A COST EFFECTIVE MIXTURE FOR REARING OF EARTHWORMS (*EISENIA FETIDA*) FOR LOCAL FARMERS IN SRI LANKA

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ABSTRACT

Eisenia fetida is the most utilized worm species in worm composting and organic gardening. However, population of this important species is gradually decreasing in agricultural fields due to land degradation and excess usage of pesticides and inorganic fertilizers. Moreover, the commercial availability of this species in Sri Lanka is limited. This research attempted to develop a cost effective earthworm rearing method for farmers. Six low cost easily available materials i.e. straw, kitchen waste, market refuse, poultry manure (with bedding material), cow dung, and garden refuse, mixed with top soil were used along with top soil alone (as the control) as treatments and treatments were arranged in a Completely Randomized Design (CRD) with four replicates. Each treatment used two juvenile earthworms. Number of worms, length, weight, survival rate of earthworms, pH and N content of each mixture were recorded once a month. In addition, number of days taken for the clitellum to be appeared, colour change of the clitellum, and first hatchling were also recorded. Results showed a significant difference between the treatments for weight, length, number of days taken for the clitellum to be appeared, and number of earthworms. The most cost effective treatment for population increase was the medium consisting of top soil and cow dung. In contrast, the fastest clitellum appearance was observed in the medium consisting of top soil and straw. The lowest growth was recorded in medium where top soil was solely used and when it was mixed with poultry manure. This study concludes that the mixture consisting of top soil and cow dung is the best medium for rearing earthworms. This research implies that farmers could rear earthworms in easily available cost effective mixtures and these earthworms can be added to the soil to enhance the population of earthworms in agricultural fields. These farmers may also be able to act as a supplier of earthworms.

Key words: *Eisenia fetida*, cow dung, straw, cost effectiveness, multiplication

Introduction

Earthworms are a kind of macro animals that lives in the soil. The worms have millions of beneficial bacteria associated with them, both externally, on their skin, in the mucus secretions that keep them moist and also swarming internally inside their gut. These macro animals in the soils are considered to be interesting 'bio indicators', because they respond quickly to land-use changes and they can be used to monitor the effects of farming practices, landscape structures or transformations on the soil environment (Paoletti, 1999). Three groups of earthworms can be distinguished (Edwards and Lofty, 1977): Epigeic, Endigeia and Anecic. The epigeic group is the important group of earthworms as far as the agricultural production is concerned since they live in the superficial soil layers near the surface (Garg and Kaushik, 2005) and feed on un-decomposed plant litter. There are three species commonly available in Sri Lanka. There are *Periyonix excavates*, *Eudrilus eugeniae* and *Eisenia fetida*. The most common species of this group is *Eisenia fetida* (Reinecke A.J. et. al., 2002) and it is the most utilized worm species in vermicomposting and in organic gardening.

Earthworm burrows persist as macro pores which provide low resistance channels for root growth, water infiltration, and gas exchange (Kladivko and Timmenga, 1990). They enhance soil aggregation (Shipitalo and Protz, 1989) and increase the amount of nitrogen mineralized from organic matter in soil (Ruz Jerez et al., 1988). Finally it has been shown that in the presence of earthworms shoot biomass of plants can be increased as much as by 79% (Scheu, 2003). However, Scheu, (2003) has also showed a large numbers of earthworms are needed in the soils to obtain a significant improvement in yields.

However, earthworm populations in agricultural soils are affected greatly by many of the main agricultural practices; in particular cultivation practices (Edwards and Lofty, 1977) inorganic fertilizers (Edwards, 1983), excess usage of pesticides

(Doran and Werner, 1990). It has been shown that if the population of earthworms can be increased in agricultural soils the productivity of agricultural fields could be improved significantly in an environmental friendly manner. It has also been shown that earthworms multiplied somewhere else can be added to the agricultural fields to improve the productivity. Thus if the farmers themselves could multiply the earthworms, using cost effective methods the productivity of the lands could be significantly improved.

