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Vermicompost (Traditional Methods) is an Important Component of Agricultural Productivity and an Efficient Tool for Environmental and Economic Sustainability

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Abstract: Vermicompost, a nutrient-rich organic fertilizer produced by vermicomposting, has emerged as an environmentally acceptable and sustainable waste management and organic agriculture option. It investigates the production, economics, and sustainability of vermicompost. Vermicomposting is the process of collecting organic waste and feeding it to specific earthworm species. Worms digest organic materials, transforming it into nutrient-rich castings that are collected and cured. Vermiculture has the potential to be profitable economically. Consumer awareness, distribution routes, and production scale all play important roles in determining profitability. Vermiculture contributes to sustainability goals by tackling waste management issues. It keeps organic waste out of landfills, which reduces methane emissions and pollution. Vermicompost promotes soil health, fertility, water retention, and erosion control, hence promoting sustainable agriculture. Its incorporation into other agricultural systems, including as organic farming and urban gardening, increases adaptability and broadens its impact on sustainability. Vermicomposting is a sustainable method of waste management and organic fertilizer generation. Its ease of use and scalability make it suitable for both individuals and corporations. Vermicompost production is projected to play an important role in sustainable agricultural and waste management practises as awareness and uptake grow.

Keywords: Vermicompost, Earthworms, Sustainability, Vermi- Economics, Vermi-production

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Introduction

Vermicompost, commonly referred to as worm compost, is an organic fertiliser rich in nutrients that is created through the vermicomposting process. Earthworms are used to decompose organic waste in a regulated manner (Abafita *et al.*, 2014). Vermiculture has grown in popularity recently as a sustainable and eco-friendly way to manage garbage and produce organic fertiliser. The production, economics, and sustainability elements of vermiculture are examined in this paper. Vermicomposting is a straightforward process that uses earthworms to turn partially decomposed organic wastes into organic compost (Adiloğlu *et al.*, 2018). Organic farming is growing more and more popular, but managing organic waste is also becoming a hot topic. Vermicomposting is the most effective method for combining them. Vermicomposting is a successful way to turn "garbage to gold" (Ahirwar and Hussain, 2015).

Vermicompost has been eagerly investigated by scientists and government authorities as a clear advantage for agriculture in warm-weather regions where compost worms can thrive in outdoor commercial facilities, such as the Southeast United States, the Philippines, Cuba, Australia, and South Africa (Suthar, 2010). The Organic Agriculture Centre of Canada performs research on adjustments to maintain year-round vermicompost operations that enable worms to survive and thrive in colder climes in the Canadian province of Nova Scotia.

History:

Charles Darwin wrote a laudatory essay about earthworms in 1881 -- The Formation of Vegetable Mould through the Action of Worms, With Observations on Their Habits, which credited annelid activity with creating Britain's massive topsoil recent (Suthar, 2010.). The mid-1990s saw a resurgence of interest in vermicompost as a useful soil additive and a way to lessen the burden of kitchen and other organic waste on landfills throughout the world after a century of relatively sporadic research (Donghong Wang *et al.*, 2010). Since ancient times, worms have been produced for use as bait through vermiculture. Vermi-composting was praised for turning organic materials into compost by both Aristotle and Darwin. A bin-controlled system is a recent development with pioneers as its foundation. Worm bins were invented by Appelhof and Edwards, and vermicomposting was used in nations such as the Netherlands, England, and Canada (Sinha *et al.*, 2010).

Home vermicomposting was invented by Michigan-based biology professor Mary Appelhof in 1972, she realized to keep composting despite living in a northern climate and placed a mail order for one pound of red wiggler worms, or *Eisenia fetida*, from a bait provider (Leong *et al.*, 2017). She constructed a shallow bucket in her cellar and filled it with her leftover food and blankets. They had processed 65 pounds of trash at the end of the winter and had produced worm compost, which had helped her garden grow some excellent vegetables (Shahbazi *et al.*, 2019). Vermicomposting is still changing today as academics look into new methods and uses. Its incorporation with other ecologically friendly practises like organic farming and permaculture strengthens its contribution to creating a more sustainable and resilient future.

Vermicompost:

Vermiculture is the cultivation of earthworms for the purpose of converting organic waste into nutritional and helpful microorganism rice fertilizer. It enables us to create organically rich compost all year.

Vermicompost is a black, granular, odourless substance that resembles fertile soil and is a nutrient-rich organic material formed by earthworms decomposing organic waste. It is well-known for its capacity to improve soil structure, increase nutrient content, and promote healthy plant growth (Prabha *et al.*, 2008). It has a well-balanced composition of important plant nutrients, helpful microbes, enzymes, humus, and organic matter.

