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Growth and reproduction performances of *Eisenia fetida* fed with different municipal waste materials

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ABSTRACT

The present research is designed to evaluate the growth and reproduction rate of *Eisenia fetida* on different organic substrates of municipal solid wastes. The aim of this paper was to identify the organic waste that provide maximum biomass gain and cocoon production. The growth and reproduction of *Eisenia fetida* was measured by studying parameters like gain in body weight, clitellum development, no. of cocoons and emergence of hatchlings. The study was designed with 6 treatments, each having three replicates. In control treatment (T_1), cow dung was used as the only food source for earthworm. In another five treatments, vegetable market wastes and fruit market wastes (T_2), hotel and restaurant food wastes (T_3), Garibnath temple wastes (T_4) and banana plant wastes (T_5) were used as food sources with cow dung as bedding material. The maximum weight gain of earthworm *Eisenia fetida* was (888 mg) for the food stuff of banana plant wastes (T_5) showed a very similar weight gain of 864 mg for the food stuff of belpatra leaves and floral wastes (T_4). The maximum cocoon number was observed in T_5 whereas, the minimum number in Control (T_1). The highest number of hatchlings were recorded in treatment 3 (T_2) whereas least number of hatchlings was observed in control (T_1). It was concluded that among the 5 different food sources, chopped banana plant sources were preferable food sources to the earthworm for growth and reproduction.

Keywords: *Eisenia fetida*, Municipal solid wastes, Vermicomposting, Biomass gain, Cocoon production

Introduction

In recent years, Vermicomposting from agricultural wastes and cattle dung is becoming a well described process in organic farming. In this process organic waste material get converted into useful fertilizer (vermicast) by using Earthworms (Verma and prasad, 2005) [1].

This technique can also be used to convert organic municipal wastes into value added product. It is used for mustering the carbon-based portion of community solid wastes for meeting crop nutritive requirements. Vermicompost can rejuvenate the soil by enriching essential components and minerals by increasing aeration, water holding capacity, high porosity and microbial activity. Vermicompost is the casting of earthworm which has a beneficial effect on soil health by enhancing their physical, chemical and biological properties which results in better agrarian production (Chatterjee et al., 2020) [2].

The current research is designed to evaluate the growth and reproduction rate of *Eisenia fetida* on different organic substrates of municipal organic solid wastes and determining the most suitable substrate for their growth for more than a year in laboratory. The main criteria for selecting the *Eisenia fetida* species for this experiment was the rapid growth and reproduction rate as well as a voracious feeder of organic wastes (Yahyaabadi, 2018) [3]. The growth and reproduction of earthworms depend on the food substrates they feed (Jicong et al., 2005) [4].

Material and methods

Study area

The experimental set up was installed at Gobarsahi, Muzaffarpur, Bihar, is located in India country in the district place category with the gps coordinates of 26.1197° N and 85.3910° E.

Raw materials

The different municipal organic substrates were collected from Chandwara dumping site, Muzaffarpur, Bihar. The cow dung was made available from local cow herder. The earthworm, *Eisenia fetida* species was procured from the Krishi Vigyan Kendra, Saraiya block, Muzaffarpur, Bihar. The materials used for vermicomposting were control treatment (T_1), cow dung was used as the only food source for earthworm. In an

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other five treatments, vegetable and fruit market wastes (T_2), hotel and restaurant food wastes (T_3), Garibnath temple Belpatra and floral wastes (T_4) and banana plant wastes (T_5).

Experimental design for determination of reproductive potential

The experiments were conducted in 15 vermi-bins. The solid organic wastes and cow dung were used in a ratio of 60:40 for better survival and growth of earthworms and microbes. Now, this mixture was allowed to pre-digest for about 15 days. [Partial digestion of waste materials made them suitable for earthworm consumption](#). After 15 days, 10 preclitellate *Eisenia fetida*, in good health condition, were taken and rinsed with distilled water for removing adhered materials, dried with tissue paper, weighed with digital balance and finally, introduced in each vermi-bin during evening hours. Regular sprinkling of water had been done to maintain 70 to 80% moisture content, which was essential for proper growth of earthworms. The bin was then covered with jute bags to avoid loss of moisture content and to protect from birds & insects. At a regular interval of 15, 30, and 45 days the bed material was turned upside down for proper digestion of organic waste materials.