The purpose of this research was to study the multiplication of *Eisenia fetida* which is the commonly available earthworm species in Sri Lankan soils using a simple cost effective method. The objectives of this research were to compare the effectiveness of the selected low cost and easily available mixtures in multiplication of *Eisenia fetida* and to compare the cost of each mixture for rearing the selected earthworm species. The next section of the paper describes the methodology of the paper followed by a section on results and discussion. Finally paper draws the conclusions the study.

Methods

Treatments and Experimental Design

This experiment was conducted at Dept. of Zoology, Faculty of Science, University of Colombo during the period from February to August 2015. The study used seven easily available waste materials mixed with top soil at the ratio of 1:1 (Table 2.1) as treatments. The treatments were replicated four times and arranged in a Completely Randomized Design (CRD). The results were subjected to ANOVA and the means were compared using the Duncan's New Multiple Range Test (DNMRT).

Table 2.1: Treatments

Treatments	Composition of the Mixture
T_1	Top soil only – control
T_2	Top soil + straw
T_3	Top soil + kitchen waste
T_4	Top soil + market refuse
T_5	Top soil + poultry manure (with bedding material)
T_6	Top soil + cow dung
T_7	Top soil + garden refuse

The treatment composition was taken 1:1 ratio (except T_1 treatment)

Procedure

The mixtures given above were added to dark plastic containers (diameter - 19.5 cm and height 12.5 cm) and were sealed using black polythene (gauge 200) after adding approximately 200 ml of water. After four weeks of incubation, two juvenile of earthworms were placed in each container. Approximately 20 ml of water was added to each container daily and approximately 20 g of relevant mixture was added to each container once a fortnight.
Number of worms, length and weight, survival rate of earthworms, pH and N content of each mixture were recorded once a month. In addition, number of days taken for the clitellum to be appeared, colour change of the clitellum, and first hatchling were also recorded.

Results And Discussion

Growth Parameters of Earthworms

Table 3.1 depicts the comparison of the mean values of weight and length at four months after introducing them into different mixtures. The results show that weight, length and the multiplication of earthworms are significantly affected by different growing mixtures. The highest weight (0.25g) and length (7.90cm) of the earthworms were observed when top soil is mixed with cow dung and they are significantly different from other treatments. The lowest weight was observed when top soil was solely used and it was not significantly different when top soil is mixed with poultry manure. In contrast the lowest length of earthworms was observed in the treatment where top soil was mixed with poultry manure.

Table 3.1 Effects of Different Substrate on Weight and Length of Earthworms

Treatments	Weight (g)	Length (cm)
T_1	0.1012^{a}	5.13^{bc}
T_2	0.2275^{c}	6.60^{f}
T_3	0.1725^{b}	5.50^{e}

T_4	0.1638^b	5.36^{cd}
T_5	0.1125^a	4.90^a
T_6	0.2513^d	7.90^g
T_7	0.2088^c	6.51^f

Cow dung contains several cellulose and lignin degrading microbes which help in initial degradation of the agro-wastes. Cow dung also contains simplified material which can be easily digested by worms. The higher growth rates of earthworms can be attributed to these factors in the mixture containing cow dung. These results are in consistent with Hand at al., (1988b) who have shown the suitability of cow slurry substrate for vermin-composting and the symbiosis relationship between *E. fetida* and micro organisms. According to Ismail (1997), carbon sources also affect to the thickness of earthworms. The second highest population was recorded in T_2 where straw has been used as the substrate. In contrast, Elvira et. al., (1996), found better growth rates of *E. andrei* when cow manure was mixed with straw than cow manure alone.

Reproductivity of Earthworms

Table 3.2 shows the reproductive characters of earthworms as affected by different substrate. The analysis shows that these characters are significantly affected by the different substrate used with top soil as bedding materials.

