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Vermicompost: Significance and Benefits for Agriculture

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ABSTRACT

Vermicomposting is defined as the process of biodegradation and stabilization of organic materials, facilitated by the collaborative efforts of earthworms and mesophilic microorganisms. The activity of earthworms in vermicomposting results in the production of nutrient-rich vermicompost. This organic amendment is abundant in macro and micronutrients, vitamins, growth hormones, as well as enzymes like proteases, amylases, lipase, cellulase, and chitinase. Additionally, vermicompost harbors a diverse community of immobilized microflora. Even after being excreted by the worms, the enzymes in vermicompost persist in their ability to decompose organic matter, facilitating continued breakdown and nutrient release. The utilization of vermicompost in agricultural production brings forth a multitude of beneficial effects. These include decreased water requirements for irrigation, reduced susceptibility to pest and termite attacks, suppression of weed growth, and enhanced seed germination rates, accelerated growth and development of seedlings, as well as increased yield of fruits per plant in vegetable crops and a higher number of seeds per year in cereal crops. These advantages highlight the positive impact of incorporating vermicompost into agricultural practices, fostering sustainable and productive farming systems. The combination of earthworms and vermicompost presents a valuable opportunity to enhance horticultural production in a sustainable manner, reducing reliance on agrochemical inputs. Despite the numerous benefits associated with vermicompost, its widespread implementation and adoption are still relatively limited. This review aims to raise awareness and promote the understanding of this valuable local soil amendment.

Keywords: Vermicomposting, Nutrient-rich vermicompost, Sustainable agriculture, Enhanced plant growth, Promoting adoption.

I. INTRODUCTION

In recent years, the growing concern over the environmental and economic issues related to the disposal of organic wastes from domestic, agricultural, and industrial sources has led to the development of various technologies to address this problem. One prominent trend involves the utilization of novel technologies, particularly those based on biological processes, to recycle and effectively utilize organic residues. These approaches offer the potential to conserve available resources, recover natural products, and address waste disposal and pollution issues.

Among these innovative biotechnologies, vermicomposting has emerged as a promising method for converting agro-industrial wastes into value-added products. Vermicomposting involves the use of earthworms to decompose organic materials, such as food scraps, agricultural residues, and manure, into nutrient-rich vermicompost. This process not only facilitates waste management but also produces a valuable soil amendment that can enhance soil structure, fertility, and overall soil health. (Garg, V. K, and Gupta, R. 2009)

Vermicomposting is a decomposition process that relies on the collaborative efforts of earthworms and microorganisms. While microorganisms play a vital role in the biochemical breakdown of organic matter, earthworms are key drivers of the process. They contribute by fragmenting and conditioning the substrate, which leads to significant changes in its biological activity. (Dominguez, J. and Edwars, C.A. 2004).

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Vermiculture refers to the cultivation and growth of earthworms in organic wastes, while vermicomposting is the process of utilizing earthworms to process organic wastes. According to Edwards *et al.* (2004), vermicompost produced by earthworm activity is rich in macro and micronutrients, vitamins, growth hormones, enzymes (such as proteases, amylases, lipase, cellulose chitinase), and immobilized microflora. Remarkably, these enzymes continue to break down organic matter even after being excreted by the worms (Barik *et al.*, 2011).

Vermicomposting is a self-sustaining, self-regulating, and self-improving technology that requires minimal or no energy input, making it an environmentally friendly waste management option. It is relatively simple to set up, operate, and maintain vermicomposting systems. When compared to other biological or mechanical technologies for producing "bio-fertilizers," vermicomposting technology stands out as superior (Mistry, 2015).

The usage of vermicompost in agricultural production brings about numerous benefits, including reduced water requirements for irrigation, decreased pest and termite attacks, and suppressed weed growth. Furthermore, vermicompost promotes faster seed germination, rapid seedling growth and development, and increased fruit yield per plant in vegetable crops and seed production per year in cereal crops (Sinha, R. K. *et al.*, 2009).

II. HISTORY

Earthworms have long been recognized and valued for their contributions to soil health and fertility by various civilizations throughout history. Ancient civilizations like Greece and Egypt held a deep respect for the role of earthworms in maintaining fertile soils. In fact, the ancient Egyptians, including the Pharaoh Cleopatra (69–30 B.C.), were among the first to acknowledge the beneficial impact of earthworms on the fertility of the Nile Valley crop lands following annual floods.

