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Vermicomposting: A Practice Towards Sustainable Farming

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Abstract

Vermicompost is an important organic nutrient source for the plants as well as for soil conditioning. Vermicompost is a organic nutrient product forms due to the activity of Earthworm on feeding the kitchen, farm and Livestock residue. 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 and Farm Yard Manure, not only it supplies major nutrients but it also carries macro and micro nutrients, beneficial micro-organisms and growth regulators. Therefore, keeping in view, reviewing the good package of practice on vermicompost production technology over the years..

Introduction

Vermicomposting is an inventive eco-technological practice for altering different types of wastes into vermicompost. Vermicompost is a finely globulated and alleviated humus material often utilized as a soil conditioner and reunite the organic matter to the agricultural soils.

Out of various kinds of wastes the industrial wastes releases foul odour are remain largely unutilized and cause various environmental hazards like water pollution including both ground and surface water and also spreading vast land areas etc. Organic industrial wastes with low toxic value could be effective raw material for vermicomposting. Purpose of recycling of industrial wastes and sludge has been carried out by applying vermicomposting methods since last two decades to convert them into land-fill practices. The successful operation of vermicomposting depends upon different parameters like pH, salinity, temperature, moisture, aeration and quality of raw material etc. Types of vermicomposting system and earthworm species are other important parameters. To augment the recycling of waste into enriched product by using certain species of earthworms is vermicomposting, a simple biotechnological process of composting. Vermicomposting distinguishes from composting in several aspects (Gandhi et al. 1997). It is a mesophilic process that actively involved with earthworms as well as microorganisms that are sustain at 10–32^{0}C (not ambient temperature but temperature within the pile of moist organic material). As comparable this process is a faster than composting due to the assimilation of material through earthworm gut. A significant transformation during vermicomposting takes place by earthworm resulting with humus earthworm castings (worm manure) are rich in microbial activity, plant growth regulators and stimulated with pest repellence attributes as well. In short, earthworms are type of biological transformers are capable of converting garbage into 'Blackgold' (Vermi Co 2001, Tara Crescent 2003).

Importance of vermicompost

Earthworms are merely capable of consuming several organic wastes and lessen the volume by 40–60%. The weight of each earthworm nearly about 0.5 to 0.6 g, feeds on waste same as to its body weight and releases cast/vermicasts equivalent to about 50% of the waste it consumes in a day. These vermicasts have chemical and biological properties for enhancing soil fertility. The pH of cast maintains around 7.0 whereas the moisture content ranges between 32 and 66% provides humus soil. The vermicasts contain higher percentage (nearly twofold) of both macro and micronutrients than the normal compost.

Table 1. Nutrient composition of vermicompost and garden compost

Nutrient Element	Vermicompost (%)	Garden compost (%)
Organic Carbon	9.8–13.4	12.2
Nitrogen	0.51–1.61	0.8
Phosphorous	19–1.02	0.35
Potassium	0.15–0.73	0.48
Calcium	1.18–7.61	2.27
Magnesium	0.093–0.568	0.57
Sodium	0.058–0.158	<0.01
Zinc	0.0042–0.110	0.0012
Copper	0.0026–0.0048	0.0017
Iron	0.2050–1.3313	1.1690
Manganese	0.0105–0.2038	0.0414

Source: Sujit Adhikary, 2012.Indian Statistical Institute, Kolkata

The air-water relationship improves after application of vermicompost in the soil due to increase in macropore space ranging from 50 to 500 µm, which suitably affect plant growth (Marinari et al. 2000). The soil pH, microbial population and soil enzyme activities are favorably affected by application vermicompost including organic matter (Maheswarappa et al. 1999). It also diminishes the proportion of contamination (Mitchell and Edwards 1997). Earthworms maintain the aerobic conditions under favorable ranges of temperature and moisture during vermicomposting process. It ingest organic waste materials and egest a humus-like substance which is more homogenous than the organic wastes or raw materials used (Arancon et al. q2003; Edwards and Burrows 1988). During this process the earthworms are involved with both physical and biochemical actions. The physical actions include fragmentation, turnover and aeration. The biochemical actions include enzymatic digestion, nitrogen enrichment, transport of inorganic and organic materials (Edwards and Lofty 1972). During this process, important plant nutrients such as nitrogen, potassium, phosphorus and calcium present in the waste materials are converted into chemical forms through microbial action are much more soluble and available to the plants than those in the parent substrate (Ndegwa and Thompson 2001).

Classification of earthworms

Earthworms are belongs to phylum annelida of invertebrates. Approximately 3600 types of earthworms are found throughout the world and are primarily divided into two major catagories: (1) burrowing and (2) non-burrowing. The burrowing types *Pheretima* elongate and live deep in the soil. On the other hand, *Eisenia foetida* and *Eudrilus eugeniae are* the non-burrowing types live in the upper layer of soil surface. The burrowing types are 20 to 30 cm long, pale, and live for 15 years. The non-burrowing types are 10 to 18 cm long, red or purple but their life span is only 28 months.

