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Biomanagement of Rose and carnation wastes in flower industries with three epigeic earthworm species: *Eisenia fetida, Eisenia andrie* and *Dendrobanae veneta*

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The horticulture sector in Ethiopia is being challenged by multifaceted hitches, among which managing excess wastes produced from the farms and minimizing the cost of inorganic fertilizers are the major ones. The performance of three epigeic earthworm species, *Eisenia fetida, Eisenia andrie* and *Dendrobanae veneta*, in managing flower (Rose and Carnation) wastes through vermicomposting was evaluated. The study was done using wastes collected from two flower farms, Dugda Flora (Debre Zeit) and Ethiopian Magical Farm (Legedadi). The wastes were pre-composted by mixing with cow dung and arranged in piles with 80 cm height and 1.5 m width under different treatments. The worms were introduced into the piles when the temperature and moisture of the piles was lowered to a level suitable for the worms. The physico-chemical variables of the vermicompost and size reduction of the wastes were evaluated at the beginning, middle and conclusion of the experiment. It took 3 months for all Rose wastes to be converted into vermicompost and 6 months for Carnation wastes. There could be multifaceted reason for the delay of Carnation, but the recalcitrant nature of the plant seems to be the main reason. Size reduction ranged from 49.6 to 87.5%, Total Nitrogen (TN) (1.43 to 2.5%), Available Phosphorus (P_2O_5) (1879 to 2600 ppm), Available Potassium (AV.K) (73.3 to 105.5 c mol(+)/kg), Carbon to Nitrogen ratio (C:N) (12:1 to 28:1) for Rose while TN ranged from 1.6 to 2.3%, P_2O_5 from 1867 to 2112 ppm, AV.K from 73.3 to 103 c mol(+)/kg, and C:N from 14.4:1 to 25:1 for carnation during the same study period. There was no significant variation in terms of the quality of vermicompost produced by the worms and between the waste types. The overall results showed that all the three worms can be employed to manage both types of wastes.

Key words: Earthworms, *Eisenia fetida*, *Eisenia andrie*, *Dendrobaena veneta.*

INTRODUCTION

Ethiopia ranked second in Africa in exporting cut flowers (Getu, 2009). The horticulture sector is growing rapidly in the country in the last two decades and hugely contributing to the Gross Domestic Production (GDP) of the country. It is also providing job opportunity to more than hundred thousands of Ethiopians, mainly females, throughout the country. However, the sector is currently being challenged by multifaceted hitches problems; among which is the management of excess wastes produced from the farms and minimizing the cost of inorganic fertilizers which are the major ones. Thus, managing these wastes at low capital, in eco-friendly,

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and environmentally harmonious ways has become the main issue of these farms recently (Manaf et al., 2009). There are over 100 flower growers on 1700 ha (Bogale, 2017) in the country and are producing, with rough estimation, between 500 to 3000 kg dry flower waste per day. Furthermore, they are expending at least 1USD per m^2 to buy inorganic fertilizers (Unpublished data). Such figures show how much the sector is being challenged in the country. Thus, managing these wastes at low capital, in eco-friendly, and environmentally harmonious ways along with producing biofertilizers have become the main issue of these farms recently (Manaf et al., 2009).

Nowadays, vermicomposting is being considered as an important means for managing solid wastes that have been applied in various parts of the world. This method is highly advantageous in decreasing the need for landfill space alongside successfully diminishing the volume of wastes. Concurrently, this technology produces excellent biofertilizer (vermicompost) which has an important role in sustainable agriculture (Sharma et al., 2005).

The main actors in vermicomposting process are earthworms and microorganisms. Earthworms consume biomass and excrete it in digested form called worm casts which are rich in nutrients, growth promoting substances, and having properties of inhibiting pathogenic microbes (Maheswari and Ilakkiya, 2015). Earthworms have physical and biochemical role in the vermicomposting process (Aalok et al., 2009); they grind the waste, aerate the substrate and the biochemical process produce vermicompost (Frederickson et al., 1998).

Hitherto, earthworms have been employed and were able to successfully manage wastes such as garden waste (Dickerson, 2001), sludge and fibers (Garg et al., 2006), agricultural and domestic wastes (Handreck, 1986). These worms were also able to completely degrade vegetable waste, coffee husk and 'Khat' (Degefe et al., 2016). However, the performance of these worms in managing wastes of cut flowers has never been evaluated locally as well as internationally. In this study, the appropriateness and efficiency of three earthworm species; *Eisenia fetida*, *Eisenia andrei* and *Dendrobaena veneta* was investigated in managing wastes of Rose and Carnation flowers. These worms were preferred for vermicompost because they are resilient earthworms that can be readily handled and tolerate wider moisture and temperature ranges (Dominguez and Edwards, 2011). It was hypothesized that these worms can effectively manage cut flower wastes and produce good quality of soil amendments.

