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Vermicompost Technology: Impact on the Environment and Food Security

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In recent years, increasing consumer concern about issues such as food quality, environmental safety, and soil conservation has lead to a substantial increase in the use of sustainable agricultural practices. Globally, roughly one-third of the food produced for human consumption is lost or wasted, which amounts to about 1.3 billion tonnes per year. Vermicomposting is one of the most sustainable methods of handling food waste and is a completely environmentally friendly technology that is a viable method of diverting the organic portion of waste streams, avoiding the costs of disposal, and converting it to value-added vermicompost. This product is nutrient-rich but also contains high-quality humus, plant growth hormones, enzymes, and substances that can protect plants against pests and diseases. Many cropping areas in the world are deficient in organic matter and nutrients.

Introduction

The use of *Perionyx excavatus* was the beginning of a pioneering attempt in India to employ earthworms for the degradation of solid waste. Later *Eudrillus eugeniae* was brought to the laboratory at the University of Agricultural Sciences Bangalore to test the possibility of their establishment in this sub-continent which has similar climatic conditions as that of its place of origin. Vermicompost is a nutrient-rich, microbiologically-active organic amendment that results from the interactions between earthworms and microorganisms during the breakdown of organic matter. It is a stabilized, finely divided peat-like material with a low C: N ratio, high porosity, and high water-holding capacity, in which most nutrients are present in forms that are readily taken up by plants (Domínguez, 2004).

Vermicompost technology is a biotechnological process of converting organic waste into compost using specialized earthworms. Earthworms in recent times have become very beneficial following several kinds of research concerning their ability to efficiently convert organic waste into nutrient-rich compost known as vermicast. The vermicast is proven to increase crop growth and yield substantially compared to conventional compost and chemical fertilizers because the product is nutrient-rich and also contains high-quality humus, plant growth hormones, enzymes, and substances that can protect plants against pests and diseases.

There are three basic types of vermicomposting systems of interest to farmers which are windrows, beds or bins, and flow-through reactors. Each type has several variants. Windrows and bins can be batch or continuous-flow systems, while all flow-through systems, as the name suggests, are of the continuous-flow variety.

Fig 1: Schematic description of vermitech impact

The power of earthworms

Earthworms act as mechanical blenders, and by fragmenting the organic matter they modify its physical and chemical status by gradually reducing the ratio of C:N and increasing the surface area exposed to microorganisms - thus making it much more favorable for microbial activity and further decomposition (Domínguez *et al.*, 2010). Various types of earthworms and the methods adopted in the production of vermicompost gives an insight into the different aspects associated with the production of vermicompost.

Fig 2: **Vermicompost**

Fig 3: **Digested by Vermicompostion**

It has been suggested that earthworms may be important agents capable of influencing the production of PGRs by microorganisms through the stimulation and promotion of microbial activity in organic substrates (Tomati *et al.*, 1990). Nevertheless, some authors suggest that earthworms, and not microorganisms, are responsible for the production of PGRs. Nielson (1965) reported the first evidence of the presence of indole compounds in the tissues of *Aporrectodea caliginosa*, *Lumbricus rubellus*, and *Eisenia fetida*.

Earthworms were discovered by scientists as efficient decomposers of complex organic constituents including garden waste, municipal solid waste (MSW), animal waste(poultry, cattle, etc), domestic waste(food, paper, fiber), etc. According to scientists, earthworms possess special cellulose-degrading bacteria in their guts that enable rapid decomposition of organic residue. Upon feeding on their substrates the earthworm assimilates about 5-10% of the substrate and the rest pass through the alimentary canal and excreted as cast (Aira *et al*., 2007). The earthworm cast also known as the new 'black gold' is known to be rich in nutrients compared to conventional composts and chemical fertilizers. Scientists have reported a significant increase in plant growth and crop yield in paddy, wheat, soybean, and vegetables (Parkin and Berry, 1994) compared to conventional composts and chemical fertilizers. Aside from producing earthworm cast, vermiwash; a liquid substance

collected during the composting process is produced. Vermiwash is known for its soil conditioning properties; rich in microbes that increase microbial activity in the soil. The liquid extract is also known for prophylactic properties hence used in foliar spray as bio-pesticide (Booshan and Prasad, 1999)

Fig 4: Organic Vermicompost

Fig 5: Vermifilter

Vermicompost is a method of making compost with the use of earthworm, which eats biomass and excreta in a digested form. This compost is generally called Vermicompost. Locally available earthworms are also used for vermicomposting but their mode of feeding is very slow and the earthworm which lives below the soil is also not suitable for vermicompost production. The Red wriggler worms (*Eisenia fetida*) and African Night Crawler (*Eudrillus eugeniae*) are promising worms used for vermicompost production. All two worms can be mixed for vermicompost production.