The non-burrowing earthworms feed on 10% soil and 90% organic waste materials and convert these organic waste into vermicompost quicker than the burrowing earthworms. They can survive with the temperature ranging from 0 to 40^0C but the reproduction capacity is more at 25 to 30^0C and the moisture level in the pile is required within 40-45%.The burrowing type of earthworms comes onto the soil surface only at night. These form holes in the soil up to a depth of 3.5m and produce 5.6kg casts by ingesting 90% soil and 10% organic waste.Earthworms have been categorized into three groups according to morpho-ecological characteristics(Bouche1977]. There are the following categories: (1) Epigeic, (2) Endogeic, (3) Anecic. Among these, smallsized worms are epigeic earthworms, living in organic horizon s and feeding on rotting organic matter. They create transient burrows, but for diapauses only do not have permanent burrows in mineral soil. These species are naturally phytophagous and have a relatively short life span with a rapid rate of reproduction.These organisms contribute to organic matter biodegradation and release nutrients into the sol. These organisms are ideall y suited for vermicomposting and efficient processing of litters of plants or animal waste into proteins of the body, given their high growth rates. There is a high rate of intake, absorption a nd assimilation of these epigenic species. It should be tolerant ofdifferent climatic temperatur es. Eisenia foetida and Eudrilus eugeniae can be grown in higher temperature regions (upto 4 3^0C) such as well as lower temperature (<5^0C) (Gajalakshmi and Abbasi 2004).

Factors detrimental for vermicomposting

Moisture content: Earthworms show cutaneous respiration, hence the body system is acquainted with adequate moisture content. The required moisture range in vermicomposting or vermiculture process is 60-80% (Neuhauser et al. 1988, Edwards 1998).

pH: The pH range of 5.58.5 is sufficient for the activity of earthworms and microorganisms. However, neutral or near neutral is the optimal pH.The pH values of the feed substrate are sig nificantly changed during vermicomposting. Considerable differences occur in the pH values of the feed substrate. An initial step characterized by a low pH of the feed substrate is typicall y observed during vermicomposting. This is due to the formation of carbon dioxide and volati le fatty acids at the initial level. As the mechanism progresses with the subsequent evolution of CO2 and utilization of volatile fatty acids, the pH starts to increase (Kaushik and Garg 2004).

Temperature: The optimum temperature ranges 12-28^{0}C for earthworms during vermicomposting process. The worm actions are significantly influenced by temperature. The temperature should be maintained above 10^{0}C and below 35^{0}C during winter and in summer respectively (Ismail 1997). As temperature reduce in the vermicomposting system the rate of reproduction as well as metabolic activity of earthworms also get dropped. Earthworms do not consume food at very low temperatures. At higher temperature (above 35^{0}C) the rate of mortality increase as there metabolic activity and reproduction of earthworms begin to decline (Riggle and Holmes 1994). The verms varies from species to species with refer to their tolerances and preferences for temperatures.

Aeration: As earthworms are aerobic species, oxygen is important for vermicomposting. As it is also a feature of microbial and earthworm activity mostly during ingestion, oxygen evels a re also related to substrate temperatures. In a vermicomposting system, excessive moisture m ay cause poor aeration and can affect the supply of oxygen to the worms.

Light: In nature, earthworms are photophobic (Edwards and Lofty 1972). So they need to be shielded from light.

C:N: The growth and reproduction rate of earthworms also depends on the feed material's C: N ratio. The higher C:N ratio in the feed material accelerates worm growth and reproduction. The degradation of waste is decreased if the C:N ratio is too high or too low. Unless the C:N i s in the 25-20:1 range, plants can not assimilate mineral nitrogen.

Vermicompost: process and methods

A. Process

For vermicompost production, the following method could be adopted. For this reason, it is a ppropriate to use a wooden box measuring 45 x 30 x 45 cm or an earthen/plastic container wit h a wide base and drainage holes. A plastic sheet should be placed at the bottom of the woode n box with small holes. For the drainage of excess moisture, a layer of 3 cm of soil and a laye r of 5 cm of coconut fiber should be stored underneath the package. A thin layer of compost was put above it along with worms as inoculums. About 250 worms are necessary for the box.

Vegetable waste should be added to the inoculum in layers on a regular basis. A piece of gun ny bag should cover the top of the box to provide dim light inside the box. The box should be left undisturbed for a week when the box is full. The box should e kept light for 23 hours wh en the compost appears to be ready so that the worms go down to the lowest layer of coconut fiber. It is important to remove the composted materials from the top of the box and gradually down and sieve for use in the urban or intensive horticultural and agricultural systems (S. Adhikary, 2012).

