Vermicompost in soil quality and soil sustainable development – A Review
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Abstract
Vermicompost is a bio-organic fertilizer resulting from the slow and steady passage of decaying organic material through the digestive system of earthworms and disposal of these materials from the worms' bodies. The most important worm with a key role in the production of vermicompost is Eisenia fetida. The earthworms eat a lot of dirt while consuming organic matter. The materials from earthworms' feeding after disposal form strong aggregates, which are considered as one of the most stable forms of soil aggregates as well as the best type of soil aggregates, the spherical aggregates. Depletion of soil nutrients, especially in areas, renewing by chemical fertilizer, has become an extremely dangerous factor causing numerous environmental problems. Nitrates entering into the water can be mentioned as one of the major problems. Vermicompost contains nutrient-rich elements and is very important for soil fertility. In the present study review an attempt has been made to study the essentials in vermicomposting.

Keywords: Soil quality, fertilizer, soil development, earthworm, vermicompost, and nutrient.

Introduction
Darwin (1838) announced for the first time the role of earthworms on soil fertility. In terms of historical background, the earthworms have been created about 600 million years ago, and since then have witnessed the evolution of different plant and animal species. The appearance of these organisms did not change much during this period, and even now, no considerable differences are seen between different species. Worms are cylindrical and tubular form animals. Their body is composed of a large number of rings. The number of rings and the length of earthworms vary in different species. The number of rings varies in a range from 80 to 190. The last ring is called an anal ring, and the mouth is located on the first ring, which is responsible for the act of taking food and its dipping. Earthworms vary in size from 23 to 210 mm (Gupta, 2003 and Edwards, 2004).

There is a special ring on the earthworm rings, which is called a sex ring or "Clitellum" located at the front of the body. This organ lacks hair unlike other rings of the body with surface hair. This organ functions at reproductive stage.

Earthworms are hermaphrodite; that each worm has both male and female organs. However, eventually worm by connecting to another worm through two clitellums and exchanging sperm does mating. Then, each worm forms a spawning sac in its clitellum. The spawn sacs of the cocoons is yellow amber in color, within which there are about 3-7 newborn larvae.
Thus, increasing the number of worms in each generation will occur relatively in a geometric progression manner (Edwards, 2004).

The weight of each adult worm is between 0.5 to 1 g, and there are approximately 1,000 to 2,000 worms per kg. The interval between the two generations (from egg to egg) in normal conditions is about 3 months, and the worms' life varies from one to 15 years.

Charles Darwin (1882) is among the firsts to introduce the earthworm for decomposing of dead plant and animal material, attributing the soil improvement is to the presence of these animals. Later, Oliver and Baroot in 1942 proposed for the first time that materials fed by earthworms can be used to improve the soil fertility. The industry was rapidly growing and earthworm growers in all parts of the world began to sell vermicompost in addition to selling worms. Other studies on the ability of earthworms to convert organic waste were conducted in Germany (1974), and later in America (1977) and subsequently in England (1982). Edwards in 1983, using plant and animal waste, waste to materials as plant growth factors conducted an experiment. Then, for commercial success in selling vermicompost, some standards were developed. In 1988, Scott showed that the vermicompost is more effective in seed germination than conventional compost. However, what's more interesting nowadays is the evaluation of the performance potential of earthworm species on organic materials, including agricultural waste and manure, domestic and industrial waste and municipal sewage (McDonald et al., 1998).

Since the vermicompost resulting from worms' activities on plant and animal waste on a large scale often faces some deficiencies, nowadays, the scientists' attention is drawn to address such deficiencies and problems. Defects needing much more research to be addressed include dissimilar structure and food composition of vermicompost, presence of grains, molds and lack of ability to retain moisture, which leads to drying and reducing the size of vermicompost (Ghorbani, 1995).

One of the most important earthworm species used globally for the production of vermicompost is the tiger earthworm or Eisenia fetida, which can be seen in the figure below.

The worm is known as red earth and rain worm in Persian, and Californian red worm at global level, and as garbage eating worms among the people. Their color is reddish brown and smaller in size than common earthworms. The weekly reproduction with having more than 70% protein can be noted as their characteristics, which is more than three times compared to the red meat protein. Feeding on the organic material in nature, the worms convert them to nutritious organic fertilizer, which is used as one of the richest bio-organic fertilizers known in the world. Also, the Lampitera mauritii species is used to manage and improve the soil structure. However, the best species to produce vermicompost is Eisenia fetida.

Objectives of using vermicompost
- Reducing the adverse effects of waste,
- Prevention of environmental pollution,
- Economical advantage,
• Maintaining long-term productivity,
• Stability of soil resources,
• Confronting the disadvantages of chemical fertilizers and their high costs,
• An effective step in achieving sustainable development,
• Ensuring and guaranteeing the physical health,
• Producing food products with proper quality, etc.