The Ancient Greeks also attributed great importance to earthworms in improving soil quality. The renowned Greek philosopher Aristotle (384–322 B.C.) referred to earthworms as the "intestines of the earth," emphasizing their crucial role in soil health and ecosystem functioning (Medany, 2011).

Additionally, ancient Indian scientist Sir Surpala (10th century A.D.) recommended the addition of earthworms to the soil to enhance the quality and productivity of pomegranate fruits. Furthermore, Russian scientist Dr. Anatoly Igonin highlighted the unparalleled significance of earthworms and their positive impact on the entire biosphere. He emphasized that earthworms not only create soil but also improve its fertility, providing essential functions such as disinfection, neutralization, protection, and productivity (Sinha *et al.*, 2014).

Table 1: Chemical composition of vermicompost (Garg, V.K and Gupta, R. 2009)

Characteristics	**Value**
Organic carbon, %	**9.15 to 17.88**
Total Nitrogen, %	**0.5 to 0.9**
Phosphorus, %	**0.1 to 0.26**
Potassium %	**0.15 to 0.256**
Sodium %	**0.055 to 0.3**
Calcium & magnesium (Meq /100 g)	**22.67 to 47.6**
Copper; mg per kg	**2.0 to 9.5**
Iron, mg per kg	**2.0 to 9.3**
Zinc, mg per kg	**5.7 to 9.3**
Sulphur, mg per kg	**128.0to 548.0**

The beneficial impacts of vermicompost on soil: Vermicompost has following positive effect on soil which are summarized by Sinha *et al.* (2014).

1. Increase in Soil Organic Matter (SOM): Vermicompost enhances the content of organic matter in the soil, contributing to improved soil structure and preventing soil erosion.
2. Enhancement of Beneficial Microbes and Nutrients: Vermicompost promotes the growth and activity of beneficial soil microbes, leading to increased microbial activity and nutrient availability.
3. Improvement in Cation Exchange Capacity: Vermicompost improves the cation exchange capacity of the soil, facilitating the retention and exchange of essential nutrients.
4. Reduction of Bulk Density and Soil Compaction: Vermicompost helps reduce the bulk density of soil, preventing compaction and erosion, thus improving soil porosity and aeration.
5. Suppression of Soil-Borne Diseases: The application of vermicompost has been associated with the suppression of soil-borne plant diseases, contributing to healthier crops.
6. Increase in Water-Holding Capacity: Vermicompost enhances the water-holding capacity of the soil, reducing water stress for plants and improving drought resistance.
7. Soil Salinity and Sodicity Management: Vermicompost has the ability to alleviate soil salinity and sodicity issues, creating a more favorable environment for plant growth.
8. Maintenance of Optimal Soil pH: Vermicompost helps in maintaining the optimal pH value of the soil, creating a suitable environment for plant nutrient uptake.

Vermicompost is considered an ideal organic manure for promoting growth and yield in various plants, as highlighted by Joshi, *et al.* (2015).

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1. Higher Nutritional Value: Vermicompost exhibits higher nutritional value compared to traditional composts, primarily due to increased mineralization and humification facilitated by earthworm activity.
2. Improved Soil Characteristics: Vermicompost enhances soil porosity, aeration, drainage, and water-holding capacity, creating favorable conditions for plant growth.
3. Presence of Beneficial Microbiota: Vermicompost contains a diverse range of beneficial microbiota, including fungi, bacteria, and actinomycetes, which contribute to plant growth. It provides plant-available forms of nutrients such as nitrates, phosphates, exchangeable calcium, and soluble potassium.
4. Plant Growth Regulators: Vermicompost contains plant growth regulators and other growth-influencing substances produced by microorganisms, further promoting plant growth and development.
5. Production of Cytokinins and Auxins: Organic waste processed by earthworms has been found to produce cytokinins and auxins, hormones that positively influence plant growth.
6. Release of Metabolites: Earthworms release various metabolites, including vitamins B and D, into the soil, contributing to plant health and growth.

The nutrient-rich vermicast and vermiwash act as organic fertilizers, enriching the soil with humus, NPK, micronutrients, and beneficial soil microbes, including nitrogen-fixing and phosphate-solubilizing bacteria, actinomycetes, and growth hormones. Furthermore, vermicompost, along with its liquid extract known as vermiwash, serves as both a growth promoter and protector for crop plants, as emphasized by Sujit Adhikary, S. A. (2012).

