Research Journal of Agricultural Sciences
Volume 15; Issue 03 (May–Jun 2024); pp 731–735

Research Review

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

From Scraps to Soil Gold: Vermicomposting

Rekha Sansanwal*[1] and Lalita Singh[2]

[1-2] Department of Microbiology, Faculty of Life Sciences, Chaudhary Bansi Lal University, Bhiwani - 127 031, Haryana, India

Received: 16 Mar 2024; Revised accepted: 03 May 2024

Abstract

The escalating use of chemical fertilizers in agriculture has exacerbated environmental degradation, marked by fossil fuel depletion, CO_2 emissions, and water contamination. In India, the disproportionate reliance on these fertilizers poses a significant concern. Meanwhile, organic residues, often disposed of through burning or landfilling, contribute to soil degradation and the decline of essential environmental organisms. Among these, bacteria, fungi, actinomycetes, and earthworms are pivotal in enhancing soil health. Vermicomposting emerges as a sustainable solution, leveraging earthworms to decompose organic waste and yield nutrient-rich vermicast or vermicompost. This organic fertilizer enriches soil fertility, enhancing nutrient availability and soil structure. Earthworms efficiently process various organic materials such as paper, manure, crop residues, food leftovers, and yard trimmings, transforming them into valuable products like worm meal and castings. Vermicompost not only reduces reliance on chemical fertilizers but also serves as a biocontrol agent, mitigating plant diseases caused by soil-borne pathogens. Additionally, it improves the soil's C:N ratio, mitigates heavy metal impacts, and fosters beneficial soil microflora. Thus, vermicomposting presents a promising avenue for sustainable agriculture and environmental stewardship.

***Key words*:** Vermicompost, Earthworms, Nutrients, C:N ratio, Agriculture, Fertilizers

Vermicomposting presents a straightforward biotechnological method for composting, employing specific earthworm species to enhance waste conversion and yield a superior end product. Unlike traditional composting, vermicomposting operates within a mesophilic range, utilizing both microorganisms and earthworms active at temperatures between 10–32°C (not ambient temperature, but that within the moist organic material pile). This process surpasses composting in speed; as materials pass through earthworm guts, significant vermicast is produced. Although the complete process remains somewhat enigmatic, it results in valuable transformations, yielding earthworm castings teeming with microbial activity, plant growth regulators, and even pest-repelling attributes. Essentially, earthworms, through their organic alchemy, turn waste into invaluable resources [1].

Vermicomposting indeed offers a fascinating approach to composting that leverages the synergistic action of earthworms and microorganisms to rapidly convert organic waste into nutrient-rich vermicast, or worm castings. Unlike traditional composting methods, which rely solely on microbial activity and operate at higher temperatures, vermicomposting occurs within a mesophilic range, making it suitable for a wider variety of climates and conditions [2-3]. The process of vermicomposting involves the feeding of organic waste materials to specific species of earthworms, such as *Eisenia fetida* or *Lumbricus rubellus*, within a controlled environment. These earthworms consume the organic matter, breaking it down physically and chemically as it passes through their digestive systems. During this process, the waste is transformed into vermicast, which is excreted by the earthworms as a nutrient-rich material. The vermicast produced through this process is highly beneficial for soil health and plant growth. It contains a diverse array of microorganisms that contribute to soil fertility and nutrient availability, as well as plant growth regulators that can enhance plant vigor and resilience. Additionally, vermicast often exhibits pest-repelling attributes, making it a valuable resource for organic farming and gardening practices. While the exact mechanisms underlying vermicomposting are not fully understood, it is clear that earthworms play a central role in accelerating the decomposition of organic matter and enhancing the quality of the end product [4]. By harnessing the natural abilities of earthworms, vermicomposting offers a sustainable and environmentally friendly solution for managing organic waste while simultaneously improving soil health and agricultural productivity.

Organisms utilized

Earthworms are remarkably diverse, with approximately 3600 species worldwide, typically categorized into two main types:

Burrowing earthworms

Peretima elongata: These earthworms burrow holes in the soil up to depths of 3.5 meters, yielding approximately 5.6 kilograms of castings. *Peretima asiatica*, another species in this category, resides deep within the soil, measuring 20-30 centimeters in length, with a lifespan of around 15 years. They emerge to the soil surface solely during nighttime hours [5].