Interestingly, earthworms require no soil medium to produce earthworm cast. The principal medium is their substrate coupled with already existing soil microbes in the soil. During vermicomposting, earthworms carry out a non-thermophilic transformation of organic residue with accelerated microbial decomposition and humification (Atiyeh, *et. al.*, 1999). More recently, El Harti et al. (2001a, 2001b) showed that a crude extract of the earthworm *Lumbricus terrestris* was able to stimulate rooting in bean seeds due to the presence of indole compounds of endogenous origin.

Problems in Vermicomposting

Odours: Putting over-abundance of "greens" in the bin, which is too much nitrogen combining with hydrogen and forms the ammonia? To neutralize the odours, add some sources of carbon like paper and dried leaves etc.

Pests: Bad odour can attract pests such as rodents and flies. Fix plastic nets around the bins. The Eisenia fetida can attack native worms in natural areas. Don't allow them to go out of natural places.

In employing highly efficient worms for the hard work, the goal is to have a system that mimics the worm's natural environment. An ideal system must be self-contained, self-sustaining, odourless, high yielding, low maintenance, and easy to operate (Cristina and Dominguez, 2011).

The work of earthworms in converting organic residues into renewable energy sources places vermicomposting technology in a very crucial position in waste management and recycling. The technology has gained more popularity in the scientific research circles also because of the use of natural resources for efficient ecological conservation. Vermicompost technology promises a future possible efficient organic waste management system using cheap and sustainable technology.

Environmental sustainability

The technology of vermicomposting containing their leachates, teas, and other extracts such as vermiwash as a result of earthworm action is widely applied for the safe management of agricultural, industrial, domestic, and hospital wastes. Vermicompost technique of waste recycling has a greater potential to drastically mitigate organic waste generation. The effort to make the earth a healthier and pollution-free environment calls for a holistic approach that will reduce environmental pollution to the barest minimum, yet, conserving natural resources. It is almost impossible to have a world without waste generated either by households, industries, or agricultural fields.

Reports have shown that an average of about 0.45% of waste is generated daily per person per day. According to World Bank, 2.01 billion municipal waste is generated annually worldwide out of which 33 percent are extremely conservatively not managed in an environmentally safe manner (Cristina and Dominguez, 2011). Moreover, most waste management techniques require a more complex infrastructural apparatus, making the process of labour intensive and expensive. Concerns have been raised concerning the effectiveness of recycling plants since they eventually contribute to greenhouse gas emissions. Moreover, such complex systems demand intensive structural system maintenance to ensure smooth running.

Considering the demerits, a more robust eco-technological approach designed to be ecologically sound, environmentally friendly, and cost-effective is crucial if the world is serious about achieving sustainable development.

Effective waste management

Remediation of polluted soils, improving crop productivity, and inducing the resistance against biotic and abiotic stresses are other advantages of vermicompost derived liquids when used in agriculture. Contrary to the fact that chemical fertilizers are still widely used in agriculture, societies gradually become aware of the negative effects of these fertilizers on their health. Therefore, vermicompost derived liquids contain a high amount of valuable plant nutrients which has the potential to be used as liquid fertilizer. Vermicompost technology has over the years proven to provide a cleaner alternative to recycling organic waste in an ecologically sound manner. Thankfully, nature has an already inbuilt recycling system powered by soil biota that science and research have tapped to solve human waste problems.

Earthworms are voracious feeders. The average adult worm weighs 0.5 - 0.6g, eats waste equivalent to its body weight, and excretes about 50 percent of the waste it consumes per day. About 1000 adult worms can successfully convert 5kg of waste into compost in a day. The red wriggler worm can efficiently convert one tonne of garbage into nutrient-rich compost in a year. This is a massive game-changer burgeoning sustainable waste management especially for smallholder farmers, agricultural industries, municipal solid waste management in urban households.

Restaurants, hotels, market places, and households can conveniently micro-manage their waste using vermicomposting technology.