Moreover, vermicompost contains essential plant nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), and boron (B). The significant presence of humic acids in vermicompost contributes to plant health by promoting the synthesis of phenolic compounds, such as anthocyanins and flavonoids, which enhance plant quality and act as natural deterrents against pests and diseases (Theunissen, *et al*., 2010)

The utilization of earthworms and vermicompost in agricultural practices offers numerous benefits, as highlighted by Sinha, *et al*. (2013). These include the production of chemical-free, nutrient-rich, and health-protective (rich in minerals and antioxidants) foods, the sustainable management of human waste, and the reduction of agrochemical usage. Additionally, the use of vermicompost helps sequester significant amounts of atmospheric carbon, contributing to improved soil fertility, erosion prevention, greenhouse gas reduction, and mitigation of global warming.

III. EFFECT OF VERMICOMPOST ON AGRICULTURAL CROP PERFORMANCE

Yield: Vermicompost is known to significantly enhance the growth and yield of various field crops, vegetables, flower crops, and fruit crops, as highlighted by Karmegam, *et al.* in their 1999 study. According to Seetha Lakshmi's research in (2011), the utilization of vermicompost has been attributed to the notable improvement in crop yield, which can be primarily attributed to its ability to enhance nutrient uptake. Additionally, the application of vermicompost has shown substantial positive effects on the growth and yield of mung beans.

Similarly, in a separate pot experiment conducted by Karmegam and Daniel in (2000), the utilization of vermicompost as a soil amendment resulted in significantly higher fresh and dry matter yields of cowpea (Vigna unguiculata) compared to the application of biodigested slurry. In a study conducted by Reddy *et al*. in 1998, the application of vermicompost at a rate of 5 tons per hectare demonstrated a significant increase in tomato (Lycopersicon esculentum) yield. The research was conducted in the farmers' fields located in Adarsha watershed, Kothapally, Andhra Pradesh. The yield of tomato in the vermicompost-treated plots reached 5.8 tons per hectare, surpassing the control group's yield of 3.5 tons per hectare. Research focusing on the cultivation of key vegetable crops such as tomato (Lycopersicon esculentum) and eggplant (Solanum melongena) has consistently demonstrated highly favorable outcomes, as indicated by Sujit Adhikary, S. A. in 2012. Likewise, Adhikary's study in 2012 highlighted the substantial benefits of vermicompost application on potato cultivation.

The utilization of vermicompost at a rate of approximately 6 tons per hectare resulted in significantly increased productivity of potato crops in comparison to the control group. According to Adhikary's findings in 2012, the utilization of vermicast, a byproduct of vermicompost, yielded superior results in the cultivation of garden peas. In comparison to chemical fertilizer, vermicast application resulted in notable advancements such as increased growth of garden pea green pod plants, higher weight of green grains per plant, and a greater overall yield of green pods. Upon examining the data, it was evident that the application of "Parthenium Vermicompost" at a rate of 5 tons per hectare exhibited a positive impact on the yield of eggplants (Solanum melongena), as noted in Seetha lakshmi's study in (2011).
Growth: In Adhikary's study conducted in (2012), the presence of worms and the application of vermicompost were found to have a profound positive impact on the growth of vegetable crops. The inclusion of worms and vermicompost in the cultivation process resulted in

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remarkable growth, characterized by increased flower production and enhanced fruit development. According to Mistry's research in (2015), the utilization of vermicompost can yield remarkable outcomes in various stages of crop development. It has been observed to have significant and transformative effects on germination, growth, flowering, fruiting, and overall yield of crops. In a study conducted by Karmegam and Daniel in (2000), it was observed that the application of vermicompost resulted in a significantly higher germination rate of mung bean (Vigna radiata) compared to the control group.

The germination rate of mung bean seeds treated with vermicompost reached 93%, surpassing the control group's germination rate of 84%. In a study conducted by Nethra *et al*. in (1999), it was observed that the application of varying levels of vermicompost resulted in an increase in the fresh weight of flowers, specifically Chrysanthemum chinensis. Furthermore, the optimal combination for achieving maximum results included the application of 10 tons per hectare of vermicompost alongside 50% of the recommended dose of NPK fertilizer. Joshi *et al*. conducted a study in (2015), which demonstrated that the application of vermicompost had a positive influence on multiple aspects of plant growth and yield. The utilization of vermicompost resulted in increased seed germination, taller stem height, higher leaf count, greater leaf area, enhanced leaf dry weight, longer root length, greater root density, improved overall yield, and a higher number of fruits per plant.

