PERFORMANCE OF DIFFERENT SPECIES OF EARTHWORMS ON VERMICOMPOSTING

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Abstract

The main objective of this study was to evaluate the performance of different species of earthworm viz., P. excavatus, E. eugeniae and E. fetida on vermicomposting. In this study, growth performance of worms and physico-chemical characteristics of vermicompost were examined with time span of vermicomposting. The worm P. excavatus showed better growth performance during the process of composting. The pH of vermicompost went down ranging from 7.03 to 7.33 while EC went up and ranged from 1.75 ds-m⁻¹ to 2.25 ds-m⁻¹ during the process of vermicomposting. The levels of major nutrients were recorded in increasing order while levels of organic carbon and C:N ratio recorded in decreasing order across different intervals irrespective of the treatments. Vermicompost of E. eugeniae had highest concentrations of nitrogen (2.04%), phosphorus (1.64%), potassium (1.32%) and organic carbon (28.5%) with lowest C:N ratio (14:1). This study suggests that the E. eugeniae could be used efficiently to produce good quality vermicompost.

Keywords: Nutrients, earthworms, vegetable waste, vermicompost

1. INTRODUCTION

The rampant use of inorganic fertilizers is one of the major factors leads to environmental deterioration. Continual use of such imbalanced fertilizers in agriculture affects both soil fertility and agricultural productivity. Organic fertilizer could be used as an alternative source of plant nutrients in crop production to reduce the impacts of chemical fertilizers on environment and human health. However, nutrient concentrations of such organic fertilizers are very low and thus required in large quantities to satisfy crop requirements. For an instance, garden compost consists of 0.8%, 0.35% and 0.48% of nitrogen, phosphorus and potassium respectively (Nagavallemma et al., 2004). Moreover, nutrients in compost are not readily available to the plants. It is therefore essential to find out an alternative nutrient source which could be used in eco-friendly manner without affecting crop yields. Wani et al. (1995) stated that the adoption of ecological and sustainable farming practices can only reverse the declining trend in the global productivity and environment protection.

Vermicompost is one of the plant nutrient sources produced through decomposition process of organic wastes in which earthworms ingest organic wastes and eventually excrete dark colour, odourless casts. This method of composting is much different from traditional method of composting and can be conducted all year-round, providing suitable environmental conditions. Since vermicompost consists mostly of worm casts and some decayed organic matter, it could be used as an excellent soil conditioner in crop production than traditional compost. Maheswarappa et al. (1999) stated that application of organic matter including vermicompost favourably affects soil pH, microbial population and soil enzyme activities. In addition, earthworms are being used for safe disposal of certain organic wastes in many countries in the world as earthworms act as natural bioreactor.

There are nearly 4,400 species of earthworms have been identified in the world. However, only few of these earthworms are used in vermicomposting. In broad, earthworms can be
classified as soil dwelling worms and compost worms. Soil worms eat soil minerals and some organic matter in the soil or on its surface while compost worms prefer an environment of decaying organic matter rather than soil. The growth rate and tolerance level to environmental changes differ from species to species in vermicomposting. And the quality of final compost is also affected by the species of worm used in decomposition process. This study is therefore aimed to find out most efficient species of earthworm for vermicomposting by comparing the performance of different species of earthworms on composting of organic wastes.

2.1 MATERIALS AND METHODS

2.1 Collection of waste and pre-composting

Vegetable waste comprised of different leftover putrefied vegetables was collected from the vegetable market and air dried for three days. Thereafter, air dried waste was subjected to aerobic decomposition process. This pre-composted waste was used to produce initial substrate for worms.

2.2 Experimental design

Plastic trays were used as composting bin. In each tray, small holes were made at the bottom to facilitate good drainage and aeration. Three sets of plastic trays each set comprised of three replicates was used for each species of earthworm. Required number of adult worms of each species was obtained through vermiculture. The substrate for vermicomposting was prepared by mixing pre-composted vegetable waste along with fresh cow dung in 3:1 ratio. Each tray was filled with 6 kg of substrate. Thereafter, a total of fifty adult worms of Perionyx excavatus, Eudrilus eugeniae and Eisenia fetida were introduced into respective designated experimental trays. Each tray was covered with cotton cloth to protect the worms from predators. Temperature and moisture content were maintained by sprinkling water twice a day. The process of vermicomposting was carried out for 60 days.

