Influence of C:N ratio on the Growth and Reproduction of Different Epigeic Earthworms

Aishwarya Shetty., Suhas H. S., and Pulikeshi M. Biradar

Department of Zoology, Karnatak University, Dharwad, Karnataka

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INTRODUCTION

The role of organic carbon and inorganic nitrogen for cell synthesis, growth and metabolism is very important for all living organisms. To provide proper nutrition for earthworms during the composting process, a correct ratio of Carbon and Nitrogen should be provided and it is also essential for microbial activity and multiplication (Jiang, et. al. 2011; Lv, et. al. 2018). The distribution of earthworm in their natural habitat with respect to C:N ratio has well reviewed by Lee, 1985. The C:N ratio also plays an important role in determining the quality of substrate (food) and another factor whether it is fully fermented (Ndewa, 2000). The pH, temperature, moisture and C:N ratio of organic wastes used in composting are important factors influencing the growth, reproduction and survival of earthworms (Qiao, 2003 and Hou, 2005). The balanced C:N ratio of about 25 is improved in the vermicomposting (Butt, 1993) but, different earthworm species responded differently to the different sources of nitrogen present in the food.

While many studies have documented the utilization of common plant wastes, agricultural residues, and animal manures for vermicomposting and composting, there are relatively few systematic studies that concentrate on Samanea saman (rain tree) or Albizia saman a species of flowering tree with umbrella shaped canopy belonging to the family Fabaceae, (Sharma 2019) which is widely distributed in urban, semi-urban and roadside areas of India and in many government and private organizations have various trees particularly rain trees in their campuses (Jadhav, 2023). The rain trees are also more in the researcher's study campus Karnatak University, Dharwad which produce large quantities of tree litter. The leaves fall every year in our campus and are not used for either composting due to the constraints in the collection, transport and technical expertise. Presently these litter was burned in the campus which in turn increases CO2 in the air.

The majority of current research focuses on readily biodegradable substrates, such as agricultural residues, vegetable waste, or cow dung, while resistant leaf litters with a high lignocellulosic content are still not well studied. Furthermore, many studies use a single or fixed carbon-to-nitrogen (C:N) ratio without assessing how different initial C:N ratios affect decomposition efficiency, nutrient transformation and biological responses, despite the fact that the C:N ratio is a crucial factor controlling microbial activity, decomposition rate and earthworm performance. The effects of different C:N ratios of leaf-based substrates on earthworm development, reproduction and compost quality especially on rain tree are similarly little. Therefore, this study investigated the C:N ratio requirement for the vermicomposting of organic matter samanea saman using three different epigeic earthworm species.

MATERIALS AND METHODS

Collection of earthworms:

The epigeic earthworm species such as, Eudrilus eugeniae, Eisenia fetida, Perionyx excavatus, were collected from the stock culture maintained at Vermitechnology Laboratory, Department of Zoology, Karnatak University, Dharwad.

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Preparation of food

The locally available organic waste, Samanea saman (Rain tree) was selected and their leaves were collected. The collected organic waste was chopped finely and sun dried for about 15-20 days and mixed with cattle manure in various proportions to get different C:N ratios such as 5:1, 10:1 and 15:1. Cattle manure alone serves as standard. The organic waste in different C:N ratios were added to individual earthen pots (in triplicates), watered sufficiently and kept for primary degradation for about seven days to initiate microbial activity. The pots were covered with nets to avoid any predatory action that contaminates the organic food in the pot. The moisture content (70-80%) was maintained throughout the experimental period (17 weeks).

Inoculation of earthworms:

One week aged five juveniles of three different epigeic earthworm species, Eudrilus eugeniae, Eisenia fetida and Perionyx excavatus were taken and inoculated in each experimental pots in triplicates.

Observation

Regular observations were made with respect to increase in biomass, sexual maturity and cocoon production for 17 weeks. The growth rate of worms was calculated by using the formula as given by Biradar, et. al. (1999).

$$\textbf{Growth rate of worms (day/g)} = \frac{(\textbf{Weight of worm on the day of observation} - \textbf{Initial weight (IW)})}{\textbf{Number of days on the day of observation}} \times 1000$$

Statistical analysis:

The significant difference of the data of the present study was analyzed through one way ANOVA followed by Post Hoc-LSD by using SPSS software (version 21.0).

