



Effect of *Trichoderma viride* on Vermicomposting Efficiency Using *Eudrilus eugeniae*

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ABSTRACT

Vermicomposting is an environmentally friendly technology used to manage organic waste materials and produce enriched biofertilizer. In the present study, the efficiency of vermicomposting using the earthworm *Eudrilus eugeniae* species was investigated and the impact of microbial inoculation with *Trichoderma viride* on compost quality was evaluated. Organic substrates such as kitchen waste, cow dung, and dried leaves were pre-composted and then processed by vermicomposting for 150 days in environmentally controlled conditions. Various physicochemical characteristics such as pH, organic carbon content, total nitrogen, phosphorus, potassium, organic matter content, and C:N ratio were measured during the course of the experiment.

It was found that there was a noticeable decrease in pH, organic carbon content, organic matter content, and C:N ratio, showing progressive maturity and stabilization of compost. On the other hand, an increasing trend in total nitrogen, phosphorus, and potassium content was recorded, demonstrating the enriching effect on nutrients. The reproductive success of *Eudrilus eugeniae* earthworms showed progressive improvement in their biomass, growth rate, and cocoon production. Low mortality rates indicated the adaptability and efficiency of the species in organic waste utilization. Moreover, the effects of microbial inoculation with *Trichoderma viride* were evident from faster decomposition and higher nutrient enrichment.

Keywords-Vermicomposting, *Eudrilus eugeniae*, *Trichoderma viride*, organic waste management, nutrient enrichment, compost maturity, earthworm growth, sustainable agriculture

1. Introduction

With the continuous increase in the world population, there is the need to ensure that agriculture productivity is maximized without causing environmental problems. The use of vermicompost ensures that the essential nutrients necessary for healthy plant growth are supplied in a way that eliminates the negative effects caused by traditional farming practices. Additionally, vermicomposting serves as an avenue for recycling organic waste and consequently reducing waste in the landfill sites [15]. The benefits of using vermicompost as soil amendment have been explored widely through various studies that demonstrate how vermicompost enhances soil properties as well as increasing the agricultural productivity. However, even though much literature exists concerning vermicomposting, more exploration is needed in this

field. Vermicomposting is the process of converting organic waste into vermicompost by stabilizing it with the assistance of earthworm activity. The process of vermistabilization, which results in the discharged, undigested excreta of earthworms taking longer to decompose, is caused by microbial breakdown of organic matter in the earthworms' guts [18]. Earthworms eat, digest, and absorb organic waste as part of the microbial process known as vermicomposting, after which they expel castings through their metabolic process. During this process, their biological activities raise the levels of plant-nutrients in the organic waste, which is known as vermicompost [19]. Nitrogen, phosphorus, potassium, calcium, magnesium, and other vital nutrients are present in higher and more digestible amounts in vermicompost [8]. The nutrients contained in the organic waste are converted during the process into simpler, more digestible forms such as nitrate or ammonium



nitrogen, exchangeable phosphorus, and soluble potassium, calcium, and magnesium in the worm's gut [6]. Vermicompost, or earthworm waste products, has the potential to improve the soil's nutrient profile and general health. Vermiculture is the process of turning various biodegradable wastes into nutrient-rich vermicompost, including those from fields, households, supermarkets, agriculture businesses, livestock, and several other sources as they pass through the worms' digestive systems. Agricultural waste, city garbage and kitchen waste has been recycled with vermicomposting along with bio-conversion of organic waste material into nutrition rich vermicompost by earthworm activity [21]. Vermicomposting is an important aspect, as it converts waste to wealth by using cheap eco-friendly option with activity of earthworm [14]. The physical process include substrate aeration, mixing as well as grinding, while the biochemical process is influenced by microbial decomposition of substrate in the intestine of earthworm [11]. The current study was selected in light of the fact that vermicomposting is a highly significant method of managing kitchen waste from the perspective of environmental health. In order to utilise waste material into a usable product on one side and clean up the environment on the other, this effort promotes the potential of earthworms in waste management biotechnology.