Vermicomposting is the practise of feeding organic waste to earthworms, such as kitchen scraps, yard trimmings, agricultural wastes and manure, which undergoes biological and chemical changes in their digestive track (Kayabasi and Yilmaz, 2021). The garbage is decomposed and supplemented with nutrients and helpful microbes. The resulting vermicompost is teeming with helpful microorganisms, such as bacteria, fungi, and other decomposers, which aid in the suppression of harmful diseases, the improvement of nutrient availability, and the overall health of the soil (Rivasol, 2021). These microbes are essential for further decomposing organic materials and releasing nutrients in plant-available forms.

Benefits of Vermicompost:

Improved Soil Fertility: Nitrogen, phosphorus, potassium, calcium, magnesium, and trace elements are all abundant in vermicompost. These nutrients are released slowly and in a plant-available form, allowing for optimal growth and development.

Enhanced Soil Structure: Vermicompost enhances soil structure by increasing water-holding capacity, enabling improved drainage, and decreasing soil compaction. It contributes to the formation of a well-aerated and friable soil environment, which allows plant roots to grow more efficiently.

Increased Nutrient Availability: Vermicompost, which is made up of humus and organic matter, works as a nutrient reservoir, giving continuous plant sustenance and assisting in chelation, which reduces leaching and increases plant availability.

Beneficial Microbial Activity: Vermicompost has a wide population of helpful microorganisms that help to maintain soil health. These bacteria contribute in nutrient cycling, disease control, and organic matter breakdown, resulting in a more balanced and robust soil ecosystem.

Reduced Environmental Impact: Vermicomposting decreases methane emissions and the environmental impact of organic waste by reusing it. It can be used in landscaping, gardening, lawn maintenance, and agriculture. It can be used as a topdressing, incorporated into the soil, or made into compost teas or liquid fertilisers (Adiloğlu *et al.*, 2018). Vermicompost is a useful and organic soil additive that boosts plant health, increases soil fertility, and promotes sustainable agricultural and gardening practices (Ahirwar and Hussain, 2015).

Vermicompost Production:

Vermicomposting is a sustainable approach that employs earthworms to decompose organic waste, resulting in nutrient-rich compost that may be used to enhance soil. (Abafita *et al.*, 2014). Earthworms, usually of species like *Eisenia fetida* or *Lumbricus rubellus*, are added to the vermicomposting bed once the bedding has been prepared. These worms, often referred to as epigeic worms, are excellent at rotting organic material in a controlled setting (Yağmur and Esiyok, 2019). Earthworms consume organic waste, digesting it with helpful microorganisms and enzymes that break down complex organic compounds into simpler forms (Aksu *et al.*, 2017; Yağmur and Esiyok, 2019).

Earthworms create vermicompost, which contains critical plant nutrients as well as beneficial microorganisms and improves soil fertility and structure. Depending on the conditions, the process could take weeks or months (Mu *et al.*, 2023). Regular moisture and temperature monitoring is required to guarantee ideal conditions for worm activity and decomposition. The vermicompost can be retrieved from the vermicomposting bed once it has been fully processed and matured (Aksu *et al.*, 2017). Vermicompost collected can be used as a soil supplement, potting mix ingredient, or fertiliser. It improves soil health, encourages plant development, increases water retention, and decreases the need for synthetic fertilizers and pesticides. Overall, vermicomposting is a natural and sustainable method of transforming organic waste into a useful resource that benefits both the environment and agriculture.

Vermicomposting methods:

There are several different methods of vermicomposting that can be used depending on the scale of production, available space, and specific needs. Here are some commonly used methods:

Traditional Bed Method:

Using this technique, vermicomposting beds can be built either on the ground or in raised beds. The introduction of earthworms occurs when organic waste and bedding are piled in the selected location. The vermicompost matures towards the bottom of the bed, therefore the vermicompost is periodically removed and additional organic waste is periodically added.

Windrow Method:

This technique involves creating windrows or long, narrow mounds of organic waste on the ground. To keep the windrows moist and periodically turned, the conditions for earthworm activity are maintained. Earthworms are initially added, and as they move along the windrow, they consume the organic waste and produce vermicompost.

Bin Method:

This method entails creating a controlled environment for vermicomposting by employing containers or bins. Bins can be formed of wood, plastic, or other appropriate materials. The bin is filled with organic garbage and bedding, and earthworms are introduced. The container is covered to keep moisture and temperature levels stable. The vermicompost container can be harvested as it matures.

