Performance of Three Epigeic Earthworm Species, *Eisenia fetida, Eisenia andrie* and *Dendrobanae veneta*, in Managing Rose and Carnation Wastes in some Selected Ethiopian Flower Farms

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Abstract

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 1.5m 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 at the end of the experiment. It took 3 months for all rose wastes to be converted into vermicompost while it took 6 months for carnation wastes. Size reduction ranged (from 49.6 to 87.5%), total nitrogen (TN) (1.43 to 2.5%), available phosphorus (P_2O_5) (1879 to 2600ppm), Available Potassium (AV.K) (73.3 to 105.5 cmol(+)/kg), carbon to nitrogen ratio (C:N) (12:1 to 28:1) for rose while TN ranged (1.6 to 2.3%), P_2O_5 (1867 to 2112 ppm), AV.K (73.3 to 103 cmol(+)/kg), C:N (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; however, the process of vermicompost was delayed for carnation. There could be multifaceted reason for the delay but the recalcitrant nature of the plant seems to be the main reason. 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 from Africa in exporting cut flowers (Mulugeta Getu, 2016). 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 for females, throughout the country. However, the sector is currently 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. Thus, managing these wastes at low capital, in eco-friendly, and environmentally harmonious ways have become the main issues of these farms recently (Manaf *et al*., 2009).

Now days, vermicomposting is being considered as an important means in solid waste management that have been applied in various parts of the world. This method is highly advantageous in decreasing the need for landfill space along with 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' (Gezahegn 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).

Material 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 twenty four piles with eight treatments (in triplicate) 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; *Eisenia fetida*, *Eisenia andrei* and *Dendrobaena 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 Efficient Microorganisms (EM) with the worms 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 experiment (at Dugda Farm) and compared with 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 and sent to laboratory for physico-chemical analysis. Moisture level was determined using AOAC Official Method (AOAC, 1999) while pH was determined FAO potentiometric – water extract procedure (APHA, 1999). Total nitrogen (TN) was determined using Kjeldahl method Bremner and Mulvaney procedure (1982), available phosphorous (P_2O_5) using Olsen (1963) and available potassium (AV.K) 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

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 where as 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 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

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 (Table 3); however, the variation was not statistically significant ($P>0.05$). Phosphorous content was also increased during the vermicomposting process in all the treatments (Table 3). 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. Alike 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 relatively to be 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 TN, P_2O_5 and AV. K were slightly higher in *E. andrie* and *E. andrie* + EM piles than Other treatments (Tables 3 and 4), though it was not significant statistically. The reduction of C:N ratio in vermicompost was also relatively higher in these piles.

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 in percentage
E. andrie	80	15	16	16	15.6[a]	80.5
D. veneta	80	10	11	10	10.3[a]	87.1
E.fetida	80	16	16	17	16.3[a]	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[a]	78.75
D. veneta + EM	80	10	10	10	10[a]	87.5
E.fetida + EM	80	15	17	14	15.3[a]	80.3

Data on the same column marked with the same letter index ([a]) do not differ significantly statistically ($P > 0.05$)

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 in percentage
E. andrie	80	25	26	22	24.3[a]	69.2
D. veneta	80	28	26	27	26[a]	67.5
E.fetida	80	21	23	22	22[a]	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[a]	70.8
D. veneta + EM	80	29	29	26	28[a]	65
E.fetida + EM	80	26	25	24	25[a]	68.7

Data on the same column marked with the same letter index ([a]) do not differ significantly statistically ($P > 0.05$)

Table 3. Changes in chemical variables during vermicomposting process in the **rose waste** (Abbrevation are described in the methodology)

Treatment	Total Nitrogen (%)			P_2O_5(ppm)			Av.K (cmol (+)/kg)			pH			C:N		
	Day 0	Day 45	Day 90	Day 0	Day 45	Day 90	Day 0	Day 45	Day 90	Day 0	Day 45	Day 90	Day 0	Day 45	Day 90
T1	1.21	1.4	1.9	1797.5	1823.2	2000.2	67.6	77.8	95.9	8.40	7.9	6.8	34.2:1	23:1	16:1
T2	1.23	1.56	2.01	1836	1909	2123	65.7	93.0	98.9	8.43	7.5	6.8	32.2:1	24:1	14:1
T3	1.31	1.7	2.35	1873	2032	2235	70.0	78.8	102.9	8.3	7.5	6.9	30:1	20.3:1	12:1
T4	1.27	1.65	1.98	1763	1898	2078	64.3	89.8	98.3	8.2	7.9	6.8	37:1	25:1	13.2:1
T5	1.32	1.67	2.2	1654	1964	2509	65.4	87.8	99.3	7.9	7.8	6.8	34:1	24:1	13:1
T6	1.23	1.79	2.51	1878	2094	2600	64.4	87.4	105.5	8.4	7.2	6.9	33:1	18.8:1	12.6:1
T7	1.26	1.34	1.43	1676	1690	1878	65.8	67.3	73.3	8.5	7.9	7.6	35:1	30.3:1	28:1
T8	1.22	1.43	1.51	1787	1798	1900	67.1	69.4	78.9	8.4	7.0	6.8	36:1	28:1	25:1

Table 4. Changes in chemical variables during vermicomposting process in the **carnationwaste** (Abbrevation are described in the methodology)

Treatment	Total Nitrogen (%)			P_2O_5(ppm)			Av.K (cmol (+)/kg)			pH			C:N		
	Day 0	Day 45	Day 90	Day 0	Day 45	Day 90	Day 0	Day 45	Day 90	Day 0	Day 45	Day 90	Day 0	Day 45	Day 90
T1	1.64	1.9	2.3	1743	1898	2100.2	71.1	89.9	103.	7.8	7.2	6.9	29:1	21:1	15:1
T2	1.58	1.7	1.81	1786	1809	1974	72.7	87.0	90.9	7.7	7.4	6.9	28:1	23:1	18:1
T3	1.59	1.76	1.87	1745	1789	1835	70.0	86.8	95.0	8.1	7.4	7.2	28.5:1	24.3:1	17:1
T4	1.59	1.70	2.1	1721	1907	2112	69.8	89.8	101.	7.9	7.5	7.0	28.7:1	20:1	14.4:1
T5	1.63	1.7	1.8	1676	1773	1867	75.4	89.2	91.3	7.7	7.3	6.9	29:1	22:1	19:1
T6	1.67	1.79	1.83	1709	1879	1984	71.4	77.4	85.5	8.0	7.3	7.0	30:1	24:1	19.6:1
T7	1.56	1.64	1.67	1645	1656	1700	69.1	71.3	73.3	7.9	7.4	7.1	29.3:1	27:1	25:1
T8	1.68	1.73	1.75	1743	1799	1899	70.7	70.9	72.9	7.7	7.3	6.9	29:1	25:1	22:1

Discussion

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 researcher. 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 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 be contributed by earthworms through 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 was by the worm was slower in carnation wastes. There could be multifaceted reason for the delay but 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 work should be done to confirm or refute this hypothesis and the cellulose and lignin content of the plants should be determined.

Conclusion

All the three worms used in this study were able to manage both types of wastes, however, their performance and time taken in managing the wastes was variable 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. The application of Efficient Microorganisms (EM) hasten the vermicomposting process

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Authors Contribution

Gezahegn Degefe was responsible for initiating the research, setting up the field work, write up the report and editing the document. Girum Tamire was responsible for sampling work, analyzing and interpretation the data and preparation of the manuscript.

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