Table 3.2 Effects of Different Substrates on the Reproduction of Earthworms

Treatments	No. of Days Taken for Clitellum Appearance	No. of Days Taken for Changing the Clitellum Colour	No. of Days Taken for First Hatchling of Earthworms after Releasing
T_2	7.5^a	4.25^a	23.25^{ab}
T_3	16.5^d	34.50^b	54.25^e
T_4	16.75^d	46.25^c	65.25^f
T_6	11.0^b	4.25^a	25.5^a
T_7	15.0^c	4.25^a	33.0^c
T_1	*	*	*
T_5	*	*	*

*The clitellum did not appear during the research

T_2 treatment required minimum days for clitellum appearance among the treatments. T_6 treatment required more days for clitellum appearance than the treatment T_2. T_2 treatment was a good carbon resource that stimulates their reproductive organs at a faster rate (Tinouv and Scheu 2004). The T_4 and T_3 treatments had taken more time, and did not significant difference from each other because both treatments contain chemical residues that directly affects for the reproduction of the earthworms (Edwards and Bohlen, 1992) : (Mangala P. et. al., (2009).

Survivals and Population of Earthworms

Table 3.3 shows the population of earthworms as affected by different substrates. The analysis shows that these characters are significantly affected by the different substrate used with top soil as bedding materials.

Table 3.3 Effects of Different Substrates on the Survivals and Population of Earthworms

Treatments	Survival of Parent Earthworms (from 08.04.2015 – 10.08.2015)	Population of Earthworms at the end of the Research
T_1	2.0^b	2.00^a
T_2	2.0^b	23.75^d
T_3	2.0^b	8.00^b
T_4	2.0^b	8.25^b
T_5	1.5^a	1.50^a
T_6	2.0^b	41.00^e
T_7	2.0^b	18.25^c

The highest population was recorded in T_6 and it was significant difference from the rest of treatments. T_6 contained top soil and cow dung. The second highest population was recorded in T_2. The survival rate of T_5 recorded as the lowest. It contained top soil and poultry manure. Ammoniacal nitrogen of poultry manure, also known as total ammonia, is considered toxic to earthworms

(Edwards and Bohlen, 1996). The highest N amount (1.55 mg/100g) and lowest pH value (5.44) recorded in T_5 which contained poultry manure and top soil. T_2 and T_7 showed a lower population than T_6 but higher than the other treatments' population. The control had recorded pH 6.94.

Table 3.4 shows the N content and pH characters of different substrates. The analysis shows that these characters are significantly affected by the different substrate used with top soil as bedding materials.

Table 3.4 Effect of Different Substrates on the N amount and pH Values

Treatments	Nitrogen Amount of Treatments (mg/100g)	pH Value
T_1	1.39^{de}	6.94^{b}
T_2	0.67^{ab}	8.72^{e}
T_3	1.47^{e}	8.54^{d}
T_4	1.48^{e}	6.96^{b}
T_5	1.55^{f}	5.44^{a}
T_6	0.79^{bc}	7.43^{c}
T_7	0.75^{bc}	7.43^{c}

Cost Analysis

Table 3.5 depicts the cost of rearing earthworms (calculated for 100 earthworms) with different substrate for four months. The costs include the costs of substrate, topsoil, and labor cost collecting and watering. The results show that replacing top soil with any of the substrate except poultry manure is cost effective.

Table 3.5 Cost for each Earthworm Rearing Mixture

Treatments	Cost per 100 earthworms (Rs.)
T_1	112.50
T_2	5.3
T_3	101.34
T_4	21.12
T_5	114.66
T_6	3.95
T_7	8.70

The most cost effective treatment was the T_6 (top soil+ cow dung). Then it was followed by the T_2 (top soil+ straw) and T_7 (top soil+ garden refuse) treatments. The highest cost of rearing earth worm was observed in the treatment where topsoil was mixed with poultry manure (T_5).

Conclusions And Recommondations

This study demonstrates that earthworms can be reared using top soil as a bedding material with easily available and low cost substrates. The study also concludes that the best performing and the most cost effective earthworm rearing mixture was the treatment consisting of top soil and cow dung. Straw can also be a better substrate for rearing earthworms since it has higher carbon content which enhances the reproductivity of earthworms. However, there growth of the earthworms once they are released to the agricultural fields should be studied.

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