Non-burrowing earthworms

***Correspondence to:** Rekha Sansanwal, E-mail: rsansanwal90@gmil.com; Tel: +91 9992223035

Citation: Sansanwal R, Singh L. 2024. From scraps to soil gold: Vermicomposting. *Res. Jr. Agril. Sci.* 15(3): 731-735.

Eisenia fatida and *Endrils eugenia*: These earthworms inhabit the upper layers of the soil surface. Typically, red or purple in color, they measure 10 to 15 centimeters in length, yet have a shorter lifespan of about 28 months. They consume approximately 10% soil and 90% organic waste materials, converting them into vermicompost at an even faster rate than their burrowing counterparts. They exhibit a remarkable tolerance to temperatures ranging from 0 to 40°C and possess a high regeneration capacity, particularly thriving in conditions with 25-30°C temperatures and 40-45% moisture levels within the pile [5].

Biology, reproduction, and life cycle

i) Earthworms are ectothermic, meaning their body temperature is not internally regulated. Consequently, when temperatures rise above or drop below their optimal range for growth, their activity diminishes or slows down.
ii) In unfavorable environmental conditions, earthworms exhibit migratory behavior, seeking more suitable habitats, even if relocation leads to desiccation and mortality. Light serves as a deterrent to migration.
iii) *Eisenia fetida* reproduces rapidly in the presence of adequate food and water, relying on cocoon formation for survival. These cocoons can remain viable for months or even years in the absence of suitable environmental conditions.
iv) Earthworms are hermaphroditic, possessing both male and female reproductive organs, and engage in reciprocal mating to exchange genetic material. Sperm is stored and gradually utilized for fertilizing eggs.
v) Each cocoon typically contains multiple eggs (usually 2 to 4), which remain enclosed until hatching, giving rise to juvenile worms.
vi) The presence of cocoons and newly hatched juvenile worms within compost indicates a healthy culture and favorable environmental conditions.
vii) The presence of a prominent band or clitellum encircling the earthworm's body signifies its reproductive capability.
viii) Under favorable conditions, cocoons take approximately 4 to 6 weeks to hatch.
   a. Cocoons can provide protection in adverse conditions for extended periods, ranging from months to years.
   b. From emergence to maturity (i.e., the production of young), cocoons typically take 6 to 8 weeks to develop.
ix) In optimal environments, *Eisenia fetida* can live, feed, and reproduce for approximately 3 to 4 years.
x) Mature earthworms are capable of releasing up to 2 to 3 cocoons per week.
xi) In a controlled environment such as a worm bin, the earthworm population can potentially double every 2 months.

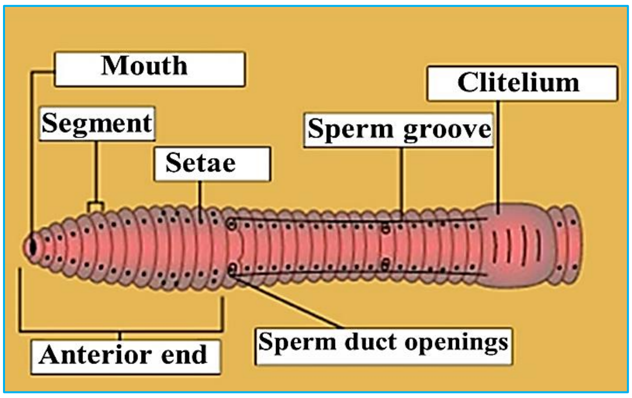


Fig 1 Diagrammatic representation of earthworm anatomy

Earthworm multiplication

Various organic materials have been assessed for their suitability in promoting the growth and reproduction of earthworms, directly impacting the effectiveness of vermicomposting. Benitez *et al.* [6] conducted a study evaluating the efficacy of dry olive cake, municipal biosolids, and cattle manure as substrates for vermicomposting. In substrates containing dry olive cake, newly hatched earthworms were successfully obtained. Another study found maize straw to be the most conducive feed for earthworms compared to soybean straw, chickpea, and wheat straw. While tobacco used as a substrate increased the weight of earthworms, it hindered their reproductive capabilities. These findings collectively suggest that *Gliricidia* and tobacco leaves are unsuitable for earthworm multiplication.

