International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 15-07-2026, Accepted: 16-08-2026, Published: 03-09-2026
Volume 11, Issue 3, 2026, Page No. 419-423

Bioconversion of Floral Waste into Vermicompost Using the Earthworm *Eudrilus eugeniae*

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DOI: https://doi.org/10.66856/ijer.2026.11.3.11305

Abstract
Earthworms of the species *Eudrilus eugeniae* play a pivotal role in converting various types of organic waste into valuable by-products, such as worm biomass and nutrient-rich vermicompost. The present study aimed to evaluate the efficiency of these earthworms in the bioconversion of floral organic waste derived from *Rosa damascena*, *Tagetes erecta*, and *Chrysanthemum* species. The analysis focused on monitoring worm biomass development, including initial biomass, final biomass, biomass growth ratio, and overall biomass increase, at intervals of 15, 30, and 45 days. The results demonstrated that gross biomass, the number of worms, and biomass increase varied significantly ($P < 0.05$) among the different flower species. Notably, all parameters showed a positive correlation with time, indicating that longer durations resulted in increased worm biomass and higher vermicompost production. Among all the experimental treatments, the highest worm biomass and vermicompost production were consistently observed, confirming the suitability of all three flower species as effective substrates for vermicomposting. These findings highlight their potential for sustainable vermicomposting practices and the production of high-quality worm biomass.

Keywords: Earthworm, vermicompost, worm biomass and flower species

Introduction
Earthworms are terrestrial invertebrates belonging to the order Oligochaeta, class Chaetopoda, and phylum Annelida, which originated approximately 600 million years ago during the Precambrian era (Piearce *et al*., 1990) [9]. Earthworms contribute significantly to the management of various types of organic waste through the production of useful products such as vermicompost and worm biomass (Abad & Shafiqi, 2024) [1]. The effective recycling of different organic wastes is considered an innovative approach to waste management and helps address numerous environmental challenges (Garg & Gupta, 2009) [4]. Organic wastes influence environmental factors that affect the growth and reproduction of earthworms (Atiyeh *et al*., 2000) [3]. The activities of earthworms are influenced by the quality of food and moisture; among these factors, food quality and environmental conditions play important roles in the biology of earthworms (Senthil Kumar *et al*., 2013) [6].
Vermitechnology is a method of producing high-quality natural manure using suitable earthworm species for waste recycling (Mistry *et al*., 2015) [8]. Vermicomposting is a specially designed composting system for organic waste in which earthworms act as accelerators of decomposition and facilitate the conversion of organic matter into plant-available nutrients. This process results in an increase in earthworm numbers and promotes higher worm production and conservation (Ansari & Ismail, 2012) [2]. Vermicompost primarily consists of carbon (C), hydrogen (H), and oxygen (O) and contains essential nutrients such as nitrogen (N), phosphorus (P), calcium (Ca), potassium (K), magnesium (Mg), and sulfur (S), along with various micronutrients (Srivastava & Sinha, 2024) [13]. It also provides numerous sites for microbial communities, including bacteria such as *Bacillus*, yeasts such as *Sporobolomyces* and *Cryptococcus*, and fungi such as *Trichoderma*, which enhance plant growth and contribute to disease suppression (Theunissen *et al*., 2010) [15].
At present, *Eudrilus eugeniae*, *Eisenia fetida*, and *Perionyx excavatus* are among the most commonly used earthworm species for vermicomposting. In the present study, *Eudrilus eugeniae* was used for vermicompost production. *E. eugeniae* is an epigeic earthworm species of African origin. This species has been used in monoculture or polyculture with other earthworm species for the production of vermicompost, vermicast, vermiwash, and related products (Suthar, 2010) [14]. The anterior region shows the presence of spermathecal openings. A pair of female genital openings is present on the 12th segment. Segments 13, 14, and 15 form an unsegmented, collar-like structure called the clitellum. A pair of male genital openings is present on the 16th segment below the clitellum. The ovaries are the female gonads in *E. eugeniae*, and a pair of ovaries is located in the 13th segment below the alimentary canal within the coelomic cavity (Vijaya *et al*., 2012) [16]. The reproductive pattern is directly related to the feed provided in the vermibed, and the substrate of the vermibed significantly influences reproduction (Yadav & Garg, 2011) [17].
The flower species used in this study were Chrysanthemum, *Rosa damascena*, and *Tagetes erecta*. Chrysanthemums are largely leafy plants and are naturally heavy feeders during their growth cycle (Mir & Shrivastava, 2022) [7]. *Tagetes erecta* is one of the most commonly cultivated herbaceous ornamental annuals. It has high nitrogen and potassium requirements, particularly during the early stages of growth, and responds well to increased applications of nitrogen (N) and potassium (K) (Shetty & Biradar, 2023) [12]. *Rosa damascena* belongs to the family Rosaceae and has