Cocoon production rate determination

For determining reproductive potential of earthworm two freshly clitellated earthworm in a good health condition, were collected from bins and rinsed with distilled water, dried with tissue paper, weighed with electronic balance and introduced in different treatments. The substrate in each bin was examined daily in order to determine the beginning of cocoon production. Once the cocoons produced, they were separated by hand sorting, washed with distilled water and counted to determine the total number of cocoon and the reproductive rate.

Methods used to study cocoon incubation period and number of hatchlings

The substrates in each bin were examined weekly to determine the phases of the life cycle means hatched cocoons. After cocoon production 10 freshly laid cocoons from each treatment were taken and

placed in another container containing same substrates as their parent were placed and reared. Now, the containers in which the cocoons were placed observed daily to determine the emergence of hatchlings per cocoons. The hatchlings were removed daily using a paint brush and counted to determine the total number of hatchlings that had emerged from a single cocoon. The number of unhatched cocoons were also counted with the help of magnifying glass. Three replicates were prepared for each treatment to monitor growth and reproduction.

For determining biomass of earthworm

For determining biomass, the hatchlings were rinsed with distilled water, dried with tissue paper, weighed with digital balance and reared in different treatments. Three replications for each treatment were done. The bins were observed weekly to analyse maturation, three phases of life cycle were observed, pre-clitellate, clitellate and regression in which clitellum got lost as soon as clitellum appearance were identified the worms were weighed. On the basis of data obtained on the biomass of worm other parameters such as growth rate or biomass increase rate (g/earthworm /day), maximum weight achieved and net weight gain were calculated.

Statistical analysis

All the results presented here are mean of single measurements from each of the three replicates. The data were analysed using one way ANNOVA (analysis of variance).

Results

The effect of different organic waste substrates on the growth (weight gain) of *Eisenia fetida* is presented in Table 1. Earthworm biomass gain showed variation as it was recorded highest in T_5 (Banana plant waste) with 692.67 ± 0.57 mg, which was followed by T_4 (Temple Waste) with 670.00 ± 1.00 mg. In T_2 and T_3 treatments the growth was moderate showing mean weight gain of 608.67 ± 4.04 mg and 604.00 ± 1.73 mg respectively. The lowest weight gain was recorded in control with 465.67 ± 0.57 mg.

Table 1. Effect of different organic waste substrates on growth (weight gain) of *Eisenia fetida*

Treatment	Substrate type	Rep 1 (mg)	Rep 2 (mg)	Rep 3 (mg)	Mean weight gain (mg) $\pm$ SE	Significance group
T_1	Cow dung (Control)	466	465	466	465.67 ± 0.57	a
T_2	Vegetable & fruit waste	613	608	605	608.67 ± 4.04	b
T_3	Hotel & restaurant waste	605	605	602	604.00 ± 1.73	b
T_4	Temple waste (Belpatra & floral)	671	669	670	670.00 ± 1.00	c
T_5	Banana plant waste	693	693	692	692.67 ± 0.57	d

The effect of different organic waste substrates on cocoon production of *Eisenia fetida* is presented in Table 2. There were significant differences in cocoon production among different treatments. The highest mean cocoon production was recorded in T_2 (Vegetable and Fruit wastes) having 24.00 ± 1.00 cocoons, which was followed by T_5

(Banana plant waste) with 22.00 ± 1.00 cocoons. The cocoon production was moderate in T_3 (Hotel and restaurant waste) and T_4 (Temple waste) treatments with mean values of 19.00 ± 1.00 and 19.33 ± 1.53 cocoons respectively. The lowest cocoon production was recorded T_1 control with 16.00 ± 1.00 cocoons.

Table 2. Effect of different organic waste substrates on cocoon production of *Eisenia fetida*

Treatment	Substrate type	Rep 1	Rep 2	Rep 3	Mean cocoon production $\pm$ SE	Significance group
T_1	Cow dung (Control)	17	16	15	16.00 ± 1.00	a
T_2	Vegetable & fruit waste	23	25	24	24.00 ± 1.00	d
T_3	Hotel & restaurant waste	20	18	19	19.00 ± 1.00	b
T_4	Temple waste (Belpatra & floral)	19	18	21	19.33 ± 1.53	b
T_5	Banana plant waste	21	23	22	22.00 ± 1.00	c

(continued on next page)

T2 (d) → significantly highest cocoon production**T5 (c)** → significantly lower than T_2 , but higher than others**T3 & T4 (b)** → not significantly different**T1 (a)** → significantly lowest

The effect of different organic waste substrates on cocoon incubation period and the hatchling production of *Eisenia fetida* is presented in Table 3. Among different treatments, the incubation period varied from 24 to 28 days. The shortest incubation period was recorded in T_1

(Control) with 24 days, whereas, the longest incubation period of 28 days was observed in T_5 (Banana plant waste). T_2 (Vegetable and fruit waste), T_3 (Hotel and restaurant waste) and T_4 (Temple waste) showed a similar incubation period of 26 days.