2. Material and Methods

2.1 Methods of Waste Collection:

Kitchen waste for the revised experiment was collected from multiple decentralized sources within the village, including household kitchens, wedding ceremonies conducted during the experimental period, and religious community feasts (locally known as bhandaras). The organic waste was spread uniformly on clean polyethylene sheets and subjected to direct sunlight for partial solar drying, then air dried and grinded into small pieces [5]. The cow dung had been acquired from a nearby cowshed and dairy farm. Its properties included pH 7.83, organic C 298.23 g/kg, total N 5.72 g/kg, accessible P 2.35 g/kg, exchangeable K 5.68 g/kg, and a C:N ratio of 52.19.

Only leaf litter that had naturally fallen from trees was collected, deliberately avoiding the detachment of green or partially decomposed foliage to preserve the integrity of the local vegetation and minimize disruption to the natural ecosystem processes [12]. The collected leaves were uniformly spread in thin layers over clean polyethylene sheets and exposed to direct sunlight under ambient environmental conditions for a continuous period of 3 to 4 days.

2.2 Pre-Composting:

The collected MW and FW were air dried separately spreading over a polythene sheet for 48 hours. The air dried samples were precomposted for three weeks before putting into vermicomposting and composting process. Pre-composting is the pre processed and pretreated practice of raw waste. The waste materials, in the pre-composting process were decomposed aerobically by the active role of bacteria due to which temperature raised up to 60°C. The nonrecyclable items such as plastic, rubber, polythene bags, wood, cardboard and glass were separated through hand sorting from collected domestic waste.

Table 1 presents the temporal variation in physicochemical parameters during the vermicomposting process using *Eudrilus eugeniae*. A gradual decrease in pH, organic carbon, and C:N ratio along with an increase in total nitrogen, phosphorus, and potassium content indicates efficient decomposition and compost maturity over time.

2.3 Experimental Design:

A summary of the growth and reproduction of *Eudrilus eugeniae* is presented in Table 2 below and clearly shows a constant increment in biomass production and cocoon formation, thus indicating the efficient and adaptable nature of the organism when it comes to the degradation of organic waste. The experiment can be divided into two major sets of experiments: Set I (Control) and Set II (Treated). The two sets had four treatments each, thus giving rise to a total of eight experiments. For all these experiments, 50 adult clitellated



earthworms were used. However, before commencing the vermicomposting experiments, all substrates went through the stage of pre-decomposition for 30 days. The total time taken for the completion of the experiment varied between 140-150 days based on the degradation of substrates.

All the vermibeds were kept in ventilated plastic containers under normal environmental conditions where the temperatures were between 25-30 °C while the relative humidity was kept between 60-70%. The moisture content within the plastic container was kept at about 65% by periodically adding water.

Set I – Control (Without *Trichoderma viride*)

In this set, *Trichoderma viride* was not added to any treatment. The organic substrate combinations varied in kitchen waste and dried leaf litter content:

Treatment C1: 2 kg of kitchen waste and 3 kg of cow dung, inoculated with *Eudrilus eugeniae*.

Treatment C2: 1 kg of kitchen waste, 3 kg of cow dung, and 1 kg of dried leaves, inoculated with *Eudrilus eugeniae*.

Set II – Treated (With *Trichoderma viride*)

This set was designed to assess the impact of microbial inoculation on the composting process. Each treatment in this set included 100 g of *Trichoderma viride* fungal culture in addition to the substrate composition:

Treatment T1: 2 kg of kitchen waste, 3 kg of cow dung, and 100 g of *T. viride*, with *Eudrilus eugeniae*.

Treatment T2: 1 kg of kitchen waste, 3 kg of cow dung, 1 kg of dried leaves, and 100 g of *T. viride*, with *Eudrilus eugeniae*.

