Vermicompost – The Organic Gold for Agriculture

***Satpal[1], Kanika Pareek[2], Neelam[3] and Pratibha Bharti[4]**
[1]Department of Genetics & Plant Breeding (Forage Section), [2]College of Agriculture,
[3]Department of Agronomy, [4]Department of Mathematics & Statistics
CCS Haryana Agricultural University, Hisar – 125004 (Haryana) India
*Corresponding Author: satpal_fpj@hau.ac.in

Post Covid-19 pandemic, the masses become more conscious, regarding the quality of the produce, even they enquire about the inputs used in the produce. The organic farming and natural farming are gaining momentum due to the residue free and quality produce. However, the organic farming is more common and largely based on the nutrient inputs like FYM, vermicompost and bio-fertilizer as they are the most easily available inputs but bulky in nature and their quality need to be governed.

Earthworms have been on the earth for over 20 million years. Afterwards with the use of worms, vermicompost has been the most nutrient rich and oldest compost. Even the ancient civilizations, including Greece and Egypt valued the role of earthworms in agriculture. The Egyptian Pharaoh, Cleopatra recognized the important role of worms in fertilizing the Nile Valley croplands after annual floods. 2400 years back, Aristotle called worms the "intestines of the earth" and Charles Darwin was also intrigued by the worms and studied them for 39 years. Charles Darwin wrote a book on worms and their activities, in which he stated that there may not be any other creature that has played so important a role in the history of life on earth (Bogdanov, 1996) and called them as 'unheralded soldiers of mankind' and 'friends of farmers'. The earthworm is a natural resource of fertility and life. A Biology teacher and Environmentalist, Marry Appelhof first introduced the vermiculture in 1970s. She developed the idea of using red wiggler worms (*Eisenia foetida*) for composting in in-door and out-door system to convert the kitchen waste to worm compost. Her book *'Worms Eat My Garbage'* (publication year 1982) is still held as seminal reading in the field of vermicomposting.

The worm castings contain higher percentage of nutrients than the garden compost. Apart from other nutrients, a fine worm cast is rich in NPK which are in readily available form and are released within a month of application. Vermicompost enhances plant growth, suppresses disease in plants, increases porosity and microbial activity in soil, and improves aeration and water retention. Vermicompost also benefits the environment by reducing the need for chemical fertilizers. Vermicompost production is trending up worldwide and it is finding increasing use especially in Western countries, Asia-Pacific and Southeast Asia. A relatively new product from vermicomposting is vermicompost tea which is a nutrient-rich liquid created by steeping finished vermicompost in water. It is sometimes sprayed directly on foliage to reduce pests and disease or used as a soil drench around plants to enrich soil in the root zone to increase the biological activity.

Feedstock for earthworm and their activity

A wide range of organic residues, such as leaves, straw, stalks, husk and weeds etc can be converted into vermicompost. However, the potential feedstock for vermicompost production are livestock wastes, poultry litter, dairy wastes, food processing wastes, organic fraction of municipal solid waste, bagasse, digestate from biogas plants etc. Earthworms consume organic wastes and reduce the volume by 1/3 to 2/3. Each earthworm weighs about 0.5 to 0.6 gram, eats waste equivalent to its body weight and produces cast equivalent to about 50 % of the waste it consumes in a day. The moisture content of castings ranges between 1/3 to 2/3 and the pH is around 7.0. The level of nutrients in compost depends upon the source of the raw material and the species of earthworm. There are nearly 3600 types of earthworms which are divided into burrowing and non-burrowing types. Red earthworm species, like *Eisenia foetida,* and are most efficient in compost making. The non-burrowing earthworms eat 10 percent soil and 90 percent organic waste; these convert the organic waste into vermicompost faster than the burrowing earthworms. They can tolerate temperatures ranging from 0 to 40°C but the multiplication is more at 25 to 30°C and 40–45 % moisture level in the pile. The burrowing types of earthworms come on to the soil surface only at night. These make holes in the soil up to a depth of 3.5 m and produce 5.6 kg casts by ingesting 90 % soil and 10 % organic waste.