considerable potential for vermicomposting due to its low pH and high organic matter content, along with significant concentrations of nutrients such as N, K, Ca, Mg, and Fe. It also contains high moisture levels (approximately 66%), a low C/N ratio (approximately 21), and substantial amounts of phenolic acids and lignin (Idrovo Novillo *et al*., 2018).

Methods and methodology

Collection of Flower Waste

Different flower species, including *Chrysanthemum* spp., *Rosa damascena*, and *Tagetes erecta*, were collected from the local flower market in Mysore and from various event venues. Approximately 15 kg of mixed flower waste was initially collected. Non-decomposable materials, such as plastic threads, wires, and synthetic decorations, were manually removed. The remaining decomposable floral waste was sorted, cleaned, and cut into small pieces to ensure uniform decomposition.

Collection of Earthworms

The epigeic earthworm species *Eudrilus eugeniae* was procured from VC Farm, Agricultural College, Mandya. Only healthy and active worms were selected for experimental use.

Preparation of Composting Substrates

Substrate Composition

Three types of floral waste, namely *Chrysanthemum* spp., *Rosa damascena*, and *Tagetes erecta*, were mixed with cow dung in three different proportions by dry weight. For each flower species, the following substrate combinations were prepared:

- **30% floral waste:** 600 g flower waste + 3 kg cow dung + earthworms
- **40% floral waste:** 800 g flower waste + 3 kg cow dung + earthworms
- **50% floral waste:** 1,500 g flower waste + 3 kg cow dung + earthworms
- Each substrate mixture was placed separately in plastic pots, resulting in nine experimental combinations (three flower types × three proportions).

Pre-composting of Substrates

The substrates were subjected to a pre-composting phase to reduce the initial temperature, initiate microbial activity, and soften the organic material. The pots containing the substrate combinations were left undisturbed for 7 and 14 days, with water sprinkled on alternate days. At the end of each pre-composting period, the materials were thoroughly turned to promote aeration, microbial decomposition, and thermal stabilization.

Preparation of Vermicomposting Containers

Vermicomposting was carried out in plastic containers measuring 40 cm × 20 cm × 25 cm (length × width × depth). These containers were selected for their durability and capacity to hold organic waste efficiently. The upper surfaces were left uncovered to ensure adequate ventilation and proper aeration for aerobic decomposition.

The substrate mixtures were arranged inside the containers in three to four alternating layers of floral waste and cow dung. This structured layering facilitated the uniform distribution of organic material and improved oxygen flow. Moisture was adjusted periodically by lightly sprinkling water to support microbial activity. The pre-decomposition period lasted two weeks, during which the floral biomass began to break down into a partially decomposed substrate. All containers were maintained at an approximate temperature of 32°C during this phase.

Inoculation of Earthworms

After pre-decomposition, adult and juvenile *Eudrilus eugeniae* worms measuring 8–11 cm in length were introduced into each pot at a density of 20 g per 3–4 kg of substrate. Prior to inoculation, each worm was weighed individually to facilitate accurate monitoring of biomass changes.

The containers were maintained under natural ambient conditions and observed periodically at intervals of 15, 30, and 45 days. Moisture content was maintained at 70–75% by regularly sprinkling water. Additional organic substrate was provided as required to ensure adequate nutrition for the worms throughout the vermicomposting process.

To investigate the role of *Eudrilus eugeniae* in the vermicomposting process, healthy individuals were carefully selected from the stock culture. Each worm was weighed individually before being introduced into the respective experimental culture pots to enable precise monitoring of growth and biomass changes. The experimental containers were maintained under uncontrolled ambient environmental conditions to simulate natural composting conditions. Throughout the experimental period, each container was supplied with an adequate amount of organic substrate as feed and was regularly moistened with tap water to maintain an optimal moisture content of approximately 70–75%, which is essential for effective decomposition and earthworm activity.