RESULTS

Biomas

Table-1 & 2 represents the data of the epigeic earthworm, Eudrilus eugeniae cultured in Samanea saman with cattle manure in different C:N ratio (5:1, 10:1 and 15:1). The weight of juveniles during initial week (IW) was about 0.009-0.01g. There is a gradual increase in the biomass of worm till 11th week in 5:1 ratio, 9th week in 10:1, 15:1 ratio and Control-CM. Maximum biomass was reached on 11th week in 5:1 ratio, 17th week in 10:1, 15:1 ratio and Control-CM. The maximum mean biomass was seen in Control-CM (1.098 ± 0.08) followed by 15:1 ratio (0.524± 0.04), then in 10:1 ratio (0.482± 0.03) and least in 5:1 ratio (0.32± 0.02). Significant difference was observed among and in between different C:N ratio except 5:1 and 10:1 and 10:1 and 15:1 ratio (Table-2).

Table-3 & 4 represents the data of epigeic earthworm, Eisenia fetida cultured in Samanea saman with cattle manure in different C:N ratio (5:1, 10:1 and 15:1). The biomass of juveniles during initial week (IW) was about 0.007-0.008g. There is a gradual increase in the biomass throughout the experimental period in all the C:N ratios except 5:1 ratio. Maximum biomass was reached on 13th week in 5:1 ratio (0.341± 0.05) whereas on 17th week in 10:1 ratio (0.416±0.001), 15:1 ratio (0.477±0.04) and Control-CM (0.683±0.04). The maximum mean biomass was seen in Control (0.433± 0.02) followed by 15:1 ratio (0.298± 0.02), then in 10:1 ratio (0.260± 0.01) and least biomass was seen in 5:1 ratio (0.214± 0.01). Significant difference was observed (P= 0.000) among (Table-3) and in between different C:N ratio except 5:1 and 10:1, 10:1 and 15:1. ($P \leq 0.05$) (Table-4).

Table-5 & 6 represents the data of epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratio (5:1, 10:1 and 15:1). The biomass of juveniles during the initial week (IW) was about 0.005-0.007g. There is a gradual increase in the biomass up to 10th week in all the C:N ratios. Maximum biomass was reached on 17thweek in 5:1 ratio (0.074 ± 0.01), 10:1 ratio (0.141 ± 0.01), 15:1 (0.146 ± 0.02) and Control-CM (0.210 ± 0.02). The maximum mean biomass was seen in Control-CM (0.113 ± 0.01) followed by

15:1 ratio (0.070 ± 0.00) then in 10:1 ratio (0.059 ± 0.00) and least in 5:1 ratio (0.036 ± 0.00). Significant difference was observed among (P=0.014) and in between different C:N ratio except 5:1 and 10:1 and 5:1 and15:1, 10:1 and 15:1 (P≤0.05) (Table-6).

Growth rate:

Table-7 & 8 represents the data of growth rate (day/g) of the epigeic earthworm, Eudrilus eugeniae cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1). The growth rate is calculated based on the biomass increased by the different C: N ratios of the worms. The maximum growth rate was observed in Control-CM on 6th week (32.47±1.69). The mean growth rate was maximum in Control-CM (16.96±1.29) followed by 15:1 ratio (7.95±0.36); 10:1 ratio (7.61±0.36) and least in 5:1 (5.46±0.53). Significant difference was observed among (P=0.000) and in between different C:N ratio except 5:1 and 10:1, 5:1 and 15:1, 10:1 and 15:1, (P≤0.05) (Table-8).

Table-9 & 10 represents the data of growth rate (day/g) of the epigeic earthworm, Eisenia fetida cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1). The maximum growth rate was seen in Control-CM on 4th week (11.97±0.73). The mean growth rate was maximum in Control-CM (7.44±0.39) followed by 15:1 ratio (4.98±0.29), 10:1 ratio (4.29±0.22) and least in 5:1 ratio (3.41±0.18). Significant difference was observed among (P=0.000) and in between C:N ratio except 10:1 and 15:1 (P≤0.05) (Table-10).

Table-11 & 12 represents the data of growth rate (day/g) of the epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1). The maximum growth rate (3.41±0.12) was seen in Control-CM on 2nd week. The maximum mean growth rate was seen in Control-CM (1.77±0.12) followed by 15:1 ratio (0.95±0.06); 10:1 ratio (0.75±0.05) and least in 5:1 ratio (0.43±0.03). No significant difference was observed among or in between different C:N ratio (P≤0.05) (Table-12).

