



Physico-chemical Status of Vermicompost Processed by Earthworm Specie *Eisenia fetida*

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| ARTICLE INFO | ABSTRACT |
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| <p>Research Article</p> <p>Received : 04/07/2019 Accepted : 13/11/2019</p> <p>Keywords: <i>Eisenia fetida</i> Nutrients Organic materials Manures Vermicompost</p> | <p>Huge amount of organic wastes including agricultural field wastes, food wastes, municipal solid waste and manures can be converted into a safe and usable product that can be used as a possible substitute for chemical fertilizers. In this regard, the proposed study was designed with the aim to prepare macro and micronutrients rich vermicompost from different bio-wastes that can be used as a possible substitute to chemical fertilizers for improving plant growth. A 90 days vermicomposting experiment was conducted in wooden boxes (1×1 m) containing animal manure and waste material (grasses, brewed black tea leaf and dry leaf) mixed in 3:1 ratio with a 2.5 cm thin layer of soil. The material was at the bottom of the bed and around 10.000 earthworms of <i>Eisenia fetida</i> were settled in the box. The boxes were irrigated by sprinkled water daily and tilled from the top once every week for maintaining aeration and proper decomposition. The vermicompost production was continued for about 90 days in each box under 21-23°C room temperature. The results showed that by using animal manure and waste materials, the physical parameters like moisture content was increased upto 50 % on day 90. Likewise, the percent increase recorded for total N, organic N, total P and soluble K content on day 90 was maximum in the vermicompost prepared from animal manure and waste material. It can be concluded from this experiment that with the help of earthworm's, different field and garden residues, wastes and manures can be converted into a nutrient rich and environment friendly vermicompost that can be used as a possible substitute to chemical fertilizers for improving plant growth.</p> |

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Introduction

Applications of heavy doses of chemical fertilizers and pesticides have increased the social and environmental risks. It has also affected soil microbes and fertility as well as minimized the resistance and power of plant against insect-pest and other prevailing diseases (Sinha et al., 2010). The uses of these synthetic fertilizers have also adversely affected the human health and agricultural products (Rai et al., 2014). Recently, the scientific community is trying to adopt the environmentally friendly, economically viable, safe and sustainable ways of soil fertilization to avoid the danger of chemical fertilizers (Tilman et al., 2002; Sinha et al., 2010). Similarly, growth of population, industrialization and intensive agriculture has also increased the problem of efficient disposal and management of solid bio-wastes (Garg et al., 2006). The production of different types of solid organic wastes in the

world causes many environmental problems like environmental pollution, bad odors, contamination of soil and water, disposal and dumping (Edwards and Bater, 1992). Therefore, the proper disposal and management of solid wastes is very essential for keeping the environment healthy and safe for the growing population (Senapati and Julka, 1993).

Several physical, chemical and microbiological methods are in consideration to tackle with the safe disposal and management of different solid wastes, however, these methods are expensive, time consuming and unsuitable for environmental integrity. Therefore, there is a critical need to adopt cost effective, beneficial and short duration technology for the successful and efficient management of different wastes (Harris et al., 1990; Logsdon, 1994). In this regard, the potential use of

earthworms for natural and anthropogenic wastes management and its stabilization is getting more interest (Suthar, 2006). Earthworms are sometimes mentioned as farmer's friends, soil managers and nature's ploughmen. They consume organic matter, promote soil aeration, fragmentation and mixing of mineral particles (Saranraj and Stella, 2012). Some species of earthworms have the capability of consuming different organic wastes including animal manure, green manure, industrial wastes, sewage sludge and crop residues (Chan, 1988; Hartenstein and Bisesi, 1989; Edwards, 1998). During feeding of waste materials earthworms disintegrate and improve decomposition of the product through microbial activities and thus finally convert the unstable organic material into a stabilized form called vermicompost (Saranraj and Stella, 2012).

Verm is derived from the Latin word worms and vermicomposting is a biotechnological process in which earthworms interact with different microbes for the conversion of biologically active substances into humus like nutrients rich product. Vermicompost is different from compost due the fact that vermicompost is generated through mesophilic process in which the organic materials are degraded biochemically by the mechanical blenders called earthworms (Gandhi et al., 1997). The process of vermicompost is faster than compost because in vermicompost the transformation of materials takes place through earthworm gut where the end materials contain high microbial activities, plant growth regulator, thus it proved that earthworms are able to convert garbage into 'gold' (Crescent, 2003). In addition, bulk density, water holding capacity, pH, electrical conductivity, nitrogen, phosphorus, and potassium content are improved by vermicomposting compare to composting material (Doan et al., 2015; Rakkani et al., 2018). Furthermore, vermicompost decreases the amount of heavy metal incorporated to soil compare to compost (Lim et al., 2016). It has been also stated that vermicompost may have more compounds serve as a plant hormone which enhances plant growth and development compare to compost (Najar et al., 2015; Coulibaly et al., 2010).