2.3 Sample collection and physico-chemical analysis

Individual body length and weight were recorded at initial and at 60 days after process while total earthworm biomass, adult number, cocoon number and mortality rate were taken at the end of the experiment to evaluate the growth performance of different worms in the process of vermicomposting. From each replicate, about 200 g of sample was taken non-destructively at 0, 15, 30, 45 and 60 days of process and analyzed for nitrogen (N), phosphorus (P), potassium (K) and organic carbon (OC). Electrical conductivity (EC) and pH of harvested vermicompost were also recorded at the end of the process. The N content was determined by Kjeldahl method while P and K were estimated by calorimetric method and flame photometric method respectively. The OC was determined by Walkley-Black method. The pH and EC were estimated by a digital pH and conductivity meter respectively.

2.4 Statistical analysis

The data were analyzed by analysis of variance (ANOVA) and means were compared by Turkey’s test at 5% probability level. Microsoft Excel software package was used for easy interpretation of the results.

3. RESULTS AND DISCUSSION

3.1 Growth performance of earthworms

The data on growth performance and productivity of P. excavatus, E. eugeniae and E. fetida are given in Table 1. The present study showed that the individual body weight increased by 285% in P. excavatus, 212.5% in E. eugeniae and 282.7% in E. fetida whereas length increased by 58.5%, 19.4% and 29.8% respectively. The highest total biomass gain observed in P. excavatus (2582.2%) followed by E. fetida (2068.4%) and E. eugeniae (1330.5%). Further, it was observed that P. excavatus produced 62.4% higher number of cocoons than that of E. eugeniae and 37.1% higher than that of E. fetida whereas it produced 35.5% higher number of adult worms than E. eugeniae and 10.3% higher than that of E. fetida. The mortality rate of P. excavatus was 83.3% higher than that of E. eugeniae and 14.5% higher than E. fetida.

Pre-composted vegetable waste mixed with cow dung increased individual body weight, body length and reproduction activity in all treatments during the process of vermicomposting. Suthar (2007) found that the waste decomposition and earthworm production was associated strongly with the quality of the substrate, especially with their chemical as well as biological composition. Incorporation of fresh cow dung with pre-composted wastes may enhance the production of juveniles and provide easily digestible nutrients to
the worms. Siddique et al. (2005) also stated that cattle manure is an excellent food source for earthworm. Suthar and Singh (2008), while studying vermicomposting, observed that earthworms when introduced into organic wastes shows an increased growth rate and reproduction activity. This study also revealed that among three species of worms, *P. excavates* showed better growth performance and reproduction activity. The results are in accordance with earlier work done by Garg et al. (2006). However, it was found that mortality rate of *P. excavates* was high during the process of vermicomposting. Higher rate of mortality in *P. excavates* could be related to the species-specific in composting or to specific tolerance level in change in micro environmental conditions in vermiited (Suthar and Singh, 2008).

### 3.2 Physico-chemical characteristics

#### 3.2.1 pH

The maximum pH value (7.33) was observed in vermicompost of *E. eugeniae* while minimum pH value of 7.03 was found in vermicompost of *P. excavates*. However, there was no significant variation (p<0.05) between pH values of vermicompost produced by all three species of worms (Table 2). The pH value of vermicompost in all the treatments was lower than the pH value of initial substrate. Production of organic acids and release of CO₂ during the process of vermicomposting might have attributed for reduction of pH. These observations were in conformity with those obtained by Bisen, et al. (2011); Kaushik and Garg (2004) and Viji and Neelanarayanan (2013). However, the present results are in contradiction to the findings of Nagavallemma et al. (2006) who found the higher pH in vermicompost than substrate.

