Vermicomposting a Solution for Sustainable Farming Practices: A Review

Ekta Bhalla
Dasmesh Girls College, Chak Alla Baksh, Mukerian-144211

Abstract: **Increasing population and food demand has forced the farming community to apply excess amount of chemical fertilizer that leads to degradation of soil health and causing environmental pollution. In recent years, issues such as food quality, environmental safety and soil conservation has lead to a substantial increase in the use of sustainable farming practices. Sustainable farming practices aim to produce agricultural products at a low environmental cost, ensuring food availability for future generations. Vermicomposting is an economically feasible and environment friendly technology in which organic wastes are bio-converted into value added product and various organic wastes are used in this process. This approach utilizes the action of earthworms as well as bacteria to break down organic waste. The resultant material (vermicompost) can be a highly effective fertilizer, or soil conditioner. This paper aimed to investigate the possibility of large-scale vermicomposting; its economic and environmental potential. It has been noticed that when vermicompost applied to soil, helps in maintaining the good physico-chemical and biological characteristics of soil. Its nutrients supplying capacity fairly more than that of other composts, not only it supplies major nutrients but it also carries macro and micro nutrients, beneficial micro-organisms and growth regulators. Therefore, keeping in view, vermicomposting presents a precise and effective solution for organic waste management, playing a pivotal role in the future of agriculture and contributing significantly to environmental conservation. The proper management of waste through vermicomposting can resolve the demand for organic fertilizer globally.**

Key words: **Sustainable Farming Practices, Vermicomposting, Organic Wastes, Soil Conservation, Environmental Pollution.**

INTRODUCTION

Soil is the foundation of life on earth, sustaining a diverse array of organisms. However, industrialization and technological growth have led to sustainability challenges. Sustainability refers to the use of natural resources without compromising future generations' ability to meet their own needs. In recent years, sustainable farming has emerged as a vital priority deal with issues including climate change, environmental degradation, and food security (Olle, 2019., Ali et al, 2015., Ratnasari, et al., 2023). Vermicomposting has become increasingly significant for sustainable organic farming and environmental conservation. As an eco-friendly, high-nutrient biological fertilizer, vermicompost is believed to hold the key to enhancing the growth and yield of crops, such as vegetables, flowering plants, and fruit trees (Ali et al, 2015. Aalok et al 2008). The use of vermicompost ensures the efficient recycling of organic matter, contributing to waste reduction, mitigating the burden on landfills, and promoting a circular economy (Alshehrei and Ameen, 2021, Rupani et al 2023). It is the method of using earthworms to convert organic waste into nutrient rich compost. Earthworms play a significant role in agriculture, it decomposes dead organic litter by consuming them and release as castings. They enhance soil fertility by releasing mineral elements in the forms that are easily uptake by plants (Curry, 1987). Vermicompost contains large amount of nutrients in plant available form such as nitrates, phosphates, exchangeable calcium and soluble potassium (Edwards, 1998; Orozco, 1996). The behavioral activity of earthworms that is feeding, burrowing and casting, modify the physical, chemical and biological properties of organic matter and soil for plant growth and nutrient attainment. Due to large surface area, vermicompost offers several micro sites for nutrient retention and exchange and microbial activity (Shi-wei and Fu-Zhen, 1991). Vermicompost is usually rich in microbial populations and diversity particularly fungi, bacteria and actinomycetes (Edwards, 1998).

The compost prepared by earthworm contain several types of enzymes, hormones, vitamins, antibiotics and many essential nutrients required for plant growth and also play important role in improving soil structure and water holding capacity, thereby improving crop productivity and quality.

Vermicompost is characterized by high porosity, aeration, drainage, water holding capacity and microbial activity (Edwards and Burrows, 1988; Atiyeh et al., 1999, 2000). This process is simple, low-cost, and provides opportunities for entrepreneurship development even with low investments (Edwards, 2011; Bordoloi, 2021c).