Vermicompost is a stabilized peat like material having low C:N ratio, high porosity, aeration and water holding capacity in which the nutrients are present in plant available form (Dominguez, 2004). Due to biological activities of earthworms, vermicompost contain more nutrients than the organic product from which it is processed (Buchanam et al., 1988) and thus it act as a rich source of nutrients for plant growth and promotion. (Ismail, 2000). Sreenivas et al., (2000) applied fertilizers and vermicompost to ridge gourd (*Luffa acutangula*) to evaluate soil N and its uptake. They found a significant increase in N uptake by the plants as compared to fertilizers alone. Similarly, vermicompost also increase the NPK concentration in soil and its uptake by rice. Besides increasing plant nutrients, vermicompost also improve growth, total dry matter and grains yield of different crops like mung bean, wheat (Desai et al., 1999), coriander and cow pea (Karmegam and Daniel, 2000) as well as it improves soil physical, chemical, biological properties (Shrestha et al., 2011) and also regulates nitrogen cycle (Karmegam and Daniel, 2000).

Turkey produces approximately 28,858,880 tons of solid municipal waste every year and the annual amount of

waste generated per capita amounts to 390 kilograms (Waste Atlas, 2019). Moreover, huge amount of organic wastes, e.g., agricultural wastes, food wastes, municipal solid waste, cattle manure and poultry manure etc., are available for vermicomposting as a substitute for chemical fertilizers. Therefore, keeping in view the importance of vermicompost, the current study was designed with the aim to prepare vermicompost from common bio-waste that is rich in both macro and micronutrients and can be used as a possible substitute to chemical fertilizers for improving plant growth.

Materials and Methods

Experimental set up

The experiment for vermicompost preparation was established at the Niğde Ömer Halisdemir University, Faculty of Ayhan Şahenk Agricultural Sciences and Technologies in a cool, moist, well drained and shady site that was also accessible to water and composting materials.

Animal manure and waste material (grasses, brewed black tea leaf and dry leaf from tree) were mixed as 3:1 ratio. The compost piles were covered with plastic for partial decomposition for at least 15-20 days (Figure 1). Two wooden boxes (1×1 m) were used as a bed for vermicomposting (Figure 2). The partially decomposed-moist materials were placed 15-20 cm at the bottom of the bed and around 10,000 earthworms (*Eisenia fetida*) were settled in each box. Finally, thin layer of soil (around 2.5 cm) was placed on the decomposed material. The boxes were irrigated by sprinkled water daily and tilled from the top once every week for maintaining aeration and proper decomposition. The vermicompost production was continued for about 90 days in each box under 22±2°C temperature controlled room. Worms were feeded with decomposed material every week around 10 cm thicknesses from top part of the boxes. The temperature of vermicompost was between 22±3°C during vermicomposting process. The worms were separated by using crates with holes full of decomposed material in it in order to harvest vermicompost from the boxes (Figure 3). Harvested vermicompost from the boxes were completely mixed and composite sampling has been done after a week of drying period.

Physico-chemical Analysis of Vermicompost

The vermicomposting experiment was continued for 90 days and the samples were used to analyses at the end of experiment for different Physico-chemical properties like, moisture content, pH, electrical conductivity (EC), soil organic matter, organic carbon, C/N ratio and some macronutrients at the laboratory. During analysis the pH (conductivity meter), EC (EC meter), soil organic matter was determined by the method of Li et al. (2012). Likewise, the samples for the total and organic nitrogen, total phosphorus and soluble potassium were analyzed on Kjeldahl, Spectrophotometer and Flame photometer by the method and procedure of Wang et al. (2016), Soltanpour and Schwab, 1977 and Simard, 1993, respectively. Organic carbon content of the vermicompost determined by Walkley-Black method (1934). The C/N ratio was calculated from measured values of C and N.

Results and Discussion

Physico-chemical Parameters of Vermicompost

The data regarding different physico-chemical properties of vermicompost prepared from field and garden residues and wastes is obvious in Table 01. Some of the chemical properties like NPK contents were increased in the vermicompost with passage of time while some of the chemical parameters like organic carbon, C/N ratio and pH were decreased. By using animal manure and waste material (grasses, brewed black tea leaf and dry leaf) the recorded values of total N, organic N, total P and soluble K content on day 90 were having maximum values of 2.30, 1.9, 2.2 and 1.20 for all the total N, organic N, total P and soluble K respectively, recorded in the final vermicompost (Table 1). Likewise, a decreasing trend was recorded in some of the chemical parameters of vermicompost, in which the parameters like organic carbon, C/N ratio and pH were having higher values was found to be 17.3, 15.3 and 7.40 respectively, on day 90. This clearly indicates that due to mineralization and decomposition due to earthworms and microbes the values of NPK increased and that of organic carbon, C/N ratio and pH decreased.