Method of preparation

There are two major methods of vermicomposting *i.e.* bin and pile. The bin method is prepared to use in small scale such as home composting, in kitchen or garage and so on. The bin can be made of various materials, but wood and plastic ones are popular. Plastic bins, because of lightness, are more preferred in-home composting. A vermicompost bin may be in different sizes and shapes, but its height most be more than 30 cm. Bins with a height of 30-50 cm, and not so more than it, are prefect. Draining some holes in bottom, sides and cap of bin is so helpful to aeration and drainage. Around 10 holes with 1-1.5 cm in diameter is a good choice. Before feeding the worms by wastes, it's needed to apply a worm's bed. A height of 20-25 cm bedding is appropriate. It may be a mixture of shredded paper, mature compost, old cow or horse manure with some soil.

Table 1. Comparative parameters of vermicompost

Sl. No.	Item	Vermicompost	FYM	Enriched manure	Biochar#
1	Nutrient composition	N 2 - 3%, P 1.55 to 2.55% and K 1.85 to 2.25%	N 0.5%, P_2O_5 0.25% and K_2O 0.5%	N 3.0%, P_2O_5 1.0% and K_2O 2.0%	N 3.2%, P_2O_5 2.68% and K_2O 1 to 10%; Ash content 0.35 to 59.05%
2	Enzymatic activity	Cellulase, protease, lipase, amylase, polyphenol oxidase and phosphatase	Cellulase, protease, lipase, amylase, urease and phosphatase	Cellulase, protease, lipase, amylase, phosphatase, nitrification & denitrification enzyme activity and Mycorrhizal fungi and special bacterial stains	Enzyme stabilization, microbial habitat, pH modulation, sorption and retention, reduction of toxic compounds and enhanced nutrient cycling
3	Decomposition period	1 to 6 month	3 to 6 month	4 to 8 month	3 to 8 year
4	CN ratio	15:1 to 30:1	40:1	20:1 to 30:1	6.5-640:1
5	Optimization of C:N	It starts at a C:N of 25-30:1 and decreases during the process.	Feedstock, regular aeration, moisture management (50-60%) improve microbial activity.	Addition of nitrogen rich animal manure, urine and slaughter house waste help in reducing C:N.	Controlled Pyrolysis temperature and less residence time can avoid nitrogen loss and thus reduce the CN ratio.
6	Time of application in crop	After tillage and before planting	15-20 days before sowing/planting	7-14 days before sowing/planting	After harvest and with a cover crop
7	Preparation period	90-120 days	120-150 days	90-100 days	Batch pyrolysis: 12 h - 5 day. Continuous pyrolysis: 5 day to 3 week. Post treatment and conditioning: 3 day to 2 week
8	Bulky or not	Yes	Yes	Yes	Yes

#The nutrient content of biochar varies with feedstock and production condition.

Pile method is mostly used for vermicomposting at larger scale. Where the vermicompost is the chosen way to processing a large amount of wastes, application of piles is cost beneficial. The piles can be made in porch place like greenhouse or in a floor with some facilities for drainage in warm climates. Although the pile size may be so various in width and length, however, it can't be so high and is better to follow the height of bin method.

Steps to prepare vermicompost

1. **Bin selection:** Selections of suitable container with adequate drainage and aerations is highly desirable. However, it may be a plastic bag, wooden box, lid or concrete structure. For commercial production, the

beds can be prepared with 15 m length, 1.5 m width and 0.6 m height spread equally below and above the ground. While the length of the beds can be made as per convenience, the width and height cannot be increased as an increased width affects the ease of operation and an increased height on conversion rate due to heat built up.