Observation and Data Collection

The experiment was carried out for 45 days, and observations were recorded on Days 15, 30, and 45. At each observation interval, data were collected on the number and weight of earthworms belonging to different developmental stages, including:

- Pre-existing adult worms
- Newly matured adults
- Sub-clitellate worms approaching reproductive maturity
- Juveniles

The number and biomass of worms at each developmental stage were recorded at each observation interval.

Biomass Analysis

Gross biomass was defined as the total weight of newly developed worms generated through reproduction during the experimental period. Biomass ratio was calculated based on the increase in total worm biomass at each observation interval relative to the initial worm biomass at the beginning of the experiment. These measurements were used to evaluate the efficiency of vermicomposting across different floral waste types and substrate proportions (Sheethal Roy *et al*., 2024) [10].

Result

The results of the present study concerning the production of gross biomass, biomass ratio, and biomass increase in *Eudrilus eugeniae* reared on three different flower species at 15-, 30-, and 45-day intervals are presented in Table 1 and illustrated in Graphs 1, 2, and 3.

Worm Biomass

A progressive increase was observed in gross biomass, biomass ratio, and biomass increase across all three floral waste treatments over the 15-, 30-, and 45-day experimental periods, as shown in Table 1 and Graphs 1, 2, and 3. This trend indicates a positive association between the duration of the experimental period and the measured growth parameters. As the experimental period increased, gross biomass accumulation also increased, reflecting enhanced growth and reproductive activity of *Eudrilus eugeniae*. The results indicate that prolonged exposure to suitable vermicomposting conditions supported worm proliferation and biomass production from Day 15 to Day 45.

The mean gross biomass of *Eudrilus eugeniae* reared on *Tagetes erecta*, *Chrysanthemum* spp., and *Rosa damascena* was 43.11 ± 1.26, 52.12 ± 1.44, and 71.89 ± 2.00, respectively, at 15, 30, and 45 days for *Tagetes erecta*; 21.30 ± 1.10, 55.31 ± 1.52, and 53.20 ± 1.47 for *Chrysanthemum* spp.; and 18.25 ± 1.02, 54.30 ± 81.55, and 67.00 ± 1.88 for *Rosa damascena* (Table 1 and Graph 1).

Similarly, the biomass ratio increased progressively during the experimental period. The biomass ratios recorded for *Tagetes erecta* were 1:3.16 ± 0.09, 1:3.61 ± 0.10, and 1:4.59 ± 0.13 at 15, 30, and 45 days, respectively. For *Chrysanthemum* spp., the corresponding values were 1:2.02 ± 0.07, 1:3.77 ± 0.11, and 1:3.66 ± 0.10. For *Rosa damascena*, the biomass ratios were 1:1.91 ± 0.06, 1:3.72 ± 0.11, and 1:4.35 ± 0.13 at 15, 30, and 45 days, respectively (Table 1 and Graph 2).

Biomass Increase

The increase in worm biomass was also assessed using three different proportions of flower waste (30%, 40%, and 50%). At 15 days, the biomass increase values for the three proportions were 11.5, 16.1, and 17.29; 25, 5.12, and 9.9; and 10, 17.27, and 19.8 for *Tagetes erecta*, *Chrysanthemum* spp., and *Rosa damascena*, respectively.

At 30 days, the corresponding biomass increase values were 30.0, 26.6, and 53.09; 56.12, 37.32, and 52.90; and 16.77, 27.0, and 44.23 for the three flower species, respectively.

At 45 days, the biomass increase values were 43.11, 52.12, and 71.89; 21.30, 55.37, and 53.20; and 18.25, 54.38, and 67.00 for *Tagetes erecta*, *Chrysanthemum* spp., and *Rosa damascena*, respectively (Table 1 and Graph 3).

Comparative Analysis of Flower Species

The present investigation revealed considerable variation in gross biomass, biomass ratio, and biomass increase among the different floral waste substrates over the 15-, 30-, and 45-day vermicomposting periods. Among the flower species studied, the highest gross biomass was recorded in *Tagetes erecta*, followed by *Rosa damascena* and *Chrysanthemum* spp. at the end of the experimental period.