The higher trend of both total and organic N in the present vermicompost processed by earthworms (Balamurugan et al., 1999) was due to the decomposition and mineralization of organic substrate (Kaushik and Garg, 2003) as well as conversion of $\text{NH}_4\text{-N}$ to NH_3 (Suthar and Singh, 2008). Furthermore, the N contents of vermicompost were enhanced by earthworms during digestion by addition of nitrogenous products, body fluid and enzymes in the vermicomposting system (Suthar, 2007). Likewise, the increasing trend in both extractable P and total P levels in final vermicompost may be due to the P mineralization in which earthworms and other P solubilizing microbes convert insoluble P into soluble form through phosphatases present in the gut of earthworms (Suthar and Singh, 2008). Similarly, the increasing K content of the end product of vermicompost was due to physical decomposition, biological grinding and some enzymatic activities by earthworms (Rao et al., 1996). Delgado et al. (1995) also found increasing trend of K concentration in vermicompost. Compared to the known standard values, in the current vermicompost, the total organic C showed a minimum values at day 90 and it is because during mineralization and microbial respiration the organic C start to loss as CO_2 to the atmosphere which consequently increased the total N (Crawford, 1983). Similarly, a portion of the released CO_2 was also stored in microbial biomass (Cabrera et al., 2005; Fang and Wong, 2001) which is used as an energy source by these microbes for the decomposition of organic matter. On the other hand, compared to standard values, we observed a reduction in pH that might be due to mineralization and decomposition in which the microbes release different acids and help in lowering the pH. This study is in consistency with Suthar and Singh (2008) and Ndegwa et al. (2000) but several researchers have also shown contradictory reports (Kale et al., 1982).

Similarly, an increase in the moisture content of vermicompost is also presented in Table 1.

Table 1 Physico-chemical properties of vermicompost

| Parameters | Unit | AR (w/w) |
|---|------|----------|
| pH (24°C) | -- | 7.40 |
| Ec (24°C) | dS/m | 3.90 |
| Org. Matter. (70°C- 550°C) | (%) | 46.50 |
| Moisture (70°C) | (%) | 47.70 |
| Organic Carbon | (%) | 17.30 |
| C/N | (%) | 15.30 |
| Total (humic+fulvic) (Rc:0.51) | (%) | 36,1 |
| Organic Nitrogen | (%) | 1.90 |
| Total Nitrogen (N) | (%) | 2.30 |
| Total Phosphorus Pentoxide (P_2O_5) | (%) | 2.20 |
| Soluble Potassium Oxide (K_2O) | (%) | 1.20 |

AR: Analysis Results



Figure 1 The compost piles covered with plastic for partial decomposition



Figure 2 The wooden boxes (1×1 m)



Figure 3 Separation of worms from the produced vermicompost

It is obvious from the recorded data that the percent moisture content of vermicompost was increasing as the earthworms were boosting the process. The moisture content of grasses brewed black tea leaf and dry leaf used for vermicomposting were 47.70% on day 90. In the current analysis, vermicompost samples (grasses, brewed black tea leaf and dry leaf) indicate maximum moisture content of 50% in comparison to the substrate used initially which may be because of the high moisture absorption capacity as well as assimilation rate due to microbes population showing the role of earthworms in organic waste degradation (Swati and Reddy, 2010). Furthermore, about 85% moisture content is essential for the better growth of earthworms and decomposition of organic waste (Edwards and Bater, 1992) because at optimum moisture level the rate of mineralization and microbial activities is high (Singh et al., 2004).

Conclusion

It is concluded that the naturally occurring earthworm specie *Eisenia Fedita* can be used efficiently for the conversion of different field residues, grasses, wastes and manure into high quality, eco-friendly vermicompost at the Niğde district of Turkey. The vermicompost produced in the current study was rich in macro and some micronutrients with high water holding capacity and moisture content and can be suggested to farmers as alternative to chemical fertilizers for improving crop growth and production. Further studies are suggested with the current vermicompost for improving different crops growth in both pot and field conditions in different agroecological conditions. Furthermore, vermicomposting can also be suggested as an extra source of income through selling the vermicompost and worms for farm business purposes.

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