Agro-ecological safety

Vermicompost is a finely-divided peat-like material and because of this fine structure, the addition of vermicompost to plant potting media causes significant changes in the physical properties, altering water and air availability in the substrates and conditioning root growth. Nonetheless, the type and magnitude of these effects depend on the physical characteristics of the original growing medium. For example, the bulk density of vermicompost is usually higher and the particle size lower than in some of the most commonly used peat-based substrates (Atiyeh et al. 2001); mixing of these two substrates produces a significant increase in the bulk density and water holding capacity while decreasing particle size and total porosity (Atiyeh et al. 2001; Bachmann and Metzger, 2007)

Integrating vermicomposting into soil fertility management systems has proven to be more beneficial to the health and safety of the agro-ecosystem. The earthworm cast is known to be super rich in organic matter, Nitrogen, Potassium, Phosphorus, Magnesium, Calcium, etc. Also, vermiwash and vermicast are both known to contain vitamins, minerals, hormones, and antibodies. Vermicompost may influence plant growth directly via the supply of plant growth regulating substances (PGRs) (Tomati et al. 1990). Meanwhile, vermicompost technology has the potential to reclaim and restore degraded and depleted soils by conditioning topsoils with vermicompost.

Food security

Formidable food systems that can curtail hunger and poverty especially among the rural poor will require sustainable inclusion in crop production. Agro-ecosystems should be conditioned to support continued food production to feed the ever-increasing human population.

Vermicompost technology used in urban centers is providing a better alternative soil medium for convenient and cost-effective vegetable crop production. The fight against the effects of climate change and efforts to cut down greenhouse gas emissions in urban centres will demand a 'one household one backyard garden' approach, where vermitech is utilized. By this, households can provide enough to feed themselves and make extra income on the side.

Poverty reduction

Aside from the numerous benefits discussed, vermitech has the potential to support microeconomic boosts in the national economy. A viable business can be developed from the vermitech system that can generate substantial profit for the owner, raise their standard of living which in turn will reflect in the national economy.

- Sales of vermiwash and vermicompost: there is a huge market for the sales of vermicompost and vermiwash especially among vegetable farmers. Vermicompost is applied as biofertilizer whilst vermiwash is applied by foliar as liquid fertilizer and as an insect repellent.
- Worm farming: worm farming is the process of rearing suitable worm species purposely for vermicomposting. The demand for the supply of suitable worms in urban centres is an opportunity to build a profitable supply chain.
- Waste management services: recycling waste generated by corporate bodies and households through vermitech is another opportunity to tap into. Municipal, hotels, restaurants, canteens, farm, and individual household wastes can be recycled by a third party for a fee.

Moreover, the smallholder farmer can make extra income through vermitech by recycling their waste and making use of the compost to increase crop yield. Crop production can be cost-effective by integrating vermitech into the farming system. Increased crop yield will consequently increase farmer-income thereby reducing poverty.

Summary

Vermicompost can be described as a complex mixture of earthworm faeces, humified organic matter, and microorganisms, which when added to the soil or plant growing media, increases germination, growth, flowering, fruit production and accelerates the development of a wide range of plant species. The enhanced plant growth may be attributed to various direct and indirect mechanisms, including biologically mediated mechanisms such as the supply of plant-growth regulating substances, and improvements in soil biological functions.

Vermicompost has been found to have a wide range of indirect effects on plant growth such as the mitigation or suppression of plant diseases. Vermicompost enhances plant growth further than expected because of nutrient supply and improvements in the physical condition of substrates. This was first suggested by Scott (1988) and Edwards and Burrows (1988), who observed that small doses

of vermicompost added to the potting media of several ornamental species, produced a much larger increase in plant growth than the equivalent dose of nutrients. These effects were maintained even when vermicompost was diluted 1:20 with other potting media, resulting in a dose of vermicompost would be expected to have negligible physical effects (Edwards and Burrows, 1988).
The technology has been most preferred over chemical fertilizers by farmers due to the following reasons;

- Restores the dignity of the soil ecosystem by enhancing soil microbial activities
- Contains nitrogen-fixing properties
- Improves the water holding capacity of soil
- Nutrients composition of earthworm cast is made readily available to the plant upon application for uptake.
- Increases crop growth and development thereby increasing crop yield.
- Reduces pest and disease infestation on field crops
- Provides an efficient alternative to managing farm waste
- Provides Are higher nutrient content than conventional compost and inorganic fertilizer
- The judicious use of vermicompost will largely compensate for the indiscriminate use of chemical fertilizers on crop fields.

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