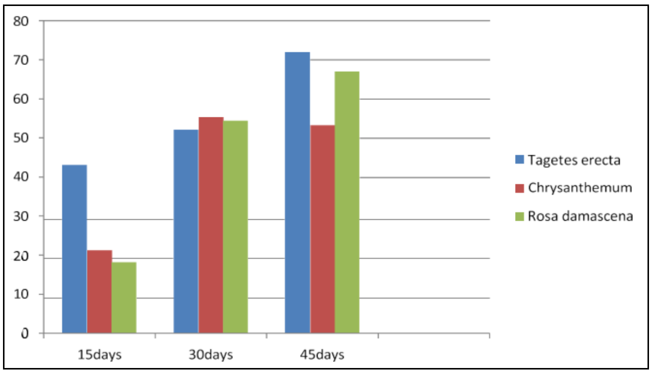
The differences observed among the floral substrates may be attributed to variations in the nutritional composition, physical characteristics, moisture content, and decomposition rate of the substrates. These factors may influence the feeding activity, growth, and reproductive performance of *Eudrilus eugeniae*. Differences in microbial activity and the suitability of each substrate for microbial decomposition may also have contributed to variations in worm biomass production.

The mean gross biomass of *Eudrilus eugeniae* increased from Day 15 to Day 45 in all three floral waste treatments. At 45 days, the highest gross biomass was recorded in *Tagetes erecta* (71.89 ± 2.00), followed by *Rosa damascena* (67.00 ± 1.88) and *Chrysanthemum* spp. (53.20 ± 1.47) (Table 1 and Graph 1). These results indicate that *Tagetes erecta* floral waste provided a comparatively favorable substrate for biomass production by *Eudrilus eugeniae* under the experimental conditions.

Table 1: Gross biomass, biomass ratio, and fold increase of earthworm *Eudrilus eugeniae* at various time intervals (15, 30 and 45 days) cultured in cowdung and their significant value (p<0.001) among different flower species

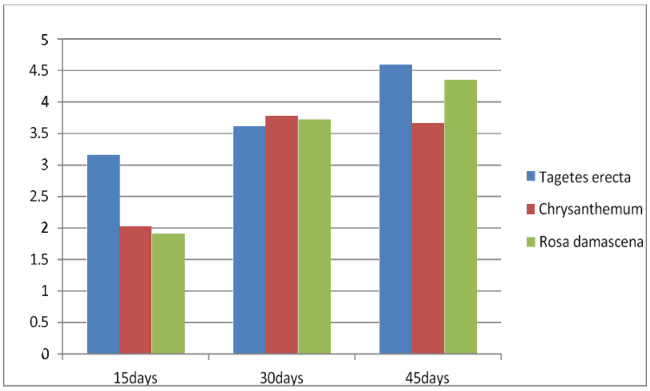
Sl. No	Flower Species	Periods (Days)	Parameters				
			Gross Biomass	Biomass Ratio (IW: GBW)	Biomass increase		
					30% Flower waste	40% Flower waste	50% Flower waste
1.	*Tagetes erecta*	15days	43.11±1.26	1:3.16±0.09	31.5	50	63.11
		30days	52.12±1.44	1:3.61±0.1	36.10	46.62	72.12
		45days	71.89±2	1:4.59±0.13	37.29	73.09	91.89
2.	Chrysanthemum	15days	21.30±1.10	1:2.02±0.07	45	76.12	41.3
		30days	55.31±1.52	1:3.77±0.11	21.12	57.32	75.31
		45days	53.20±1.47	1:3.66±0.10	29.9	72.9	73.2
3.	*Rosa damascena*	15days	18.25±1.02	1:1.91±0.06	30	36.77	38.25
		30days	54.38±1.55	1:3.72±0.11	37.27	47	74.38
		45days	67±1.88	1:4.35±0.13	39.8	64.23	87
4.	F- Value		F = 18.88	F = 17.40	F = 10.57		
5.	P- Value		P<0.001	P<0.001	P = 0.0004		

Gross Biomass(gm)