Tray Method:

This technique is frequently used for small-scale vermicomposting. It entails storing organic waste and worms in shallow trays or boxes with perforated bottoms. Each tray is layered on top of the others, allowing the worms to freely migrate between them to digest the waste. The trays are rotated on a regular basis, and ripe vermicompost is taken from the bottom tray.

Indoor Vermicomposting:

Vermicomposting can be done all year or indoors in particular containers. It entails filling the space with organic garbage, bedding, and earthworms. The approach is determined by the available resources, the volume of trash, and the intended outcome. The decision is influenced by space, scale, and ease of maintenance.

Focus to Traditional method is low cost for Agriformers:

The bed method, also known as the traditional method of vermicomposting, is a simple and widely used method that has been used for decades. It requires constructing vermicomposting beds on the ground or in raised beds (Suthar, 2010). This method is suitable for small to medium-scale vermicomposting operations and is straightforward to implement in home gardens, small farms, or community settings.

Bed Preparation:

The vermicomposting bed should be placed in a suitable area. For the worms' protection from high heat, it should be well-drained and ideally shaded. Remove any weeds, pebbles, or other objects from the area to prepare the bed. It can be of any size, based on the amount of organic waste you have and the area you have available.

Bedding Material:

The bed should be covered with bedding. Straw, dried leaves, shredded newspaper, cardboard, or a combination of these is typical bedding materials. The bedding assists with aeration and moisture retention while also providing the worms with a moist and cosy environment.

Organic Waste Layer:

Layer organic waste items on bedding, such as kitchen leftovers, garden trash, and agricultural byproducts, but avoid meat, dairy, oily materials and pet waste to avoid bugs and odours.

Influence of vermicompost on chemical characteristics and nutrient content of soil:

The nutrient-rich organic material known as vermicompost, which is created during the vermicomposting process, greatly affects the chemical properties and nutrient content of soil. Vermicompost introduces a variety of advantageous modifications to the soil that improve soil fertility and encourage plant development (Yağmur and Esiyok, 2019). Organic waste such as plant remnants, animal manure, and other organic waste that has partially decomposed makes up vermicompost. It enhances the organic matter in the soil, which is important for soil structure, moisture retention, and nutrient availability (Mu *et al.*, 2023). Vermicompost contains a high concentration of critical plant nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, iron, and zinc, which improve soil fertility and plant uptake (Mu *et al.*, 2023).

Vermicompost buffers soil pH, increasing resilience and balancing acidic or alkaline soils for plant growth, hence helping crops that require precise pH levels. It introduces advantageous microbes (Aksu *et al.*, 2017; Mu *et al.*, 2023). Vermicompost microbes improve soil health by decomposing organic materials, encouraging nutrition cycling, and suppressing pathogens. It improves drainage, builds soil structure, and stimulates root growth and nutrient absorption (Aksu *et al.*, 2017; Yağmur and Esiyok, 2019). The altered soil structure also makes it easier for nutrients and air to circulate through the soil profile.

Vermicompost improves soil water retention, reduces runoff, and increases plant access, assisting agricultural systems with water use and drought resilience (Aksu *et al.*, 2017). Vermicompost can minimise heavy metal soil contamination by immobilising and lowering heavy metal bioavailability in earthworm tissues, making the soil less toxic to plants (Yağmur and Esiyok, 2019). Vermicompost enhances soil chemical characteristics and nutrient content greatly, increasing fertility, nutrient availability, pH management, microbial activity, structural improvement, water retention, and soil pollution control, making it an important sustainable agricultural technique (Suthar, 2010).

Vermicompost and crop yield:

Vermicompost, an organic fertiliser formed from vermicomposting, has received widespread recognition for its beneficial effect on crop productivity. Vermicompost used as a soil supplement can greatly improve soil fertility and deliver necessary nutrients to plants, resulting in increased agricultural output (Ahirwar and Hussain, 2015).

Nutrient-Rich Soil:

Vermicompost is a nutrient-dense organic substance that contains a healthy balance of macro and micronutrients required for plant growth. When vermicompost is put to soil, it gradually releases these nutrients, guaranteeing a consistent supply throughout the growth season (Ahirwar and Hussain, 2015). This nutrient supplementation promotes better plant development and higher crop harvests.

Enhanced Nutrient Availability:

Vermicompost increases the soil's ability to hold onto nutrients. Vermicompost's organic material serves as a nutrient reservoir, retaining vital substances and limiting nutrient loss (Rivasol, 2021). Additionally, it encourages the growth of helpful microbes that decompose organic debris and release bound nutrients in plant-accessible forms. Optimum plant development, higher flowering, and enhanced fruit or grain output result from improved nutrient availability (Abafita *et al.*, 2014).