Sexual maturity:

Table-13 & 14 represents the data of percent sexual maturity of the epigeic earthworm, Eudrilus eugeniae cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1). Attainment of sexual maturity was first observed on 3rd week in all the C:N ratios including Control-CM. In Control-CM 100% maturity was first seen on 5th week followed by 10:1 and 15:1 ratio on 6th week and late during 7th week in 15:1 ratio. The percent sexual maturity was maximum in control (81.11±5.21) followed by 15:1 ratio (77.77±5.19); 10:1 (77.40±5.26); 5:1 (73.70±5.41). No significant difference was seen among or between the different C:N ratio except between 5:1 and 15:1, 5:1 and control (Table-14).

Table-15 & 16 represents the data of percent sexual maturity of the epigeic earthworm, Eisenia fetida cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1). Attainment of sexual maturity was first observed on 3rd week in 10:1, 15:1 and in control. Sexual maturity was 100% on 8thweek in all C:N ratios (5:1, 10:1, 15:1). The percent sexual maturity was maximum in 15:1 ratio (74.07±5.40) followed by Control-CM (70.37±5.41); 10:1 (68.51±5.68) and least in 5:1 ratio (65.18±6.03). Significant difference was seen among (P=0.021) and in between different C:N ratio except 5:1 and 10:1, 10:1 and control, 15:1 and control (Table-16).

Table-17 & 18 represents the data of percent sexual maturity of the epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1). Attainment of sexual maturity was first observed on 3rd week in all ratios including control. Sexual maturity was 100% on 8th week in all C:N ratios including Control-CM. The percent of sexual maturity was maximum in 15:1 ratio (73.33±5.18) followed by Control-CM (72.22±5.32); 10:1 ratio (71.48 ± 5.40) and least in 5:1 ratio (70.74±5.56). No significant difference was observed among (P=0.362) and in between different C:N ratio (P≤0.05) (Table-18).

Cocoon production

Table-19 & 20 represents the data of cocoon production (worm/week) of the epigeic earthworm, Eudrilus eugeniae cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1). Cocoon

production was first observed on Control-CM and 15:1 ratio in 5th week and in 5:1 and 10:1 ratio on 6th week. The mean cocoon rate was maximum in Control-CM (3.83±0.92) followed by 15:1 ratio (2.99±0.71); then in 10:1 ratio (2.45±0.56) and least in 5:1 ratio (1.15±0.23). Significant difference was observed among (P=0.006) and in between different C:N ratio except 5:1 and 10:1, 10:1 and 15:1, 15:1 and control (P≤0.05) (Table-20).

Table-21 & 22 represents the data of cocoon production (worm/week) of the epigeic earthworm, Eisenia fetida cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1). Cocoon production was first observed on 5th week in all the C:N ratio except in 5:1, where it was observed on 7th week. Cocoon production was continuous throughout the experimental period i.e. up to 17 weeks. The mean cocoon production was maximum in Control-CM (4.69±0.84) followed by 15:1 (2.72±0.70) and then in 10:1 (1.83±0.41) and least in 5:1 (1.13±0.31). Significant difference was observed among (P=0.000) and in between different ratio except in 5:1 and 10:1, 10:1 and 15:1 (Table-22).

Table-23 & 24 represents the data of cocoon production (worm/week) of the epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1). Cocoon production was first observed in Control-CM on 6th week followed by 15:1 ratio and 10:1 ratio on 7th week and in case of 5:1 ratio, it was late observed on 8th week. Here also, no cocoon production was seen on 13th week in 5:1, 10:1, 15:1 ratio except in Control-CM. Significant difference was observed among (P=0.05) and in between different ratio except 10:1 and 15:1, 15:1 and control (P≤0.05) (Table-24).