#### 3.2.2 Electrical Conductivity (EC)

The EC values of all vermicompost were higher than the EC value of initial substrate. The increase in EC may be attributed due to formation of soluble salt during the process of vermicomposting. Villar et al. (1993) stated that release of soluble salt like ammonium and phosphate after the degradation of most labile compounds in the thermophilic stage increases EC in composting. Though, Tognetti et al. (2005) stated that release of exchangeable minerals such as Ca, Mg, K and P through degradation of organic matter increases EC. Further, the variations on EC values significantly varied (p<0.05) among the treatments (Table 2). The highest value of 2.25dsm⁻¹ was recorded in vermicompost produced by *E. eugeniae*. From this, it could be concluded that the species *E. eugeniae* released more exchangeable Ca, Mg, K and P which are in available form than other two species of worms.

#### 3.2.3 Nutrient content

It was found that the nutrient content significantly varied (p<0.05) among the treatments (Table 2). The amount of major nutrients viz. N, P, K gradually increased in the process of vermicomposting whereas OC content and C:N ratio decreased gradually (Figure 1&2). This similar trend was also found by Suthar (2007) in the process of vermicomposting. The increment observed in the concentration of N, P and K probably due to mineralization of organic wastes. Kaushik and Garg (2003) stated that mineralization of organic matter containing proteins increases N content in vermicompost while Suthar and Singh (2008) stated that enhancement of N level probably due to conversion of ammonium nitrogen into nitrate. Earthworms increase N content of the substrate during digestion in their gut adding their nitrogenous excretory products, mucus, body fluid, enzymes and decaying dead tissues of worms (Suthar, 2007). Likewise, the worms during vermicomposting convert the insoluble P into soluble forms with the help of P solubilizing microbes through phosphatases present in the gut (Suthar and Singh, 2008). In addition, Dominguez and Edwards (1997) reported the general rise of total potassium in the final product in vermicomposting. However, present results contradict the results obtained by Elvira et al. (1998) who found lower content of K. It may be due to leaching of K while adding excess water into vermiished. The level of organic carbon and C:N ratio decreased with time during the process of vermicomposting. The organic carbon losses as carbon dioxide through microbial respiration and mineralization of organic matter causing increase in total N (Crawford, 1983 and Suthar, 2007).

The highest concentration of N (2.04%), P (1.64%) and K (1.32%) were found in the vermicompost of *E. eugeniae* followed by *E. fetida* and *P. excavates*. However, there were no significant differences on nutrient concentrations in the vermicompost of both *E. fetida* and *P. excavates*. The species *E. eugeniae*, in comparison with other two species of worms has high capability
of recovering nutrients from pre-composted organic waste in vermicomposting. The present results are corroborated with the results of previous works of Padmavathiamma et al. (2008). The high level of OC (28.5%) was found in the harvested vermicompost of E. eugeniae followed by P. excavates (22.07%) and E. fetida (21.67%). However, highest C:N ratio (19:1) was observed in vermicompost of P. excavates and it was low (14:1) in the compost of E. eugeniae. Higher C:N ratio indicates slower mineralization of substrate by the species (Haug, 1993).

4. CONCLUSIONS

In the present study, P. excavates showed better growth performance in vermicomposting. However, E. eugeniae showed better growth and nutrient recovery from the organic matter through efficient mineralization. Further, there was no significant variation in nutrient recovery level between E. fetida and P. excavates. From these results, it could be conclude that the E. eugeniae is more efficient species in vermicomposting.

5. REFERENCES

(Oryza sativa) straw (Pre-digested with Trichoderma viride) and Eudirlus eugeniae, Perionyx excavates and Lampito mauritii.