Soil Fertility Improvement:

Vermicompost improves soil structure, nutrient-holding capacity, and fertility by enhancing aeration, water infiltration, drainage, and aggregate development, as well as boosting root penetration, efficient nutrient uptake, and beneficial soil organisms (Rivasol, 2021).

Increased Water Retention:

Vermicompost's water-holding characteristics make it perfect for drought-prone areas, as it behaves like a sponge, lowering water stress, improving moisture access, and increasing crop output (Shahbazi *et al.*, 2019).

Disease Suppression:

Beneficial bacteria in vermicompost improve crop health, reduce plant diseases, and inhibit soil-borne pathogens, resulting in increased agricultural output due to healthier plants experiencing fewer disease-related losses (Shahbazi *et al.*, 2019).

Environmental Sustainability:

Vermicompost encourages sustainable agricultural practises by lowering dependency on synthetic fertilizers and chemical inputs. Farmers can utilize vermicompost to reduce their reliance on synthetic fertilizers that could have negative effects on the environment (Rivasol, 2021). Vermicompost's organic composition aids long-term soil health and sustainability while fostering a healthy soil ecosystem and reducing soil erosion.

The precise effect of vermicompost on crop yield can vary depending on the type of crop, the soil, the environment, and the amount of vermicompost applied. However, several studies have repeatedly demonstrated the beneficial impact of vermicompost on agricultural productivity (Leong *et al.*, 2017). Vermicompost is a natural, nutrient-rich soil supplement that offers an eco-friendly and efficient way to increase crop output and support sustainable agriculture practises.

A two-page flyer titled "Basement Worm Bins Produce Potting Soil and Reduce Garbage," which Appelhof sold by mail for 25 cents in 1973, detailed her procedure. Appelhof published a four-page pamphlet in 1979 titled "Composting Your Garbage with Worms." "Worms Eat My Garbage," her 1982 book, was released. 100 000 copies of the book were sold, and a 1997 version brought in 45,000 more.

Significance:

Vermicompost, a byproduct of the vermicomposting process, not only increases crop output and soil fertility but also makes a substantial contribution to the sustainability of the environment and the economy (Aksu *et al.*, 2017; Mu *et al.*, 2023).

(a) *Organic Waste Management*: Food scraps, agricultural waste, and green waste can all be managed organically through the use of vermicomposting. Vermicomposting lessens the creation of damaging greenhouse gases like methane, a significant contributor to climate change, by keeping organic waste out of landfills (Mu *et al.*, 2023).

(b) *Soil Health and Biodiversity*: Vermicompost improves soil structure, raises nutrient availability, and encourages advantageous microbial activity, all of which improve soil health. By providing a safe haven for a range of soil creatures, such as earthworms, bacteria, and beneficial insects, healthy soils help to preserve biodiversity (Rivasol, 2021).

(c) *Reduced Chemical Inputs*: Vermicompost is an organic fertilizer that decreases plant reliance on synthetic fertilizers and chemical inputs hence, lowering environmental impact as well as soil and water contamination (Aksu *et al.*, 2017).

(d) *Water Conservation*: Vermicompost improves soil water retention, lowering runoff and boosting plant root hydration, reducing watering requirements and conserving water resources.

Economic Sustainability:

(i) *Cost-Effective Fertilizer Alternative*: Vermicompost, a low-cost alternative to synthetic fertilisers, can be made from locally available organic waste, lowering chemical fertilizer prices and enhancing agricultural practicality.

(ii) *Increased Crop Productivity*: Vermicomposting improves soil fertility, nutrient availability, and plant health, resulting in increased agricultural productivity and yields that benefit farmers and gardeners while also increasing economic returns.

(iii) *Sustainable Agricultural Practices*: Vermicompost promotes sustainable agriculture by using organic, ecologically friendly practises that reduce soil deterioration, non-renewable resource use, and chemical-intensive farming effects, ensuring long-term economic sustainability.

(iv) Value-Added Products: Vermicompost can be processed into valuable products such as vermi-tea or liquid extract, which benefit farmers and vermicomposting firms by providing organic fertilizers, soil conditioners, and plant growth stimulants.

Conclusion

Vermicompost is a sustainable alternative to synthetic fertilizers that addresses organic waste management challenges, improves soil health and biodiversity, reduces chemical inputs, and conserves water resources for a flourishing future.

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