MATERIALS AND METHODS

Experimental design

Wastes were collected from the farms; Dugda flora (Debre Zeit) and Ethiopian Magical Flora (Legedadi). The wastes were chopped, mixed with cow dung in 3:1 ratio and 24 piles with eight treatments (in triplicate) and were established separately for each type of wastes. Each pile had 1.5 m width and 0.8 m height (approximately 40 kg). The piles were pre-composted so as to stabilize the substrate in terms of pH, temperature and moisture following the procedures of Azizi et al. (2014) and watered considering the optimum moisture level (70%) at frequent interval until the day of worm introduction. The three worms; *E. fetida*, *E. andrei* and *D. veneta* were introduced to the piles, except in the controls, when the temperature lowered (< 27°C). Introduction of worms considered optimum feeding rate of 0.75 kg feed/kg worm/day (Ndegwa et al., 2000). The synergetic effect of efficient microorganisms (EM) with the worms in managing these wastes was also assessed by inoculating them in the piles and measuring the changes in physico-chemical parameters. After the introduction of worms, the treatments were labelled as T1 (*E. andrie*), T2 (*D. veneta),* T3 *(E. fetida),* T4 (Control), T5 (Control + EM), T6 (*E. andrie* + EM), T7 (*D. veneta*+ EM) and T8 (E. *fetida* + EM). The experimental setup was similar for both types of waste.

Physico-chemical analysis

The height of each pile was measured at the end of the experiment (at Dugda Farm) and compared with the initial so as to observe the efficiency of the worms in reducing the height of waste piles. Initial samples were taken from each treatment piles before introduction of the worm and at the end of the experiment sent to laboratory for physico-chemical analysis. Moisture level was determined using AOAC Official Method 923.10 while pH was determined using FAO potentiometric–water extract procedure. Total nitrogen was determined using Kjeldahl method (Bremner and Mulvaney, 1982), available phosphorous determined using Olson (1963) and available potassium determined using ammonium acetate extract (Garg et al., 2005). TOC was measured after igniting the sample in a Muffle furnace at 550°C for 50 min by the method of Nelson and Sommers (1982).

Statistical analysis

Data were analyzed using SPSS software 15 version. Analysis of variance was used to analyze the significance in variation in the physico-chemical parameters between the treatments in each site.

RESULTS AND DISCUSSION

The worms in both (Rose and Carnation) treatment piles, were able to survive and successfully multiply; however, the rate of vermicomposting process was not uniform. The size of the piles was more reduced at Rose wastes (Tables 1 and 2) than at Carnation. The overall vermicomposting process took three months at Rose waste while it took nearly six month for Carnation waste. The change in height of the piles at the end of the experiment is presented in Tables 1 and 2. The reduction ranged from 78.75 to 87.5% in the piles where worms were introduced, whereas it was 49.25% for the control and 51.25% for control with EM. The highest reduction was observed in the pile with *D. veneta* worm with EM, although there was no significant variation statistically ($P>0.05$), and the lowest in the control. The overall result

Table 1. Height reduction of the piles during the vermicomposting process of Rose waste.

Treatment	Initial Height (cm)	Final height T1 (cm)	Final height T2 (cm)	Final height T3 (cm)	Average height (cm)	Reduction (%)
E. andrie	80	15	16	16	15.6	80.5
D. veneta	80	10	11	10	10.3	87.1
E. fetida	80	16	16	17	16.3	79.5
Control	80	38	41	43	40.6	49.25
Control + EM	80	41	40	36	39	51.25
E. andrie + EM	80	19	17	18	17	78.75
D. veneta + EM	80	10	10	10	10	87.5
E. fetida + EM	80	15	17	14	15.3	80.3

Table 2. Height reduction of the piles during the vermicomposting process of Carnation waste.

Treatment	Initial Height (cm)	Final height T1(cm)	Final height T2 (cm)	Final height T3 (cm)	Average height (cm)	Reduction (%)
E. andrie	80	25	26	22	24.3	69.2
D. veneta	80	28	26	27	26	67.5
E. fetida	80	21	23	22	22	72.5
Control	80	45	47	44	45.3	43.4
Control + EM	80	44	48	40	44	45
E. andrie + EM	80	23	20	27	23.3	70.8
D. veneta + EM	80	29	29	26	28	65
E. fetida + EM	80	26	25	24	25	68.7

showed that the worms were able to reduce the size of the pile highly in Rose waste. Unlike in Rose waste, the height reduction of waste was lower for Carnation during the vermicomposting process. The reduction ranged from 65 to 72% for the piles with the worms. The variation in reduction was not statistically significant ($P>0.05$) among the treatments.