Temperature fluctuations during the process

Throughout the vermicomposting process, temperature variations were observed over a period of 5 to 65 days using different farm residues such as *Parthenium* and grass. Initially, the temperature was relatively high, around 32-33°C, within both *Parthenium* and grass substrates, exceeding the ambient temperature range of 26-30°C. Subsequently, there was a gradual decline in temperature, eventually stabilizing at a minimum of approximately 24°C.

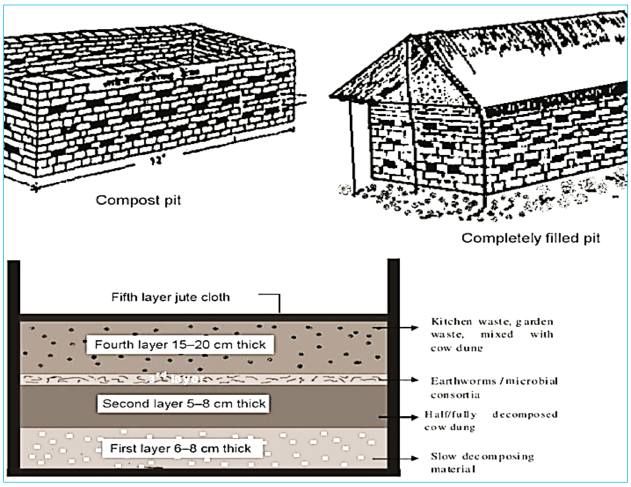


Fig 2 Diagrammatic representation of successive layers to be made for composting in pit

Source: Bhattacharjya *et al.* [7]

Methods of vermicomposting

Underground pits: Vermicomposting pits are typically dug to a depth of 1 meter and a width of 1.5 meters. The duration of composting varies according to need.

Surface heaps: Tanks constructed above ground using various materials such as standard bricks, hollow bricks, or locally sourced rocks. Tank dimensions can be customized to suit operational requirements. Commercial biodigesters often feature partition walls with small holes to facilitate earthworm movement between tanks.

Heap pit technique: In this method, vermicompost production tends to be higher compared to pit-based methods. For instance, the heap method yielded 51 kg of vermicompost, while the pit method produced 40 kg.

Cement rings: Vermicomposting can also be carried out above ground using cement rings. These rings typically have a diameter of 90 cm and a height of 30 cm.

Commercial model

The industrial-scale vermicomposting setup comprises four chambers enclosed within a wall measuring 1.5 meters in width, 4.5 meters in length, and 0.9 meters in height. These partition walls are constructed using a variety of materials such as standard bricks, hollow bricks, Shabazz stones, and locally sourced rocks. Each chamber is equipped with partition walls featuring small holes to facilitate the smooth movement of earthworms between chambers. Additionally, an outlet is provided at one corner of each chamber, designed with a slight slope to facilitate the collection of excess water. This water can be reused later or utilized as earthworm leachate.