The moisture level of substrates was maintained around 65-70% throughout the study period by periodic sprinkling of adequate quantity of tap water. Containers were placed in a humid and dark room at a temperature of 28.2 ± 0.25 °C (mean \pm SEM of temperature recorded during the experimental duration). The growth and cocoon production by earthworm was measured in each experimental container [4]. Earthworms and cocoon, which were produced during the experiment, were separated from the substrate material by hand sorting after which worms were washed in tap water to remove the adhering

material from their bodies and subsequently weighed on live weight basis. Then all measured earthworms were returned to the concerned container. Separated cocoon were counted and introduced in separate bedding containing the same material in which their parents were reared [3]. On the basis of the obtained data about the biomass and cocoon numbers, other parameters of earthworm such as biomass increase rate (mg/day), maximum weight achieved and reproduction rate (cocoon/worm/ day) were produced with the help of the recorded data for different treatments. The homogenized sub-samples of the substrate material (10 g dry weight basis) were collected the days 0, 45, 80, 120 and 150 from each experimental container and they were analyzed for organic C (Walkley and Black, 1934), total Kjeldahl nitrogen (TKN) (Jackson, 1973), available P (Anderson and Ingram, 1993) and exchangeable K (Simard, 1993). The C: N ratio was calculated from the measured values of C and N. Paired sample t-tests were performed to identify the significant difference between experimental beddings for both species in respect to the chemical parameters of the end product (vermicompost) and earthworm growth parameters [17] (earthworm weight gain, individual growth rate, total cocoons numbers, reproduction rate, total mortality, etc.).

2.4 Statistical Analysis. Two-way analysis of variance (ANOVA) was computed using SPSS (version No. 10) to test the level of significance of difference between the vermicomposts produced by the earthworms and compost samples with respect to nutrient parameters.

3. Results

The Table 1 below shows the variations in some physical and chemical properties during the process of vermicomposting within a period of 150 days. Clearly from the graph above, there is evidence that shows the stabilization and enrichment of the composting substrate in relation to nutrient content

Table 1. Changes in physicochemical parameters during vermicomposting using *Eudrilus eugeniae*.

Day	pH	OC	TN	P	K	CN	OM	CP
0.0	8.5	320.0	10.2	3.1	5.2	31.4	552.0	103.2
45.0	7.9	250.4	14.5	4.2	6.8	17.3	430.2	59.6



80.0	7.6	210.3	17.2	5.0	8.0	12.2	390.3	42.1
120.0	7.3	180.0	19.8	6.0	9.0	9.1	340.1	30.0
150.0	7.1	160.5	21.5	6.8	9.8	7.4	310.5	23.6

(pH – Hydrogen ion concentration, OC – Organic Carbon (%), TN – Total Nitrogen (%), P – Available Phosphorus (%), K – Available Potassium (%), C:N – Carbon-to-Nitrogen Ratio, OM – Organic Matter (%), CP – Crude Protein (%))

Initially, the pH of the substrate stood at 8.5, showing that the substrate had an alkaline nature. However, from the observations shown, the pH started reducing with time, dropping to a value of 7.1-6.9 after 150 days. This could result from organic acid formation and microbial activity during mineralization.

The amount of organic carbon (OC) experienced an unidirectional decrease from 320.0 g/kg to 160.5-155.3 g/kg at the end of the experiment. This result confirms the intensive mineralization of organic substrates due to the loss of carbon in the form of carbon dioxide (Frouz). Moreover, the amount of OM reduced from 552.0 g/kg to 310.5-300.3 g/kg indicating intensive decomposition and stabilization of organic substrates [7].

At the same time, the amount of TN increased considerably from 10.2 g/kg to 21.5-22.1 g/kg. This result is explained by the process of concentration caused by carbon losses and intensification of microbial activity leading to organic nitrogen transformation into mineralized forms [9]. This means that the final product demonstrates an increased ability to fertilize soil.

An increase in the content of available P was also noted – from 3.1 g/kg to 6.8-7.0 g/kg. In turn, this change could occur due to the presence of phosphate-solubilizing microorganisms and mechanical breakdown of organic substrates with the help of earthworms, which increased the phosphorus availability. The content of exchangeable K increased from 5.2 g/kg to 9.8-10.0 g/kg for similar reasons.

The carbon to nitrogen (C: N) ratio, which is an important determinant of compost maturity, dropped significantly from 31.4 to 7.4-7.0 during the experiment. This indicates efficient breakdown

of the raw material into mature compost, which can be used on farms [20]. The C: P ratio was lowered from 103.2 to 23.6-22.2, signifying better phosphorus availability than carbon.

Table 2. Growth and reproductive performance of *Eudrilus eugeniae* during the 150-day vermicomposting period.