Change in physico-chemical parameters during the vermicomposting process for the Rose and Carnation waste

The physico-chemical analysis showed that there was significant increment of TN, P_2O_5 and AV.K while C:N ratio reduced in all the treatments. Nitrogen level was slightly higher in T3 and T6 which implied that *E. fetida* can contribute more N than other worms particularly when synergistically used with EM (Figure 1); however, the variation was not statistically significant ($P>0.05$). Phosphorous content was also increased during the vermicomposting process in all the treatments (Figure 1). The increment rate was not uniform among the treatments, although it was not significant. More increment was observed in *D. veneta* and *E. fetida* piles with EM. As in the Rose waste, increment in TN, P_2O_5 and AV.K concentration and reduction of C:N ratio was observed in all the treatments for the Carnation waste. Generally, total nitrogen and available phosphorus was observed to be relatively lower in Carnation waste compared to Rose waste, although the difference was not statistically significant. Similarly, the rate of reduction of C:N ratio was more pronounced in Rose waste than Carnation. The final concentrations of total nitrogen, available phosphorous and potassium concentration were slightly higher in *E. andrie* and *E. andrie* + EM piles than other treatments, though it was not statistically significant (Figure 2). The reduction of C:N ratio in vermicompost was also relatively higher in these piles.

The higher reduction of volume of waste for both types of waste implied that all the three worms can be employed in managing the waste. However, the vermicompost process seems to be rapid for Rose waste than Carnation. The increase in nitrogen, phosphorus and potassium concentration was a common phenomenon for other types of wastes such as vegetables during vermicomposting process and similar results were observed by earlier researchers. For example, Azizi et al. (2014) observed an increasing trend in nitrogen and potassium concentration for vegetable and paddy straw wastes. Similarly Chauhan et al. (2010) reported similar trends of nutrient concentration for N, P and K in vegetable wastes. The higher concentration of TN in the produced vermicompost from both types of

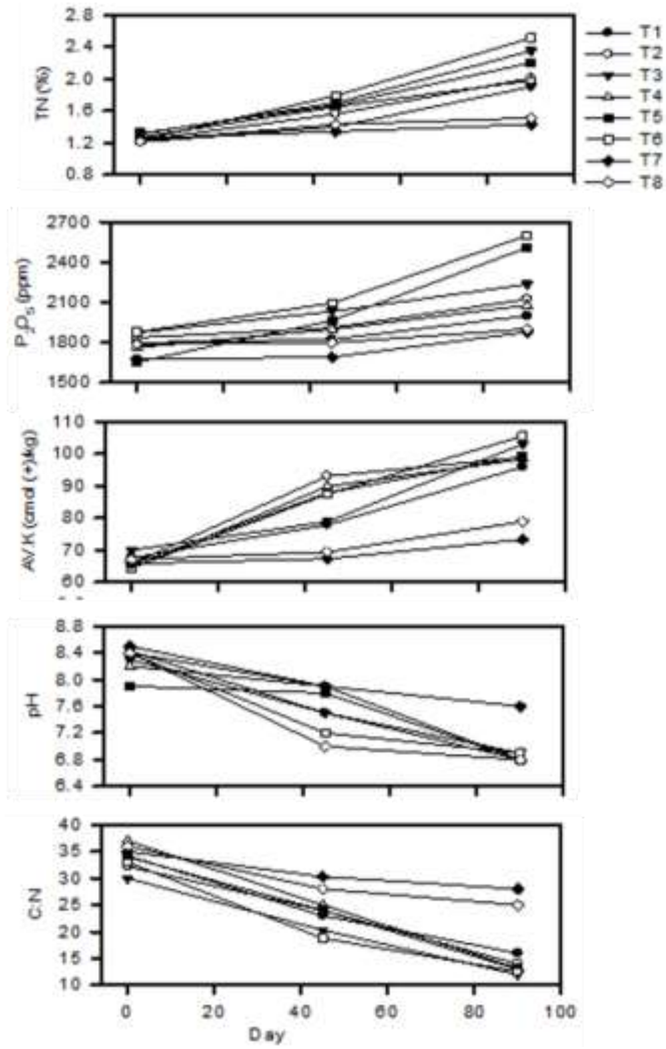

Figure 1. Changes in chemical variables during vermicomposting process in the rose waste. TN: Total Nitrogen, P_2O_5: Available Potassium, AV.K: Available Phosphorus, C:N: Carbon to Nitrogen ratio.

wastes can be attributed to minerazation of carbon rich materials, which could be facilitated by microbes, and the role of nitrogen fixing bacteria (Plaza et al., 2008). High level of nitrogen can also have been contributed by earthworms through the excretion of ammonia (Ansari and Rajpersaud, 2012). The phosphorus increase during vermicompost process can be attributed to mobilization and mineralization of phosphorus due to bacterial and fecal phosphatase activity of the worms (Asnari and Ismail, 2008).

