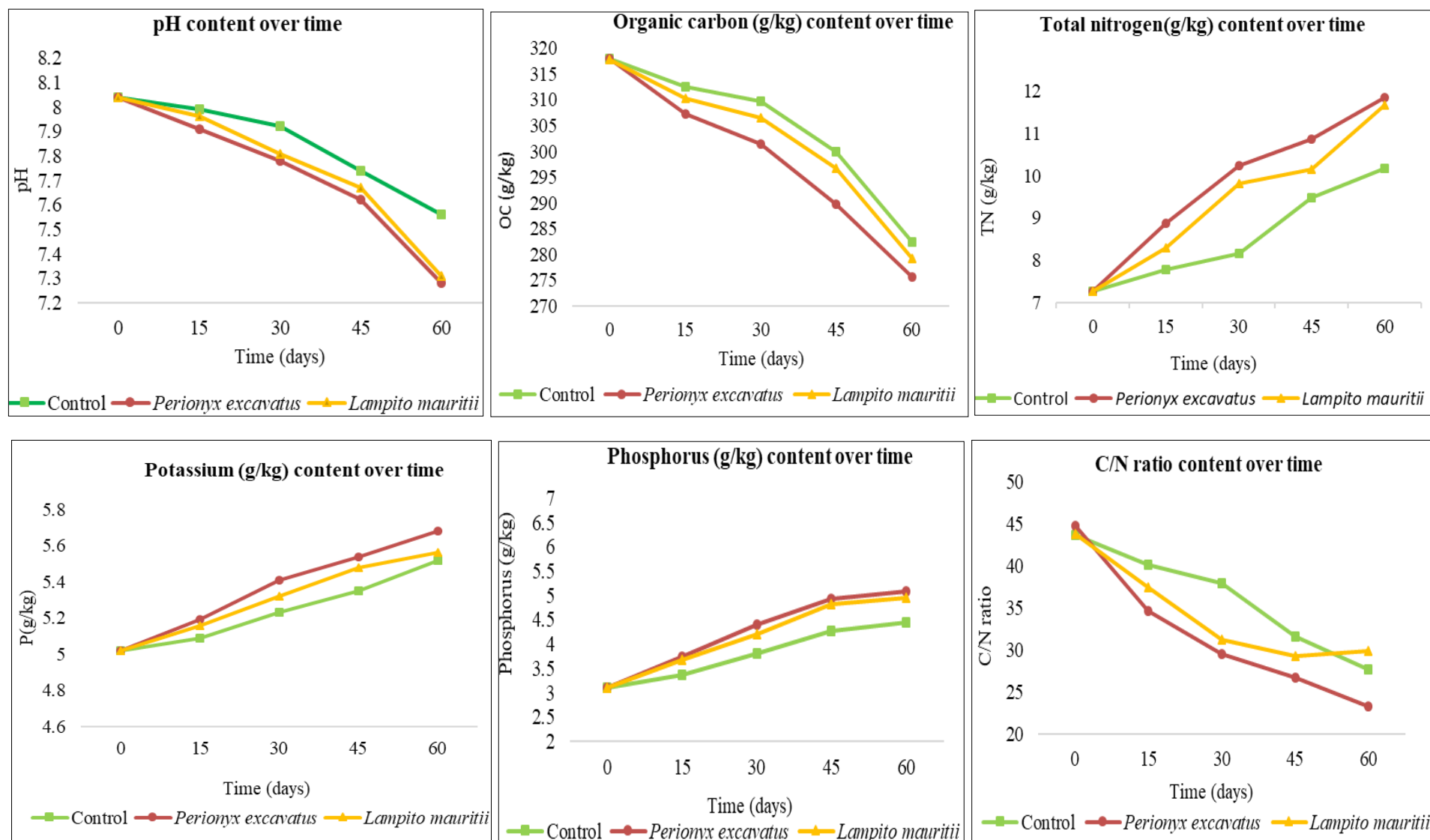


Fig 2: Variation in physicochemical characteristics of the bedding substrate over time during vermicomposting of wheat crop residue.

pH: In maize waste, pH declined from 8.15 ± 0.05 to 7.82 ± 0.03 (4.05%) in control bedding, while *P. excavatus* and *Lampito mauritii* showed significantly greater reductions of 5.64 % (7.69 ± 0.02) and 5.15% (7.73 ± 0.04), respectively ($P < 0.05$). In wheat waste, the pattern was similar but more pronounced: control declined by 5.97% (8.04 ± 0.01 to 7.56 ± 0.01), whereas *P. excavatus* achieved a 9.45% reduction (7.28 ± 0.02) and *L. mauritii* a 9.08% reduction (7.31 ± 0.02) ($P < 0.05$). Continuous microbial oxidation of organic matter produces organic acids, such as humic and fulvic acids, which contribute to the vermicompost acidification (Suthar and Singh 2008^[42], Gupta and Garg 2008^[16]). Earthworm activity, particularly digestion and the excretion of metabolic by-products, further contributes to soil acidification. Variations in acidification capacity between the two-earthworm species likely reflect differences in feeding rates, metabolic efficiency, and gut microbial assemblages, which collectively govern the rate of organic matter decomposition and associated chemical transformations of substrates (Dominguez and Edwards 2011)^[10].