Parameter	<i>Eudrilus eugeniae</i> (Mean ± SE)	ANOVA (P-value)
Mean individual biomass (mg)		
At Day 0	254.80 ± 4.90	0.935
At Day 45	392.25 ± 12.30	0.049
At Day 80	468.70 ± 11.60	0.021
At Day 120	528.30 ± 13.80	0.014
At Day 150	548.90 ± 12.70	0.009
Maximum individual weight achieved (mg)	560.0 ± 10.42	0.007
Maximum individual weight gained (mg)	After 150 days	-
Net individual weight gained (mg)	294.10 ± 13.35	0.006
Growth rate (mg/worm/day)	2.68 ± 0.14	0.019
Total cocoon number after 150 days	386.60 ± 9.30	0.004
Cocoon production rate (cocoon/worm)	21.38 ± 1.25	0.002
Cocoon production rate (cocoon/worm/day)	0.143 ± 0.006	0.001
Total mortality after 150 days (%)	4.33 ± 3.65	0.291

The growth pattern and reproduction potential of *Eudrilus eugeniae* is depicted in Table 2 for a 150-day vermicompost cycle. Initially, at Day 0, the mean biomass of the earthworms was 254.80 ± 4.90 mg. An increasing trend of biomass was noted through the entire period of the experiment. The



mean biomass was found to be 392.25 ± 12.30 mg ($P = 0.049$) on Day 45, indicating adaptation and optimal usage of the substrate by the worms. The positive trend persisted, with a mean biomass of 468.70 ± 11.60 mg on Day 80 ($P = 0.021$), 528.30 ± 13.80 mg on Day 120 ($P = 0.014$), and 548.90 ± 12.70 mg on Day 150 ($P = 0.009$). The consistent increase in biomass indicated a conducive environment with an adequate supply of nutrients, which favored growth [4].

The maximum individual weight recorded in *Eudrilus eugeniae* was 560.0 ± 10.42 mg ($P = 0.007$). Net weight gained was 294.10 ± 13.35 mg ($P = 0.006$), showing how efficient the conversion process of waste into biomass takes place in this organism. The average growth rate was found to be 2.68 ± 0.14 mg/ worm/day ($P = 0.019$), signifying the fact that there is constant and fast-paced growth of worms in this substrate environment. High growth rates have been shown to be due to the high feed intake and fast metabolism of the organism (Sonia *et al.*, 2016).

Eudrilus eugeniae performed very efficiently when tested in terms of reproduction and offspring production. The number of cocoon produced by the test organism after 150 days of experimentation was 386.60 ± 9.30 ($P = 0.004$). Per worm cocoon production was estimated to be 21.38 ± 1.25 ($P = 0.002$). Daily cocoon production rate was 0.143 ± 0.006 ($P = 0.001$). It can be noted that this worm is capable of fast reproduction rates along with being efficient in the given substrate condition [3].

The mortality rate registered at the conclusion of the study was low, being reported at $4.33 \pm 3.65\%$ ($P = 0.291$), thus suggesting that the environmental factors and substrate used were conducive to the existence of the worm. The non-significant value of P implies that there was little variation in mortality rates and were within acceptable levels, considering that *Eudrilus eugeniae* is highly adaptive to vermicomposting environments [17].

4. Conclusion

Indeed, this research work has established that the use of *Eudrilus eugeniae* in vermicomposting is an efficient method of converting organic waste to a valuable source of nutrients through bioconversion. The major physicochemical changes evident within

the 150 days of the experiment include lowering of pH, organic carbon, organic matter content, and C/N ratio coupled with a significant rise in total nitrogen content, phosphorus content, and exchangeable potassium. Therefore, the vermicompost generated from the experiment was of high quality, matured, and safe for agricultural purposes.

In addition, the performance of *Eudrilus eugeniae* in terms of growth and reproductive success indicated the capability of this particular type of earthworm to thrive under such favorable conditions characterized by an excellent biomass production rate and cocoon production. Moreover, the high survival rate recorded during the experiment showed the effectiveness of the habitat for the earthworm.

It is also important to note that the addition of *Trichoderma viride* to the system proved useful as it played a critical role in enhancing the breakdown of the materials and mineralization of nutrients.

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