The number of hatchlings also showed difference among substrates. The minimum hatchling, only 1 hatchling per cocoon was produced in T_2 (Vegetable and fruit waste), while the maximum hatchling, 5 hatchling per cocoon was observed in T_5 (Banana plant waste). The number of hatchlings produced per cocoon in T_1 (Control), T_3 (Hotel and restaurant waste) and T_4 (Temple waste) were recorded as 2, 3 and 4 respectively.

Table 3. Incubation period and number of hatchlings per cocoon of *Eisenia fetida* under different substrates.

Treatment	Substrate type	Incubation period (days)	No. of hatchlings per cocoon
T_1	Cow dung (Control)	24	2
T_2	Vegetable & fruit waste	26	1
T_3	Hotel & restaurant waste	26	3
T_4	Temple waste	26	4
T_5	Banana plant waste	28	5

Discussion

Many investigations have been done earlier by Sonia *et al.*, 2016 [5]; Ananthavalli *et al.*, 2019 [6]; Mashur *et al.*, 2021 [7]; Priya and Sudesh, 2022; Maharjan *et al.*, 2023 [5]; regarding various food sources in both natural habitats and vermicomposting units. Their findings confirmed that characteristics of substrate materials used in vermicomposting influence the growth and reproduction of earthworm like biomass gain, reproductive potential, no. of cocoon and hatchlings etc.

The present findings revealed that different municipal organic waste substrates significantly influence the growth, reproductive potential, cocoon incubation period and hatchling production of earthworm *Eisenia fetida*.

Among all substrates banana plant waste supported maximum biomass gain which suggest that banana plant waste is easily degradable, having high moisture content and rich in essential nutrients which supports favourable nutritional and physiochemical environment essential for earthworm growth. Banana waste contains high amount of easily degradable organic matter and essential nutrients which may enhance microbial activity which results in improving food availability for earthworms. Vermicompost of Temple waste also considered as a good substrate for high weight gain of earthworm.

Among all treatments, vegetable and fruit waste facilitated maximum cocoon production indicating that the substrate provides highly favourable environment for earthworm reproduction. Another substrate which showed high cocoon production was Banana plant waste as it might create an optimum environment for earthworm activity and reproduction.

Among different substrate medium for growth and reproduction the shortest incubation period was observed in control (Cow dung) which indicates that cow dung provides a favourable environment responsible for faster cocoon production as cow dung possess balanced moisture and microbial environment essential for embryonic development. Banana plant waste showed the longest incubation period but produced highest number of hatchlings per cocoon which suggests that although embryonic development require longer duration but, the conditions supported better survival and successful emergence of juveniles whereas, vegetable and fruit waste reported lowest number of hatchlings which may be due to fastest decomposition, acidic environment and fluctuation in microbial environment.

Conclusion

The present research work demonstrated that different organic waste substrates used during experiment significantly affected the growth, cocoon production, incubation period and hatchling emergence of earthworm *Eisenia fetida*. Among the substrates used during experiment, banana plant waste, vegetable and fruit waste proved to be the most appropriate substrates for enhancing the growth and reproductive potential of the earthworms.

Maximum weight gain was reported in banana plant waste, which indicates its nutritional value, in vegetable and fruit waste, the highest number of cocoons were observed which proves that this substrate type provides suitable conditions for reproductivity. The highest number of hatchlings per cocoon was observed in banana plant wastes whereas, lowest growth and reproductive potential and the shortest incubation period was estimated in control (cow dung).

The findings of experiment indicates that nutrient rich organic wastes, particularly banana plant waste, vegetable and fruit wastes, enhance the growth and reproductive performance of *Eisenia fetida* more efficiently than conventional food source cow dung.

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Author contribution statement

BKPS: Supervising, reviewing and editing manuscript

Conflict of interest

No conflict of interest.

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