B. 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. Vermicompost is developed in four different ratios, hence four beds are required for sample and 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 for personal requirements (5- 10 tons of vermicompost annually). This method is easy to maintain and practice. The tops of the beds were covered with thin mesh, to allow gaseous exchange.

Pits below the ground: The vermicomposting pit should be constructed with an approximate measurement of 1 m deep and 1.5 m wide. The length varies as required. 2.6.3

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 favourable in the heap method that increase upto a 21-fold by the action of *Eudrilus eugeniae* as compared to 17-fold increase in the compared pit method. The production of biomass was also higher in the heap method (46-fold increase) than in the pit method (31- fold). Consequent production of vermicompost was also higher in the heap method (51 kg) than in the pit method (40 kg).

Vermicomposting: precautionary measures

The following precautions should be taken during vermicomposting

- The earthworm species, *Eisenia foetida and Eudrilus eugeniae* are originated from Africa and ideal for the formation of vermicompost. Most Indian species are not suitable for the purpose.
- For production of vermicompost, precaution should be taken to utilize the types of waste material such as plant-based like grass, leaves or vegetable peels etc.
- Materials of animal origin such as powdered eggshells, droppings of fish and chicken, etc are partialy used for preparing vermicompost.
- Kitchen waste,Gliricidia loppings, tobacco leaves, onion, garlic, chilli, etc is not ideal for rearing earthworms Sujit Adhikary. (2012)
- Birds, termites, ants and rats should be avoided from earthworms.
- During the process, sufficient moisture should be preserved.
- The earthworms could be killed by either stagnant water or lack of moisture.
- After completion of the process, the vermicompost must be removed from the bed at r egular intervals and replaced by fresh waste materials.

Vermicompost: harvest

- Harvesting the compost requires separating the castings from the bed.
- Black or dark brown is the final product and is called crumbly worm compost.
- To keep the worms safe, collecting the compost and adding fresh bedding is necessary at least twice a year.
- By spreading a sheet of plastic under a bright light or in the sun, the compost can be h arvested.
- The bed contents leaving the bedding materials are separated on the sheet into a numb er of heaps.
- The worms can crawl into the center of each heap away from the sun and the worm co mpost can be hand-brushed away on the outside.
- For reuse, crawling worms will be collected Sujit Adhikary. (2012).

Vermicompost: benefits

- It facilitates and improve the physical and chemical properties of the soil.
- It improves the biological properties of the soil enriched with micro-organisms, addition of plant hormones such as Auxins and Gibberellic acid, and addition of enzymes, such as phosphates, cellulase, etc.
- It attracts deep-burrowing earthworms already present in the soil.
- Vermicompost consists high population and cocoons of earthworms including and it's all biological activity of in the soil.
- It increases the efficiency over chemical fertilizers, prevents nutrient losses and enhances the decomposition of organic matter in soil.
- Vermicompost is free flowing, easy to apply, handle and store and does not have bad odour C.Vennila et al. (2012).
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Vermicompost application: crops, dose and time

Table 2. Recommended quantity and time of application of Vermicompost

S.No	Crop	Quantity to apply per acre	Time of apply
1	Rice	1 tonne	After transplanting
2	Sugarcane	1 ½ tonnes	Last Ploughing
3	Cotton	1 tonne	Last Ploughing
4	Chilli	1 tonne	Last Ploughing
5	Groundnut	½ tonne	Last Ploughing
6	Sunflower	1 ½ tonne	Last Ploughing
7	Maize	1 tonne	Last Ploughing
8	Turmeric	1 tonne	Last Ploughing
9	Grape	1 tonne	June-July
10	Citrus, Pomegranate, Ber, Guava	2 kg per tree	At planting time and before flowering in 1-2 year old trees
11	Mango, Coconut	2 kg per tree	At planting time
		5 kg per tree	1-5 years old trees
		10 kg per tree	6-9 year old trees

		20 kg per tree	Trees older than 10 years
12	Onion, Garlic, Tomato, Potato, Bhendi, Brinjal, Cabbage, Cauliflower	1- 1 ½ tonne	Last Ploughing
13	Teak, Red Sandalwood, Mangium	3 kg per tree	At planting time

Source: Central Research Institute for Dryland Agriculture, 2010

Conclusion

In order to get the quality vermicompost production, one has to emphasis on choice of feasible earthworm species as per the local climatic context. While we take up the vermicomposting, it is very critical to maintain few factors, such as moisture content, pH, light, C: N ratio, aeration and temperature etc., on maintaining these factors production of vermicompost will not affect and also the multiplication of earthworm will go high. Looking at the present chemical agricultural practices, due to which fast declining in soil health as well as the ecosystem. To have a sustainable agricultural practices, farmers need some alternative which is economic and productive compare to chemical fertilizers, may be not complete substitute but to a portion where the soil fertility and health can be maintain for future. Therefore, a farmer can take up vermicompost production which is a good source of macro and micro nutrients, also several enzymes and growth regulators, above all it will also maintain soil organic matter.