Organic Carbon: In maize waste, the control bedding exhibited a 7.37% reduction in mass, declining from 235.64 ± 0.06 to 218.27 ± 0.04 g/kg, whereas in wheat waste, the loss was greater at 11.17%, with values decreasing from 317.95 ± 0.08 to 282.45 ± 0.04 g/kg. The earthworm-inoculated treatment showed significantly greater losses in maize; *P. excavatus* reduced OC by 13.52% (203.78 ± 0.02 g/kg) and *L. mauritii* by 10.79% (210.2 ± 0.06 g/kg) in wheat; reductions were 13.30% (*P. excavatus*) and 12.15% (*L. mauritii*) ($P < 0.05$). These findings align with Suthar and Singh (2008)^[42], who reported comparable carbon loss over a 60-day vermicomposting cycle resulting from substrate fragmentation and gut microbiota-facilitated decomposition.

Total Nitrogen: Enrichment was substantial across all treatments. In the maize waste control, available phosphorus increased by 25.63% (from 10.38 ± 0.03 to 13.04 ± 0.02 g/kg), whereas treatments with *P. excavatus* and *L. mauritii* recorded higher increases of 46.38% (15.18 ± 0.05 g/kg) and 43.35% (14.88 ± 0.02 g/kg), respectively ($P < 0.05$). In wheat waste, increases were even greater: 62.77% (*P. excavatus*) and 60.52% (*L. mauritii*) versus 38.84% in control. This nitrogen enrichment effect is consistent with Suthar (2007)^[43], earthworms can boost substrate nitrogen levels during digestion by adding nitrogenous excretory products, mucus, body fluid, and enzymes, and by decaying dead worm tissues in a vermicomposting system. A similar trend was also observed by Tripathi and Bhardwaj 2004^[46], Nath *et al.* 2009^[30], Joshi *et al.* 2010^[21], Ponmani *et al.* 2014^[35], and Daman *et al.* 2016^[9].

Phosphorus and potassium: Both micronutrients increased significantly across treatments, indicating effective earthworm-mediated solubilisation. In maize waste, phosphorus content increased by 69.70% in the control, compared with 117.75% in treatments inoculated with *Perionyx excavatus* and 105.63% in those with *Lampito mauritii*. In wheat waste, the corresponding increases were 43.55% (control), 64.19% (*P. excavatus*; $P < 0.05$), and 59.68% (*L. mauritii*). Potassium followed a similar trend in maize waste; control rose 19.82% versus 41.69% (*P.*

excavatus) and 34.62 % (*L. mauritii*). In wheat, increases were more modest: 9.96% (Control), 13.15% (*P. excavatus*), and 10.76 % (*L. mauritii*). These results are consistent with the findings of Atiyeh *et al.* (2002)^[5], and corroborate the observations reported by Padmavathi (2013)^[31], Ponmani *et al.* (2014)^[35], Chellachamy and Dinakaran (2015)^[7], and Daman *et al.* (2016)^[9].

C:N ratio: As a key indicator of compost maturity, the C: N ratio decreased significantly across all treatments. In maize waste, the control decreased by 26.59% (22.79 ± 0.08 to 16.73 ± 0.02), while *P. excavatus* achieved a 41.20 % reduction (13.39 ± 0.05) and *L. mauritii* a 37.77 % reduction (14.12 ± 0.02) ($P < 0.05$). In wheat waste, the reduction was more pronounced: control declined by 36.52%, *P. excavatus* by 47.95%, and *L. mauritii* by 31.54 % ($P < 0.05$). This reduction reflects faster C loss through respiration than N loss, leading to a lower C/N ratio in the vermicompost (Li *et al.*, 2020)^[28]. Microbial respiration resulted in carbon loss as carbon dioxide, while earthworms contributed nitrogen through mucus and nitrogenous excretory products, thereby reducing the C: N ratio of the substrate. This finding is consistent with the observations of Suthar (2007)^[43], Pattnaik and Reddy (2010)^[33], Ponmani *et al.* (2014)^[35], and Chellachamy and Dinakaran (2015)^[7].

Over the 60-days vermicomposting period, both earthworm species effectively bioconverted maize and wheat straw into nutrient-enriched vermicompost. However, *Perionyx excavatus* consistently outperformed *Lampito mauritii* across both substrates, exhibiting more pronounced reductions in pH, organic carbon, and C/N ratio, along with greater enhancements in nitrogen (N), phosphorus (P), and potassium (K) content. These findings indicate a comparatively higher rate of biochemical transformation by *P. excavatus*. This observation aligns with Paul (2017)^[34], who identified *Perionyx excavatus* as the most efficient vermicomposting species, followed by *L. mauritii* and *Drawida pellucida pallida*.

Conclusion

The results of the present study indicate that agricultural waste residues such as maize and wheat straw, when amended with cow dung, can be efficiently used as earthworm feed for producing valuable compost. Both earthworm species, *Perionyx excavatus* and *Lampito mauritii*, can efficiently convert agricultural residues into nutrient-rich vermicompost, demonstrating their potential for sustainable organic waste management and enhancement of soil fertility.

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