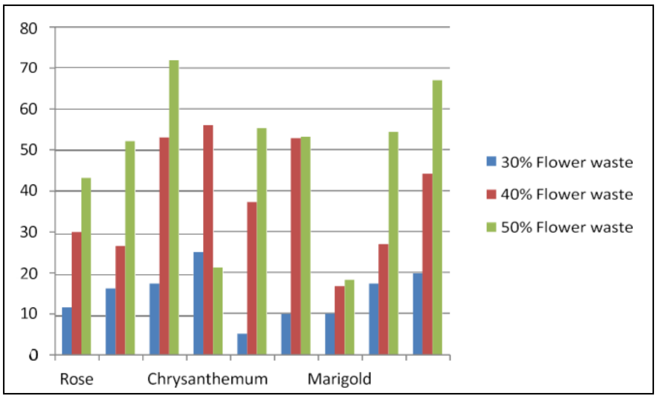
Graph 1: Gross biomass produced by different flower species in *Eudrilus eugeniae* atvarious time intervals (15, 30 and 45 days)

Biomass Ratio



Graph 2: Biomass ratio observed by different flower species in *Eudrilus eugeniae* at various time intervals (15, 30 and 45 days)

Biomass increase in different flower species



Graph 3: Biomass increase different combinations floral waste flower species in *Eudrilus eugeniae* at various time intervals (15, 30 and 45 days)

Discussion

Floral waste was efficiently decomposed through the combined activities of earthworms and microorganisms, resulting in the formation of stable, dark, and granular vermicompost. Earthworms fragmented organic matter through ingestion and grinding in the gizzard, while their movement and feeding activities stimulated microbial growth. This synergistic interaction accelerated the decomposition of complex organic compounds and enhanced nutrient mineralization.

Among the floral substrates studied (*Chrysanthemum* spp., *Tagetes erecta*, and *Rosa damascena*), *Tagetes erecta* supported the highest worm biomass, which may be attributed to its relatively higher nutrient content, particularly nitrogen and potassium, and its ability to support microbial proliferation. The progressive increase in the biomass of *Eudrilus eugeniae* throughout the experimental period further demonstrated the suitability of floral waste as a substrate for vermicomposting. The dark colour, granular texture, and overall appearance of the final product indicated a well-decomposed and mature vermicompost suitable for use as a soil amendment.

The findings of the present study are in agreement with earlier studies (Roy *et al*., 2025; Shouche *et al*., 2011) [10], which reported that substrate composition, cellulose content, and physicochemical characteristics influence decomposition efficiency and earthworm growth. Previous studies (Kale & Krishnamoorthy, 1978; Suthar, 2009, 2010) [14] have similarly emphasized that food quality, palatability, and substrate characteristics significantly influence earthworm feeding activity, biomass production, and reproduction. The observed differences in biomass production among the floral substrates may therefore be associated with variations in their nutritional composition, decomposition rate, moisture content, and suitability for microbial activity.

Conclusion

Floral waste is generated in large quantities during religious events, festivals, ceremonies, and public functions. Improper disposal of this biodegradable waste contributes to environmental pollution and results in the loss of potentially valuable organic matter. Biological treatment methods, particularly composting followed by vermicomposting, provide a sustainable approach for managing and recycling floral waste.

The present study demonstrated that floral waste can serve as an effective substrate for vermicomposting. *Eudrilus eugeniae* efficiently converted floral waste derived from *Rosa damascena*, *Tagetes erecta*, and *Chrysanthemum* spp. into valuable vermicompost and worm biomass. Observations recorded at 15, 30, and 45 days showed an overall increase in worm biomass across the floral waste substrates, indicating favourable feeding and growth conditions. Among the three floral substrates, *Tagetes erecta* supported the highest biomass production, suggesting that it may be comparatively more suitable for vermicomposting under the conditions of the present study.

The resulting vermicompost was dark, granular, and well decomposed, indicating its potential as a soil amendment. The study confirms that floral waste can be effectively transformed into a valuable organic product through the synergistic activities of earthworms and microorganisms. This approach not only facilitates the recycling of biodegradable floral waste but also provides an environmentally sustainable waste-management strategy for areas generating large quantities of floral waste. The utilization of floral waste through vermicomposting can therefore contribute to sustainable agriculture and horticulture while reducing the environmental burden associated with improper disposal.

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