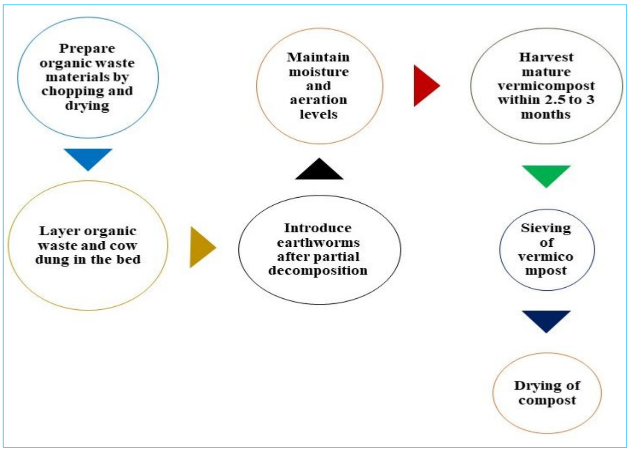


Fig 3 Process of vermicomposting

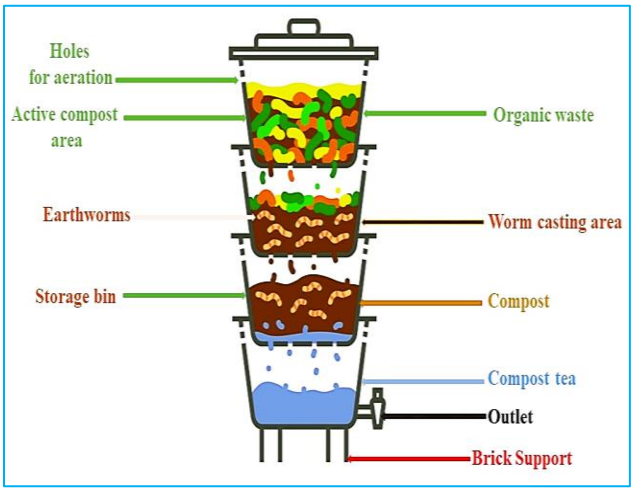


Fig 4 Diagrammatic representation of vermicomposter

Materials needed for vermicomposting

A variety of agricultural residues and dry wastes, such as sorghum straw, rice straw (post-cattle feeding), dry crop and tree leaves, pigeonpea stalks, groundnut husks, soybean residues, vegetable scraps, pre-flowering weed plants, coconut fiber, and sugarcane trash, can all be converted into vermicompost. Additionally, animal manures, dairy and poultry waste, food industry byproducts, municipal solid waste, biogas sludge, and sugarcane bagasse serve as excellent raw materials for vermicomposting.

To illustrate, using either a cement ring measuring 90 cm in diameter and 30 cm in height or a pit or tank measuring 1.5 m × 1 m × 1 m, the following quantities of raw materials are required:

- Dry organic wastes (DOW): 50 kg
- Dung slurry (DS): 15 kg
- Rock phosphate (RP): 2 kg
- Earthworms (EW): 500–700
- Water (W): 5 L every three days

These ingredients are used in a ratio of 5:1.5:0.2:50–75:0.5 of DOW:DS:RP:EW:W. For the tank or pit system, 100 kg of raw material and 15–20 kg of cow dung are necessary for each cubic meter of the bed [8].

Compost worms require five essential elements

- A suitable living environment, often referred to as "bedding"
- A food source
- Adequate moisture (greater than 50% water content by weight)
- Sufficient aeration
- Protection from extreme temperatures.

These five requirements are detailed further below:

Bedding: The bedding material provides a stable habitat for the worms, offering:
○ High absorbency
○ Good bulking potential
○ Low protein/nitrogen content (high Carbon:Nitrogen ratio)

Worm food: Worms can consume a wide range of organic materials, including manures like cattle, poultry, and biosolids.

Moisture: Proper moisture levels (above 50%) are crucial for worm survival.

Aeration: Adequate oxygen is essential for aerobic decomposition. Poorly aerated environments can lead to anaerobic conditions and worm mortality.

Temperature: Vermicomposting thrives at temperatures between 15°C and 20°C. Extreme temperatures should be avoided.

Other important parameters

pH: Worms can tolerate a pH range of 5-9.

Salt content: Worms are sensitive to salt, preferring levels below 0.5%.

Urine content: Excessive urine in animal manure should be leached before use.

Other toxic compounds: Substances like pesticides and industrial chemicals can harm worms.

Construction of a worm farm

Bedding: Coarse materials like shredded twigs or coconut fiber create a suitable habitat.

Feed: Vegetable waste and manure are layered over the bedding.

Worm introduction: Earthworms are added to the compost heap.

Watering: The compost heap is watered according to climate conditions.

Covering: The heap is covered to protect worms from predators and weather.

Monitoring: Regular checks ensure the compost heap's health.

Harvesting the vermicompost

The composting process typically takes between 2 to 5 months to reach harvest readiness. Several methods can be employed:

Windrow technique: Material is continuously added to one end of a long, narrow pile called a windrow.