Vermicompost is a bio-organic fertilizer resulting from the slow and steady passage of decaying organic material through the digestive system of species of earthworms and disposal of these materials form the worms' bodies (Gupta, 2003 and Sati, 2007). The materials are impregnated in the gastrointestinal mucosa (mucous), vitamins and enzymes while passing through the worm's body, which are ultimately produced and used as enriched and very useful composts for construction and improvement of soil nutrients. Therefore, vermicompost includes the worm manure associated with a percentage of organic and food material and the worms' carcass (Ismail et al., 2003). The continuously and smoothly passage of material through the earthworm digestive system occurs along with the actions of crushing, grinding and mixing in various sections of the digestive tract. Impregnation of these materials with a variety of gastrointestinal secretions, such as calcium carbonate particles, mucous substances, various metabolites of gastrointestinal microorganisms, and final creation of proper conditions for synthesis of humic acids to in this pathway, in general produces materials with characteristics quite different with swallowed materials.

Characteristics of vermicompost

• Lightweight with no odor,
• Free of weeds,
• Containing beneficial aerobic microorganisms like Azotobacteria,
• High levels of main food elements compared to other organic fertilizers,
• Having micronutrients such as iron, zinc, copper and manganese,
• Having plant growth stimulating material such as vitamins, especially vitamin B_{12},
• Due to having spongy properties, the produced fertilizer, in addition to maintaining and gradual releasing of the existing water, while dealing with water shortages in drought conditions, can lead to fecundity and fertility of saline soils of non-arable foothills lands,
• Easy and faster processing than the organic compost,
• Use of vermicompost in producing compost tea,
• Modification of physicochemical and biological properties of soil,
• Having elements such as nitrogen, phosphorus, potassium, calcium, iron, zinc, copper and Manganese (Sati, 2007; Abdoli and Roshani, 2008).

Effect of vermicompost on soil

Vermicompost has a considerable impact on soil physical, chemical and biological properties. This fertilizer modifies the soil physical, chemical and biological properties, and in addition to low specific gravity, lacks any odor, pathogenic microorganisms, anaerobic bacteria, fungi and weeds. Vermicompost in addition to having the water absorption capacity with high-volume provides the appropriate conditions for aggregation and ability to maintain the plants food requirements (Singh, 2004). Vermicompost contains high nutrient-rich elements, especially nitrogen that provide them gradually to the plant. Compared to other
organic fertilizers, this fertilizer has higher rates of main nutrient elements. Vermicompost, in addition to macro-elements such as nitrogen, phosphorus and potassium that play a vital role in plant life activities, contains microelements such as iron, copper, zinc and manganese as well. Moreover, having substances such as vitamin B_{12} and Oxine can provide the triggers for plant growth.

Advantages and disadvantages of vermicompost application

The followings are the benefits of compost application on soil physics: As modulators of textures and modifiers of the soil structure, facilitating the production of aggregates resistant to water, reducing specific gravity and facilitating aeration through resulting pores, increased permeability and water-holding capacity, protecting the soil surface against abrasive effects of raindrops and the wind, reducing evaporation from the soil surface, avoidance of warming and cooling of soil surfaces and avoided or reduced growth of weeds.

These benefits can be summarized from the perspective of a food material encompassing the major and minor elements, modifying pH and increasing the buffering properties of soil, a strong chelating agent, absorption and retention of heavy metals and purifying the polluted waters. In describing, the compost acts as slow-releasing fertilizer in the soil, meaning that, except for potassium that all of it can be approximately absorbed immediately. This property prevents the burning of young seedlings and seeds occurring in the vicinity of chemical fertilizers. The same property causes the sustainability of elements in the soil, and prevention of their being washed and transferred to the layers below the root with irrigation. The immediate insolubility of nutrients found in the compost will prevents the leaching of elements and their transfer to the surface.

The other advantages are:

- Less moisture, which is equal to a greater richness compared to manure based on the wet weight of the crop,
- Increased soil organic matter, which has the role of slow-releasing fertilizers that are not easily exposed to water-washing. Large quantities of organic material lead to improvement, strength and stability of the aggregates,
- Increased water holding capacity and Cation Exchange Capacity (C.E.C) and reduced erosion,
- Presence of beneficial microbes in compost accelerates the cycling of nutrients within the soil and can limit the pathogens in the soil and within the green limbs,
- Lack or negligible amounts of pathogens and weeds, which have been destroyed under the influence of environment high temperature,
- With weight loss about 50% to 70% compared to livestock manure, the transportation costs will reduce,
- Source of generating jobs and income through production requirements of different markets of demand.

B. Disadvantages are:

- High costs of equipment in mass production, requiring detailed planning and implementation of the process at all stages of development and during the production time and the need for controlling the enriched wastewater with the aim of preventing leaking into the groundwater,
- The possible need to establishment and selling license based on production size,
Higher cost per unit of nutrients compared to chemical fertilizers and livestock manure; creating an unpleasant smell (Giti, 2011).