Material Required for Vermicomposting

There are more than 3000 species of earthworms in the soil (Cook and Linden, 1996), but hardly 8-10 species are found suitable for vermicompost preparation. Julka (1986) reported a list of 20 Indian worms, which could be possible to use as agent for vermicomposting. In a comparative account of the vermicultureal characteristics of the some Indian worms are *Eisenia foetida*, *Lumbricus rubellus*, *Amyanthas diffringens*, *Eudrillus eugineae*, *Perionyx escavatus*, *Lampito mauritii*, *Drawida nepalensis*, *Pontocolex corethrurus*, *Gordiodrilus elegans* etc. are a few earthworm species widely and efficiently used in vermicompost production. The best types of earthworms for vermiculture and vermicomposting are epigaeic species such as *Eisenia fetida* and *Eudrilus eugeniae* (Bansal and Kapoor, 2000; Dominguez and Edwards, 2004). These worm species like to settle on top soil and prefer to eat organic scraps such as green waste, compost and organic bedding and produce richer casting than those that feed on plain soil. These worms have been recognized as the worm species that can eat as much as half of its weight on a daily basis. They work proficiently in breaking down and decaying natural remains and converting into high-quality organic compost. Further, above species of earthworms are resistant to temperature and moisture fluctuations. Moreover, these species multiply rapidly and remain active throughout the year, decompose organic material rapidly and help to prepare vermicompost in shorter duration. Cattle dung is used as raw material for vermicomposting, beside that any material that can be decomposed easily such as green wastes (leaves and rind), crop residue, and roughage of the animals as well as temple wastes could also be used for vermicompost preparation (Kamergam et al., 1999; Kiehl, 2001). The organic waste consumed by earthworms undergo physical breakdown in the gizzard, which is then exposed to various enzymes such as protease, cellulose, lipase, chitinase, amylase, etc. secreted into lumen by the gut wall and associated microbes. Above enzymes causes breakdown of complex biomolecules into simple ones. Only 5-10% of the ingested material is absorbed by earthworms for their growth and remaining is excreted as casting (Kumar et al., 2018).

Site Selection

Generally, earthworms like to live in shady and moist places and such conditions are favorable for their faster multiplication. High temperature and dry environment are more limiting than low temperatures and water saturated environment for the worms (Rostami et al., 2009). Earthworm cannot survive in standing water hence; ensure proper drainage across vermicompost unit. A temperature range between 20-30°C is optimum for faster multiplication and growth of the earthworms. Hence, using proper species of earthworms, excellent quality of compost can be produced in ambient temperature conditions in a short period of time.

METHODS

Bed method: In this method, the open bed is constructed which are uses 1st class bricks, and the bottom of the bed is fixed to restrict the worms. It is preferably used bed method for easy maintenance. Required size of the bed is (6x2x2) ft. The bed is constructed on the pucca / kacha floor using 1st class bricks. This size bed is used for small-scale vermicomposting (5- 10 tons of vermicompost annually). This method is easy to maintain and practice. The tops of the beds were covered with jute or gunny bags, to allow gaseous exchange.

Pit method: The vermicomposting pit should be constructed with an approximate measurement of 1 m deep and 1.5 m wide.

Heaping above the ground: In this method a polythene sheet is used to place on the ground and the waste material is spread on it covering with cattle dung. The comparison on efficacy of pit and heap methods for preparing of vermicompost was reported by under field conditions Sunitha et al., (1997). The heap method is considered as better than pit for considering the biodegradable wastes as the criterion. Earthworm population was mostly favorable in the heap method that increases upto a 21-fold by the action of *Eudrilus eugeniae* as compared to 17-fold increase in the compared pit method.

Procedure for Vermicomposting

Composting is an excellent option for reducing environmental threats and preparing a natural, beneficial soil additive. Actually, vermicompost is a great alternative that allows composting operation with minimal space considerations. Ease of vermicompost process and ability of its application in various scales made the vermicomposting an interesting topic almost everywhere. The production of quality vermicompost from the raw waste requires much knowledge of the process. The different steps involved in vermicompost production are elaborated below: After selection of site for vermicompost preparation, smoothens the surface. Now, make a bed of approximately 6x2x2 feet (LxBxH) with bricks. However, size of the bed could be decreased or increased as per the quantity of material available. Moisten the surface of the bed by sprinkling the water. Now, at the base of the bed, spread 2-3 inch thick layer of dry leaves or paddy straw, etc. Again sprinkle some amount of water over layer of dry material. Spread about 1-1.5 feet thick layer of cow dung uniformly over leaves or straw layer and sprinkler water to make it sufficient moist. The cow dung should not too fresh. It should be at least 10-15 days old because fresh cow dung produce lot of heat and it can kill the earthworms. Similarly, cow dung should not be too old as it got decomposed and earthworms will not get any food from it. Now, add the green waste such as leaves, fruits rind and or grasses, roughages of animals, etc. by chopping them into small pieces. Again, spread about 1-1.5 feet layer of cow dung uniformly and sprinkler sufficient quantity of water. Spread about one kg vermiculture (contain about 800-1000 earthworms) over the layer of cow dung. Again spread 2-3 inch layer of green leaves, etc. uniformly over the layer of cow dung and sprinkle water. Now, cover the vermicompost bed with the help of jute/gunny bags. For maintaining optimum moisture and temperature conditions in the vermicompost bed, regularly sprinkler the water over the jute/gunny bags. There should be about 35-40% moisture and 15-30°C temperature in the bed. Hence, regularly sprinkle water to maintain optimum conditions for earthworm growth and functioning. By following above steps, vermicompost is ready in about 8–10 weeks' time. The vermicompost appear dark brown in color on maturity and is very porous, granulated and free of any foul smell.