New material should be placed in contact with older substrate to encourage worm migration. As worms move to fresh material, older compost can be harvested and left to mature further if needed.

Layered tray system: Construct the worm bed using multiple trays, with the bottom tray serving as a liquid collection pan. Working trays, designed with holes or slits for worm passage, are stacked atop the collection pan. Start with a layer of coarse material (e.g., wood shavings) at the bottom of the first working tray, followed by finer material (leaves, manure). Once most of the material in a tray has composted, add the next tray on top, ensuring contact between layers. Fill the new tray with fresh material, allowing worms to migrate upward. Harvest compost from the lower tray once worms have moved up. Finished compost can be sieved if the bed is inclined or carefully hand-sifted, allowing worms to retreat downward.

Utilization: Typically, farms and cooperatives utilize worm compost for their own fields and gardens. Some facilities may sell worm humus commercially (Fig 3).

How to use vermicompost

Vermicompost is versatile and can be applied to various types of crops, including agricultural, horticultural, ornamental, and vegetables, at any stage of growth. It serves as an excellent amendment for starting seeds, providing essential nutrients for young plant development. For indoor seed starting, simply add a small amount to the seed-starting medium. For outdoor seed planting, sprinkle vermicompost along the furrow or into the holes where seeds are planted.

Vermicompost in pots: When potting new plants, mix one part garden soil, one part coco-peat, and one part vermicompost (1:1:1) thoroughly and add it to the pot. This blend, known as a universal potting mix, promotes healthy plant growth.

Use of vermicompost for houseplants: Vermicompost is ideal for most ornamental, foliage, or indoor flowering plants. It sustains the color, size, and overall appearance of foliage and branches by providing a steady supply of nutrients.

Use of vermicompost in vegetables: Vermicompost has revolutionized vegetable farming and kitchen gardening, particularly in organic farming. It yields excellent results compared to other fertilizers. Fruiting, underground, and leafy vegetables thrive with vermicompost as a primary fertilizer, whether grown in containers or raised beds.

Utilization of agricultural wastes as substrate

In agriculture, significant amounts of organic waste are generated, including crop residues, weeds, plant parts, leaf litter, and animal bedding materials. Unfortunately, much of this waste remains unused, leading to environmental problems such as air pollution. Vermicomposting offers an eco-friendly solution by converting such organic waste into high-quality manure. This process not only reduces waste but also enhances soil fertility and promotes sustainable agriculture practices.

Importance of vermicomposting

Source of plant nutrients: Vermicompost provides both major and micronutrients to plants, improving soil texture and water retention while enhancing soil aeration. This fosters better root growth and multiplication of beneficial soil microbes.

Improved crop growth: When a crop's demand for water, oxygen, or nutrients exceeds its intake, growth potential is limited. Vermicomposting helps mitigate this by enhancing soil conditions, leading to improved growth rates even under adverse weather conditions.

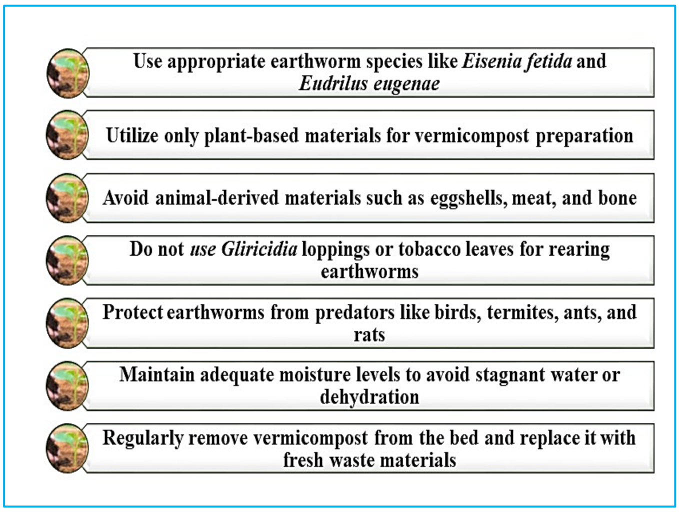
Reduction in C:N ratio: The carbon-to-nitrogen (C:N) ratio is crucial for residue decomposition and nitrogen cycling in soil. Vermicomposting optimizes this ratio, with a recommended ratio of 24:1 for efficient agricultural residue digestion. A lower ratio accelerates plant material decomposition.