The process and organic materials required for the production of vermicompost

To produce vermicompost, the decomposable organic matter should be made available to the earthworms, and then, appropriate conditions for the proliferation and maintenance of earthworms must be provided as well as protecting them against natural enemies. In the bed preparation stage required for the earthworms, it is necessary first to divide organic particles into smaller parts and then the initial preparation will be performed on them. The mass of organic matter is provided in the presence of appropriate moisture, oxygen and temperature and in the presence of initial material degrading microorganisms for the earthworms. A wide variety of materials such as animal waste, agricultural wastes, clothing and paper wastes, forest wastes, the urban small leaves, municipal wastes, industrial waste and sludge from the biogas and edible fungi bed can be used to produce vermicompost (Edwards, 2004 and Esmail, 2003). Usually, the carbon to nitrogen ratio is one of the important factors in the selection of raw materials for the production of vermicompost. In Table 1, the values of carbon to nitrogen ratio in some raw materials of vermicompost production are given.

Management principles of earthworms growing

- The worms should be fed according to their need. One kilogram of organic waste is sufficient for feeding 2 kg of worms,
- The moisture should be maintained at optimum level at the cultivating bed. Depending on weather conditions, the irrigation of stack can be done after 2 to 7 days,
- For better aeration, the content of earthworms culturing bed should be examined weekly. The bed material should be reversed weekly,
- Keep the pit or the bed beneath the canopy,
- The bed cultivating temperature should be between 12 to 25 degrees,
- The bed cultivating pH should be regularly reviewed and stabilized between 6 and 8,
- It is better to cover the bed cultivating, using gunny to avoid the flies hatching,

Production of vermicompost

The vermicomposting technology, ecologically and economically, is an appropriate process that can be implemented with minimal facilities and by ordinary people. To produce vermicompost, proper earthworms must be first provided. Then, appropriate nutritional and environmental conditions should be provided. The earthworms do not like rich food. The Eisenia fetida species is capable of feeding on semi-decayed materials such as bovine manure, horse manure (the manure should be dry), cereal straw and some waste material and plant residues (Sati, 2007). Within this main context, fresh materials such as vegetables and fruits waste, biodegradable, organic matter of household waste, food factory waste and even sewage sludge (excluding industrial waste) can be added. The organic substances added to the bed include three categories: basic food materials, food material reformers (i.e. in condition of low nitrogen in the bed, urea may be added) and the volume-increasing material (including materials with high C/N ratio). These worms do not move away from the food table, and hence, the population of worms grows and stabilizes depending on their access to food. Fresh organic matter, before being used by the worms, should be either processed to lose their original heat, or added to the substrate in a volume not to cause a sudden increase in the substrate temperature. When
the substrate temperature is approximately equal to the ambient temperature, the earthworms could be added to it. These worms are fleeing from the sunlight and the rain; thus, they must be protected from these two factors.

**Factors affecting vermicomposting**

**Ventilation**

Earthworms can survive in low oxygen and high carbon dioxide conditions. However, they will die in the absence of oxygen. In flooding conditions, due to lack of oxygen and toxins produced by anaerobic bacteria, the worms would be destroyed.

**Temperature**

Earthworms will die in freezing temperatures, but to counter such condition, they move deep into the bed. The appropriate bed temperature for their living is around 15-26°C. At a temperature of 15 to 21 °C, the production of cocoons increases; however, in general, the earthworms are capable of living in temperatures up to 35 °C.

**Moisture**

Earthworms require adequate moisture to survive and grow. Their bed growth should be saturated with water. The worms should not be exposed directly to the sunlight. The best humidity for them is between 60% - 70%. In higher and lower moisture, the earthworm growth rate decreases.

**pH**

Earthworms are capable of living at pH between 5 and 8. However, on a commercial scale, the best pH is 7. In acidic beds, limestone or shell eggs can be used to increase the pH (Saleh Rastin, 1999).

**How to use vermicompost**

Usually, the vermicompost is mixed with manure in equal proportions in gardening. For each tree, 3 to 5 kg of the mixture is placed in a ring with a depth of 15 to 30 cm and 60 to 100 cm in widths around the base of the tree. Then, a layer of soil is put on this mixture. In agriculture, the vermicompost can be used as 5 to 10 t per ha at planting stage with a half of the recommended regional amount of fertilizer for wheat farming (Nagavallem et al., 2004).

**Conclusion**

Vermicomposting is the need of the day. Vermicompost not only eliminates the unwanted chemical fertilizers hazards, but also successfully uses the organic wastes of the day to day life. It also guarantees the production of a healthy crop and at the same time eliminate the environmental problems.

**References**


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