Harvesting and Storage of Vermicompost

When vermicompost is ready, then stop watering about one week ago and make a stack of the compost. Now, earthworm will start moving downward and gathered at the bottom of the stack. Remove the upper portion of material from stack and put it in shadow for further processing i.e. sieving and packing. It should have minimum 40% moisture and sunlight should not fall directly on stacked vermicompost, which may otherwise cause loss of moisture and nutrients from the vermicompost. Now, sieve the vermicompost and transfer the earthworms, to next new bed. The lower portion of vermicompost stack contain lot of earthworms, it could be used a vermiculture for preparation of vermicompost again. Now, the vermicompost is ready for use in flower pots, field, vegetable and fruit crops, etc. Vermicompost can be stored for at least one year without any loss of its quality, if the optimum moisture level (40%) in the vermicompost is maintained.

Vermi-wash

Vermi-wash is a liquid collected from water passing through vermicompost. It is a mixture of earthworm excretions, mucus, and micronutrients from the soil. Vermi-wash is typically ready in about 40–50 days and appears as a clear, brown-colored liquid at the bottom of the container. When used as a foliar spray or soil drench, vermi-wash helps plants grow better and become more resistant to diseases. It is a clear, pale yellow fluid with reported growth-promoting effects and acts as a natural biopesticide. Vermi-wash contains enzymes, plant growth hormones, vitamins, and essential nutrients, all of which enhance crop growth and productivity while boosting their ability to fend off diseases (Boruah and Deka, 2023). By harnessing the natural processes of earthworms and soil bacteria, vermiwash proves to be a powerful and environmentally-friendly solution to support healthier plants and foster sustainable agriculture (Boruah and Deka, 2023, Mohite et al., 2024). Vermi-wash shows promise as a viable biological method for transforming food, medical, and paper waste into organic material rich in nutrients, thereby decreasing dependence on synthetic fertilizers. The integration of vermi-wash into agricultural practices showcases the broader potential of vermicomposting to augment crop performance and ecological sustainability.

Nutrient Composition of Vermicompost

Vermicompost contains nearly twofold higher percentages of both macro and micronutrients. The nutrients content in vermicompost generally depends on the waste material or base substrate that is being used for vermicompost preparation. Similarly, earthworm species used in vermicomposting may also influence the quality of vermicompost (Chowdeppa et al., 1999). Macro-nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) are present in higher concentrations, providing essential elements for plant growth and development. Also, the castings contain an increased amount of micronutrients such as iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), and boron (B), which are vital for various physiological processes in plants (Mohite et al., 2024). The presence of these abundant nutrients in worm castings contributes to the improved fertility and nutrient content of soils when vermicompost is applied as a soil amendment or fertilizer. A fine worm cast is rich in N P K besides other nutrients. Nutrients in vermicompost are in readily available form and are released within a month of application. Nutrient Analysis of Vermicompost is Nitrogen 2.0-2.5%; Phosphorus 1.3-1.8%; Potash 1.8-2.5%; Calcium 1.0-1.2%; Magnesium 0.3-0.5%; Sulphur 0.8-0.5%; Iron 0.8-1.5%; Copper 120-36 ppm; Zinc 100-1000 ppm; and Manganese 1000-2000 ppm (Rajkhowa, 2003). It is 5 times richer in N, 7 times in P, 11 times in K, 2 times in Mg, 2 times in Ca and 7 times in actinomyces than ordinary soil. Similarly, vermicompost prepared from different organic materials such as sugarcane trash, *Ipomea*, *Parthenium* and neem leaves is highly nutritive and increased rice productivity and improved soil fertility status (Vasanthi and Kumaraswamy, 1999). So, the nutritive value of vermicompost is highly dependent on base substrate used for its production.