2. **Bedding prearation:** Bedding can be made from shredded newspaper, aged horse manure, aged cow manure, cardboard, or coconut coir, saw dust, wood shavings, etc.
3. **Setup** (line the bottom of the container with a layer of bedding material about 2-3 inches)
4. **Incorporation of worms:** Out of the total 350 species, *Eisenia fetida, Eudrilus eugeniae* and *Perionyx excavatus* are some of the important earthworm species with burrowing habit that are used in India for vermicomposting that are reared to convert organic wastes into manure. Worms @ 1 kg per m^3 of bed volume should be adequate to start with and to build up the required population in about two or three cycles without unduly affecting the estimated production.
5. **Addition of organic waste:** The process of composting crop residues / agri wastes using earthworms comprise spreading the agricultural wastes and cow dung in gradually built up shallow layers. The pits are kept shallow to avoid heat built-up that could kill earthworms. To enable earthworms to transform the material relatively faster a temperature of around 30° C is maintained.
6. **Cover the bedding:** Explore the use of biodegradable plastic film made from corn starch or other renewable material. These films provide a water proof and breathable covering for earthworms while being environment friendly.
7. **Maintain moisture and aeration:** Check the moisture level regularly by squeezing a handful of bedding material, it should feel damp like squeezed sponge.
8. **Monitoring of temperature:** Keep your composting spot in a shady area where there is optimum temperature of 15-25° C.
9. **Removal of vermicompost:** After two to three months, the vermicomposting is ready for harvesting. To harvest, move the top layer of bedding and organic matter to one side of the container. The worms will migrate to other side away from light, collect the vermicompost from the side without worms.
10. **Storage and use:** Store the harvested vermicompost in a cool, dry place in an air tight container. Use it to enrich the soil in garden, potted plant or as a nutrient rich amendment.

How to measure the productivity of vermicompost?

$$PV\ (\%) = \frac{Harvested\ vermicompost\ (kg)}{Total\ mass\ of\ feed\ (kg)} x\ 100$$

Where, PV = Productivity of vermicompost

Vermicomposting Dynamics

The incorporation of vermicompost and biochar into soil has been proven to enhance soil health, nutrient cycling, and plant growth while mitigating the movement of potentially harmful elements. The positive effects of vermicompost on various crops, resulting in increased yield, improved soil structure, and enhanced plant health (Gutiérrez-Miceli *et al.*, 2007). The vermicompost can positively impact the productivity and quality of crops, making it a potential natural fertilizer for agricultural production. The vermicompost application increased the population of bacteria (5.7x10^7), fungi (22.7x10^4) and actinomycetes (17.7x10^6) as compared to conventional composts. The outstanding physico-chemical and biological properties of vermicomposts makes them organic amendment and excellent material as additives to greenhouse container media, organic fertilizers for various field and horticultural crops (Gopinath *et al.*, 2010).

Comparative Analysis and Challenges

Comparative analysis reveals that introducing *Eisenia andrei* earthworms leads to a significant decrease in CO_2 evolution, emphasizing their role in stabilizing organic matter. Earthworms initially affect microbial biomass but later demonstrate an increase in nitrogen mineralization, showcasing the complexity of their impact on microbial dynamics. Challenges in vermicomposting include managing earthworm populations and potential compost contamination with heavy metals. Despite positive effects, challenges like optimal application rates and crop-specific responses necessitate further exploration for holistic agricultural strategies. The positive outcomes of vermicompost are reported but there is need for more exploration about optimal application rates, long-term effects, and potential environmental impacts of various organic amendments (Gajalakshmi and Abbasi, 2008).

Future Prospects

Future prospects involve refining vermicomposting techniques and understanding their long-term impacts on soil fertility and plant health (Buckerfield *et al.*, 1999). The combination of vermicompost and biochar emerges as a potential strategy to improve soil fertility, plant productivity, and reduce negative impacts on water quality, paving the way for sustainable agricultural practices (Doan *et al.*, 2015). Despite challenges and variations in outcomes, the potential of vermicompost in mitigating salinity stress and enhancing plant growth opens avenues for future research. Understanding the intricate interactions between vermicompost applications, salinity stress, and plant responses can guide sustainable agricultural practices. In the era of scientific advancements and intensive farming, judicious use of biofertilizers emerges as a promising approach for higher yields, economic returns, and environmental conservation. The study sets the stage for future research on optimizing biofertilizer combinations for various crops, ensuring sustainable agricultural practices.