Nutrient content: Vermicompost is rich in plant-available nutrients, including nitrates (N), phosphates (P), soluble potassium (K), and magnesium (Mg). Additionally, it contains exchangeable phosphorus (P) and calcium (Ca) in significant quantities (Edwards and Burrow. 1988. Edwards, *et al*. 2004). (Vermicomposts possess extensive particulate surface areas, creating numerous micro-sites that support microbial activities and facilitate the effective retention of nutrients (Arancon, *et al*.2004 and Arancon, *et al*. 2006).

Numerous studies have consistently highlighted the positive influence of earthworms and vermicompost on plant growth and crop production. Notably, Bhawalker. (1995) demonstrated that the application of vermicompost consistently led to notable improvements in seed germination, enhanced growth and development of seedlings, and increased overall plant productivity. According to Adhikary's study in (2012), the utilization of vermicast, derived from vermicompost, resulted in a higher percentage of protein content and carbohydrates in garden pea compared to the use of chemical fertilizer. In a study conducted by Joshi *et al*. in (2015), it was observed that the application of vermicompost resulted in significant improvements in various parameters related to plant and fruit quality. These enhancements included increased chlorophyll content, pH of juice, total soluble solids of juice, as well as higher levels of micro and macronutrients, carbohydrates, and protein content. Furthermore, the quality of both fruits and seeds was notably improved with the use of vermicompost. These findings suggest that treatments involving humic acids, plant growth promoting bacteria, and vermicomposts can be valuable strategies for promoting sustainable agriculture practices and reducing reliance on chemical fertilizers.

Plant protection: In recent years, extensive evidence has emerged regarding the remarkable potential of vermicompost in providing plant protection against a range of pests and diseases. This protection can be achieved through various mechanisms such as pest suppression, repelling pests, inducing biological resistance in plants, or exerting pesticidal action to eliminate them (Anonymous. (2001) and Sinha, *et al*. (2009).

Extensive research has revealed that vermicompost contains antibiotics and actinomycetes, which play a vital role in enhancing the innate biological resistance of crop plants against pests and diseases. These components effectively strengthen the plant's ability to withstand and combat various harmful agents. Additionally, the integration of earthworms and vermicompost in agricultural practices has been found to significantly reduce the need for pesticide spray. This reduction in pesticide usage highlights the potential of earthworms and vermicompost as sustainable alternatives that promote environmentally friendly pest management strategies. By harnessing the benefits of vermicompost and earthworms, farmers can foster a more resilient agricultural ecosystem while minimizing the reliance on synthetic pesticides. (Singh. 1993 and Suhane. 2007). One of the most notable findings from Adhikary's study in (2012) was the significant reduction in the incidence of diseases observed in plants treated with worm and vermicompost application. According to Sinha et al.'s research in (2013), vermicompost demonstrates its ability to safeguard plants against a wide range of pests and diseases through several mechanisms. These mechanisms include the suppression or repelling of pests as well as the induction of biological resistance in plants.

Human health: Research conducted by Sinha in (2012) reveals that fruits and vegetables grown organically, particularly using earthworms and vermicompost, exhibit higher nutritional value and are rich in proteins, minerals, vitamins, and antioxidants compared to their chemically grown counterparts. These nutritious organic produce have been found to be highly beneficial for human health, with approximately 85% of the cases studied showing elevated levels of antioxidants. Consumption of these organically grown foods has been associated with protective effects against various forms of cancers and cardiovascular diseases. These findings underscore the potential health benefits of incorporating earthworms and vermicompost in organic farming practices, promoting the production of nutrient-dense and health-promoting food options for individuals.

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IV. CONCLUSION

The activity of earthworms in vermicomposting results in the production of vermicompost that is abundant in macro and micronutrients, vitamins, growth hormones, as well as enzymes like proteases, amylases, lipase, cellulase, chitinase, and a diverse community of immobilized microflora. Vermicompost serves as an optimal organic manure, contributing to enhanced growth and improved yield of numerous plants. By increasing crop production and providing protection against harmful pests, vermicompost offers a sustainable solution that mitigates environmental pollution. The application of vermicompost has demonstrated significant benefits, including enhanced growth, improved nutrient content in plants, and enhanced quality of fruits and seeds.

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