Preventive Measures

The floor of the unit should be compact to prevent earthworms' migration into the soil. 15-20 day's old cow dung should be used to avoid excess heat. The organic wastes should be free from plastics, chemicals, pesticides and metals etc. Aeration should be maintained for proper growth and multiplication of earthworms. Optimum moisture level (30-40 %) should be maintained and 18-25°C temperature should be maintained for proper decomposition.

Application of Vermicompost in Soil

Vermicompost can be applied to any crop including field and horticultural crops. There are many reports in literature showing beneficial effects on plant and soil following vermicompost application. A simple method of applying vermicompost is adding it as a thin layer to soil around the plant and mixing with the soil. In general, vermicompost should be applied to soil during last ploughing. Amount of vermicompost application rates depend on its quality, nutritive value and crop to which it is to be applied. Apply 5–6 t ha^{-1} vermicompost in field crops, 10-12 t ha^{-1} for vegetables and 8-10 kg per fruit tree depending on age of tree, whereas in flower pot apply 100-150 g of vermicompost per pot. However, different researchers have got best results at different levels of vermicompost in their respective experimentations. Reddy et al., (1998) registered highest tomato yield with 10 t ha^{-1} vermicompost application. Similarly, Nagavallemma et al., (2004) documented highest tomato yield following vermicompost incorporation @ 5 t ha-1. In another experiment, vermicompost application 2.5 t ha^{-1} gave highest rice yield of upland rice (Angadi and Radder, 1996).

Benefits of Vermicomposting

Vermicompost provides multiple agronomic, environmental, and socio-economic benefits that make it ideal for sustainable farming practices (Singh et al., 2015). The key benefits of vermicompost are improved soil health and crop productivity: Vermicompost enhances physical, chemical, and biological properties of soil. It improves porosity, aeration, and drainage, while reducing compaction of soil (Lazcano et al., 2008; Bordoloi, 2021a).

Earthworms can feed on different organic wastes such as crop residues, agro-industrial wastes and animal manure (Yadav and Garg, 2011). Vermicomposting converts these wastes into nutrient rich compost, thereby reducing waste accumulation (Bordoloi, 2021a). It requires simple farm-scale or micro-units with low capital costs compared to composting. It promotes circular economy by transforming wastes into resources. Vermicompost enhances soil carbon sequestration and mitigates climate change impacts (Bhattacharya et al., 2016). Small farmers can adopt vermicomposting with minimal training using local resources. It provides income and employment opportunities across the supply chain from production to marketing. The multifaceted advantages make vermicompost an integral component of climate-smart sustainable agriculture. Widespread adoption of vermicomposting can support green growth and rural livelihoods.

Entrepreneurship Opportunities in Vermicomposting
The rising demand for organic produce coupled with increased environmental awareness is expanding the market for vermicompost. This presents Entrepreneurship opportunities for educated yet unemployed youth from rural areas. Some key prospects for youth empowerment through vermicompost enterprises are: Youth can undertake vermicompost production as individual microenterprises with low startup costs. Available land, animal dung, and biomass are the primary resource requirements (Garg and Gupta, 2011). Small farmers can augment farm incomes by utilizing spare labor for vermicomposting using farm waste (Karmegam and Daniel, 2009). Women farmers can also manage vermicompost units along with household responsibilities. Startup and working capital needs of youth ventures can be supported through low interest credit provided by regional rural banks and national schemes for green entrepreneurship.

CONCLUSIONS

Vermicomposting provides a sustainable means for converting organic wastes into a valuable agricultural input that enhances soil health, crop yields, and food quality. The process generates environment-friendly organic fertilizer while mobilizing unutilized organic materials. The use of organic manures enhances soil water retention, prevents soil erosion, and avoids the pollution associated with synthetic fertilizers and agrochemicals, leading to cleaner soil, water, and air. Moreover, the application of organic manures enhance the crop quality and yield but also preserves soil fertility and productivity over time. Additionally, the increasing consumer demand and higher market prices for organic produce contribute to the financial prosperity of farmers. Vermicompost production through small decentralized units also offers avenues for ecoenterprise development requiring low investments. These attributes make vermicomposting well-suited for promoting green entrepreneurship opportunities for unemployed youth in India.

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