Vermiwash

Vermiwash is a brown colored liquid fertilizer, which is collected after the water passes by a worm culture column. As a storehouse of nutrients and microorganisms, it is mainly used as a foliar spray for crops. It contains high concentrations of micro and macronutrients, plant hormones and high amount of enzymes, amino acids also to ensure the healthy development of crops. It is rich in vitamins and hormones like cytokinins, auxins, and gibberellins, etc. along with nitrogen fixers, phosphate solubilizers.

Future prospects

The anticipated increase in the use of vermicompost tea as a natural fertilizer in the future is acknowledged for their positive impact on soil and plant health. However, further research is needed to optimize production methods, application rates, and address potential hazards associated with their use. Future prospects include refining vermicomposting techniques and understanding their long-term impacts on soil fertility and plant health (Buckerfield *et al.*, 1999). The combination of vermicompost and biochar emerges as a potential strategy to improve soil fertility, plant productivity, and reduce negative impacts on water quality, offering avenues for sustainable agricultural practices (Doan *et al.*, 2015). Future research should explore and refine these synergies for broader application (Doan *et al.*, 2015). Despite challenges and variations in outcomes, the potential of vermicompost in mitigating salinity stress and enhancing plant growth opens avenues for future research.

Conclusion

Application of vermicompost in agriculture gives promising results for improving soil fertility, plant growth, and environmental sustainability. But, further research is needed to optimize crop wise application rates, understand long-term effects, and address challenges associated with its use. Overall, vermicomposting holds potential for revolutionizing agricultural practices and promoting environmentally friendly farming systems. Vermicompost is not only rich in primary nutrients but also supplements the substantial quantity of secondary and micro nutrients (Ca, Mg, Na, Zn, Cu, Fe, Mn and B). Vermicompost may be sold in bulk or bagged with a variety of compost and soil blends. Markets include organic farms, home improvement centers, nurseries, landscape contractors, greenhouses, garden supply stores, grocery chains, flower shops and the general public.

References

Bogdanov, P. (1996). Commercial Vermiculture: How to Build a Thriving Business in Redworms. VermiCo Press, Oregon. pp 83.

Buckerfield, J.C., Flavel, T.C., Lee, K.E. and Webster, K.A. (1999). Vermicompost in solid and liquid forms as a plant growth promoter. *Pedobiologia*, 43(6), 753759.

Doan, T.T., Henry-des-Tureaux, T., Rumpel, C., Janeau, J. and Jouquet, P. (2015). Impact of compost, vermicompost and biochar on soil fertility, maize yield and soil erosion in Northern Vietnam: A three year mesocosm experiment. *Science of the Total Environment*, 514: 147–154.

Gajalakshmi S. and Abbasi, S.A. (2008). Solid Waste Management by Composting: State of the Art. *Critical Reviews in Environmental Science and Technology*. 38(5): 311-400.

Gopinath, K.A., Bandi, V., Mina, B. L., Nataraju, K.C. and Devi, K. G. (2010). Utilization of vermicompost as a soil amendment in organic crop production. *Dynamic soil Dynamic plant*, 4(Special issue I): 48-57.

Gutiérrez-Miceli, F.A., Santiago-Borraz, J., Montes Molina, J.A., Nafate, C.C., Abud-Archila, M., Oliva Llaven, M.A., Rincón-Rosales, R., Dendooven, L. (2007). Vermicompost as a soil supplement to improve growth, yield and fruit quality of tomato (*Lycopersicum esculentum*). *Bioresour. Technol*., 98 (15): 2781-6.

* * * * * * * *