Improved soil quality: Vermicomposting boosts soil microbial activity, increasing oxygen availability, maintaining optimal soil temperature, enhancing soil porosity and water infiltration, and improving nutrient content. This leads to enhanced plant growth, yield, and quality.

Vermicomposting - A boon for waste minimization and soil quality

Kulkarni [9] conducted research on the impact of bedding materials in the vermicomposting process, finding that newspaper bedding was more effective in worm biomass production. Sawdust bedding was observed to be better for cocoon production. Quaik *et al.* [10] evaluated the potential of vermicomposting leachate as a natural foliar fertilizer and nutrient solution in hydroponic culture, highlighting its efficacy as a plant nutrient supplement. Subbulakshmi and Thiruneelakandan [11] noted that vermicomposting improves soil structure, fertility, moisture retention, and crop yield, offering solutions to environmental challenges from waste management to soil fertility.

Precautions during the process



CONCLUSION

Vermicomposting addresses the global challenges of organic waste production and soil degradation and plays a vital role in environmental conservation. It enhances soil fertility, water retention, and nutrient availability, promoting sustainable agriculture and environmental conservation while offering economic benefits to farmers and industries.

LITERATURE CITED

1. Gandhi M, Sangwan V, Kapoor KK, Dilbaghi N. 1997. Composting of household wastes with and without earthworms. *Environment and Ecology* 15(2): 432-434.
2. Jeyabal A, Kuppuswamy G. 2001. Recycling of organic wastes for the production of vermicompost and its response in rice–legume cropping system and soil fertility. *European Journal of Agronomy* 15: 153-170.
3. Sinha RK, Herat S, Bharambe G. 2010. Brahambhatt a vermi stabilization of sewage sludge (biosolids) by earthworms: Converting a potential biohazard destined for landfill disposal into a pathogen-free, nutritive and safe biofertilizer for farms. *Waste Management and Research* 28: 872-881.
4. Vyas P, Sharma S, Gupta J. 2022. Vermicomposting with microbial amendment: implications for bioremediation of industrial and agricultural waste. *Bio Technologia* (Pozn) 103(2): 203-215.
5. Singh R, Sharma RR, Kumar S, Gupta RK, Patil RT. 2008. Vermicompost substitution influences growth, physiological disorders, fruit yield and quality of strawberry (*Fragaria* × *ananassa* Duch.). *Bioresource Technology* 99(17): 8507-8511.
6. Benitez E, Sainz H, Melgar R, Nogales R. 2002. Vermicomposting of a lignocellulosic waste from olive oil industry: a pilot scale study. *Waste Management and Research* 20(2): 134-142.
7. Bhattacharjya S, Das S, Amat D. 2021. Potential of microbial inoculants for organic waste decomposition and decontamination. *In*: *Biofertilizers*. Woodhead Publishing. pp 103-132.
8. Nagavallemma KP, Wani SP, Lacroix S, Padmaja VV, Vineela C, Rao MB, Sahrawat KL. 2004. Vermicomposting: Recycling wastes into valuable organic fertilizer. Global Theme on Agroecosystems Report No. 8.
9. Kulkarni SJ. 2017. Vermicomposting—A boon for waste minimization and soil quality. *International Journal of Research and Review* 4(2): 76-81.
10. Quaik S, Embrandiri A, Rupani PF, Singh RP, Ibrahim MH. 2012. Effect of vermiwash and vermicomposting leachate in hydroponics culture of Indian Borage (*Plectranthus ambionicus*) plantlets. *In*: *UMT 11th International Annual Symposium on Sustainability Science and Management*. pp 210-214.
11. Thiruneelakandan R, Subbulakshmi G. 2014. Recuperating waste into valuable organic manure using environment’s plowman. *Biosci. Biotechnol. Res. Asia* 11(2): 1019-1023.