### Tables and Figures

#### Table 1. Growth performance of *P. excavates*, *E. eugeniae* and *E. fetida* during the process of vermicomposting

<table>
<thead>
<tr>
<th>Parameters</th>
<th><em>P. excavates</em></th>
<th><em>E. eugeniae</em></th>
<th><em>E. fetida</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual body weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial (g)</td>
<td>0.40±0.02</td>
<td>1.36±0.04</td>
<td>0.81±0.03</td>
</tr>
<tr>
<td>Final (g)</td>
<td>1.54±0.23</td>
<td>4.25±0.20</td>
<td>3.10±0.10</td>
</tr>
<tr>
<td>Weight gain (%)</td>
<td>285.0%</td>
<td>212.5%</td>
<td>282.7%</td>
</tr>
<tr>
<td>Individual length</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial (cm)</td>
<td>5.13±0.32</td>
<td>14.47±0.38</td>
<td>7.47±0.43</td>
</tr>
<tr>
<td>Final (cm)</td>
<td>8.13±0.26</td>
<td>17.27±0.61</td>
<td>9.70±0.26</td>
</tr>
<tr>
<td>Length increment (%)</td>
<td>58.5%</td>
<td>19.4%</td>
<td>29.8%</td>
</tr>
<tr>
<td>Total biomass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial (g)</td>
<td>20.17±0.88</td>
<td>68.17±2.24</td>
<td>40.33±1.30</td>
</tr>
<tr>
<td>Final (g)</td>
<td>541.0±13.31</td>
<td>975.17±14.97</td>
<td>874.5±10.68</td>
</tr>
<tr>
<td>Biomass gain (%)</td>
<td>2582.2%</td>
<td>1330.5%</td>
<td>2068.4%</td>
</tr>
<tr>
<td>Av. Cocoon number at the end</td>
<td>76.33±2.91</td>
<td>47.00±2.31</td>
<td>55.67±1.76</td>
</tr>
<tr>
<td>Av. Adult number at the end</td>
<td>304.00±4.73</td>
<td>224.33±5.36</td>
<td>275.67±4.33</td>
</tr>
<tr>
<td>Av. Mortality rate</td>
<td>0.55±0.11</td>
<td>0.30±0.15</td>
<td>0.48±0.12</td>
</tr>
</tbody>
</table>

Each value represents the mean (Mean ± S.E) of three replicates.

#### Table 2. Physico-chemical characteristics of vermicompost produced by *P. excavates*, *E. eugeniae* and *E. fetida*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Substrate</th>
<th><em>P. excavates</em></th>
<th><em>E. eugeniae</em></th>
<th><em>E. fetida</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.12</td>
<td>7.03±0.18</td>
<td>7.33±0.12</td>
<td>7.10±0.12</td>
</tr>
<tr>
<td>EC (dsm-1)</td>
<td>1.62</td>
<td>1.75±0.04</td>
<td>2.25±0.14</td>
<td>1.86±0.04</td>
</tr>
<tr>
<td>Nitrogen (%)</td>
<td>0.60</td>
<td>1.14±0.13</td>
<td>2.04±0.03</td>
<td>1.34±0.07</td>
</tr>
<tr>
<td>Phosphorus (%)</td>
<td>0.33</td>
<td>0.86±0.04</td>
<td>1.64±0.04</td>
<td>1.10±0.10</td>
</tr>
<tr>
<td>Potassium (%)</td>
<td>0.42</td>
<td>0.87±0.03</td>
<td>1.32±0.05</td>
<td>1.02±0.06</td>
</tr>
<tr>
<td>Organic Carbon (%)</td>
<td>68.40</td>
<td>22.07±0.99</td>
<td>28.50±1.25</td>
<td>21.67±0.66</td>
</tr>
<tr>
<td>C:N ratio</td>
<td>114:1</td>
<td>19:1</td>
<td>14:1</td>
<td>16:1</td>
</tr>
</tbody>
</table>

Each value represents the mean (Mean±S.E) of three replicates, Values on the same row with different superscript are significantly different (p<0.05).
**Figure 1.** Effect of different species of earthworms on N, P and K contents across different intervals

**Figure 2.** Effect of different species of earthworms on OC and C:N ratio across different intervals