References

1. Gandhi M., Sangwan V., Kapoor K.K and Dilbaghi N. (1997). Composting of household wastes with and without earthworms. Environment and Ecology 15(2):432–434.
2. Vermi Co. (2001). Vermicomposting technology for waste management and agriculture: an executive summary. (http://www.vermico.com/summary.htm) PO Box 2334, Grants Pass, OR 97528, USA: Vermi Co.
3. Tara Crescent. (2003). Vermicomposting. Development Alternatives (DA) Sustainable Livelihoods. (http:// www.dainet.org/livelihoods/default.htm)
4. Adhikary S. (2012). Vermicompost, the story of organic gold: A review. *Agricultural Sciences,* 3(7), 905-917, doi:10.4236/as.2012.37110.
5. Marinari S., Masciandaro G, Ceccanti B. and Grego S. (2000). Influence of organic and mineral fertilisers on soil biological and physical properties. Bioresource Technology 72(1):9–17.
6. Maheswarappa H.P., Nanjappa H.V and Hegde M.R. (1999). Influence of organic manures on yield of arrowroot, soil physico-chemical and biological properties when grown as intercrop in coconut garden. Annals of Agricultural Research 20(3):318–323.
7. Mitchell A. and Edwards. C.A (1997). The production of vermicompost using Eisenia fetida from cattle manure. Soil Biology and Biochemistry 29:3–4.
8. Arancon N, Lee S, Edwards C, Atiyeh R (2003a). Effects of humic acids derived from cattle, food and paper-waste vermicomposts on the growth of greenhouse plants. Pedobiologia, 47(5): 741-744.

9. Edwards C.A , Burrows I (1988). The potential of earthworm composts as plant growth media. In: C.V Edwards and E Neuhauser (Eds.). Earthworms in Waste and Environmental Management. SPB Academic Press. The Hague, The Netherlands, pp: 21-32.
10. Edward C.A. and Lofty J.R. (1972). Biology of Earthworms: Chapman and Hall.doi: 10.1007/978-1-4613-3382-1.
11. Ndegwa P.M. and Thompson S.A (2001). Integrating composting and Vermicomposting in the Treatment of Bioconversion of Biosolids. Bioresource Technology**,** 76(2),107-112.doi:1016/s0960-8524(00)00104-8 PMID: 11131792.
12. Bouche M.B.(1977) Strategies Lombriciennes in Soil Organisms as components of ecosystem, edited by U Lohm and Person, Biol. Bull. (Stock holm), 25 :122-132.
13. Gajalakshmi S. and Abbasi S.A (2004). Earthworms and Vermicomposting. Indian Journal of Biotechnology (3), 486-494.
14. Neuhauser E.F, Loehr R.C. and Malecki M.R. (1988) "The potential of earthworms for managing sewage sludge." In: Earthworms in Waste and Environmental 114 Management, Edwards C. A. and Neuhauser E.F. (eds), The Hague: SPB Academic Publishing, pp. 9-20.
15. Edwards C.A. (1988) Breakdown of animal, vegetable and industrial organic wastes by earthworms. In: Earthworms in Waste and Environmental Management, Edwards, C.A. and Neuhauser, E. F. (Eds.). SPB Academic Publishing, The Hague, pp. 21-31.
16. Kaushik P. and Garg V.K. (2004). Dynamics of biological and Chemical parameters during vermicomposting of solid textile mill sludge mixed with cow dung agricultural residues. Bioresource Technology 94(2):203-9, doi: 10.1016/j.biortech.2003.10.033.
17. Ismail S.A. (1997) Vermicology: the biology of earthworms. Orient Longman Press, Hyderabad, p 92
18. Riggle D. and Holmes H (1994) New horizons for commercial vermiculture. Biocycle, 35(10): 58-62.
19. Sunitha N.D., Giraddi R.S, Kulkarni K.A. and Lingappa S. (1997) Evaluation methods of vermicomposting under open field conditions. Karnataka Journal of Agricultural Sciences 10(4): 987–990.
20. Vennila C, Jayanthi C, Sankaran VM (2012) Vermicompost on crop
21. production—a review. Agric Rev 33(3):265–270
22. Vennila C, Jayanthi C, Sankaran VM (2012) Vermicompost on crop
23. production—a review. Agric Rev 33(3):265–270
24. Singh S.G. (SMS Plant Breeding) KVK, Imphal West, ICAR,Vrmicompost Production Technology.
25. Vennila C. Jayanti C , Sankaran V, M (2012) Vrmicompost on crop production-a review. Agric Rev 33(3):265-270.