Reduction trend in C:N during the process of vermicomposting is also a common phenomenon and observed by many researchers (Sharma et al., 2005; Ansari and Rajpersaud, 2012). The overall quality of the vermicompost produced from both waste was with high-quality in terms of nutrient content and C:N ratio and it is within the standard level for vermicompost (MoFARA, 2016). However, the rate of waste conversion by the worm was slower in Carnation wastes. While there could be multifaceted reason for the delay, the recalcitrant nature of the plant seems to be the main reason as the environmental condition was maintained at similar level for both experiments at both flower wastes. Therefore, further research should be conducted to confirm or refute this hypothesis and the cellulose and lignin content of the plants should be determined.

Conclusions

All the three worms used in this study were able to manage both types of wastes; however, their performance

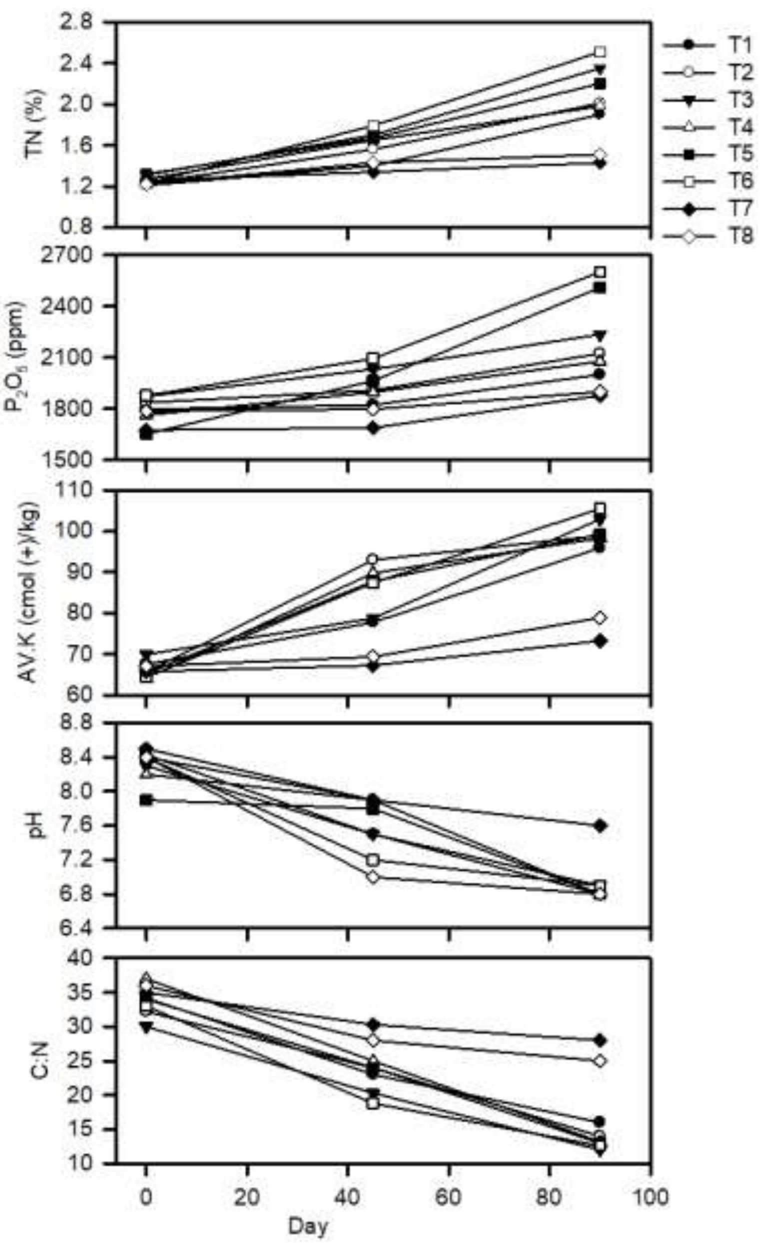

Figure 2. Changes in physico-chemical variables during vermicomposting process in the Carnation waste. TN: Total Nitrogen, P_2O_5: Available Potassium, AV.K: Available Phosphorus, C:N: Carbon to Nitrogen ratio.

and time taken in managing the wastes varied depending on the nature of the waste material. The rate of waste conversion by the worms was more brisk on Rose wastes than on Carnation. However, there was no significant variation among the quality of vermicompost produced by the worms in terms of nutrient content and C:N ratio. Therefore, it can be concluded from this study that all the three worms can be employed to manage both Rose and Carnation; however, managing the Carnation waste need relatively longer period. Also, the application of Efficient Microorganisms (EM) hastened the vermicomposting process.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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