DISCUSSION

There is a variation in the biomass, growth rate, sexual maturity and cocoon production with respect to different C:N ratio in all the epigeic earthworms throughout experimental period. These variations may be due to different C:N ratio and other factors such as temperature, moisture, pH, particle size, palatability of food. The variations on growth and reproduction of different epigeic earthworm species have been witnessed with different factors (Seenappa, et. al. 1995; Amoji, et. al. 1998). Control-CM showed good result in all three species expect 15:1 ratio with respect to Eisenia fetida and Perionyx excavates, these results revealed that different C:N ratio definitely influenced reproductive outputs of the earthworms. Therefore, earthworms require proper nutrition and C:N ratio in the substrate to enhance vermicomposting process. The results obtained have also showed slow growth, delayed maturity and less cocoon production in the 5:1 C:N ratio. Hence, the C:N ratio plays important role in determining the quality of substrate. Thus, the proper organic carbon and nitrogen ratio is very much essential for growth, metabolism, maturation and reproduction of earthworms for effective Vermitechnology.

Various literatures are available on the influence of C:N ratio on earthworms, like Bayu, et. al. (2023) reported that the highest number of worms in the variant with 18:1 C:N ratio and the least was in the variant 6:1 ratio, which was similar to our results as the growth and reproduction of worms were recorded highest in 15:1 ratio and lowest in 5:1 C:N ratio. The optimum growth of Eisenia fetida in different animal and vegetable wastes occurred at 25-30̊ C (Edwards, 1988) and the moisture content range of 75-90% but these factors could vary in different organic wastes (Gunadi, 2003). Parthasarathi, et. al. (2014) reported the influence of Cow dung and Cashew leaf litter in 2:2 C:N ratio on earthworms. Suthar, (2007) have reported that the nitrogen content of the culture media has a positive influence on the growth and reproduction of earthworms through their dietary need of proteins. Presence of some growth retarding substances in the organic waste materials may also plays a vital role in reproduction of earthworms as reported by Garcia, et. al. 2017. Hence, normal cattle manure is very congenial for epigeic earthworms as there is a variation in the substrate that indirectly influence on the growth and reproduction of the earthworms.

Table 1: Biomass (g) of the epigeic earthworm, Eudrilus eugeniae cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	Weeks	5:1	10:1	15:1	Pure cattle manure (Control)	Significant difference F and P- values
1	IW	0.01 ± 0.00	0.009 ± 0.00	0.009 ± 0.00	0.009 ± 0.00	

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2	1	0.03 ± 0.00	0.042 ± 0.00	0.040 ± 0.00	0.204 ± 0.17	
3	2	0.27 ± 0.18	0.100 ± 0.00	0.376 ± 0.25	0.110 ± 0.01	
4	3	0.13 ± 0.02	0.328 ± 0.00	0.189 ± 0.01	0.219 ± 0.00	
5	4	0.19 ± 0.02	0.429 ± 0.02	0.288 ± 0.00	0.415 ± 0.09	
6	5	0.25 ± 0.03	0.458 ± 0.04	0.358 ± 0.03	0.910 ± 0.19	
7	6	0.31 ± 0.02	0.458 ± 0.04	0.482 ± 0.01	1.374 ± 0.07	
8	7	0.35 ± 0.02	0.491 ± 0.03	0.519 ± 0.02	1.590 ± 0.06	
9	8	0.36 ± 0.02	0.517 ± 0.02	0.549 ± 0.02	1.622 ± 0.07	
10	9	0.38 ± 0.01	0.538 ± 0.02	0.565 ± 0.01	1.642 ± 0.07	F= 35.529
11	10	0.39 ± 0.06	0.511 ± 0.01	0.518 ± 0.04	1.344 ± 0.06	**P= 0.000**
12	11	0.53 ± 0.01	0.513 ± 0.01	0.521 ± 0.04	1.266 ± 0.12	
13	12	0.50 ± 0.05	0.530 ± 0.00	0.511 ± 0.02	1.344 ± 0.06	
14	13	0.30 ± 0.13	0.781 ± 0.05	0.839 ± 0.03	1.531 ± 0.25	
15	14	0.46 ± 0.02	0.804 ± 0.03	0.913 ± 0.03	1.536 ± 0.25	
16	15	0.46 ± 0.02	0.808 ± 0.03	0.915 ± 0.03	1.538 ± 0.25	
17	16	0.46 ± 0.02	0.812 ± 0.04	0.918 ± 0.03	1.547 ± 0.25	
18	17	0.46 ± 0.02	0.812 ± 0.04	0.921 ± 0.03	1.551 ± 0.25	
19	**Mean ± SE**	**0.32 ± 0.02**	**0.482 ± 0.03**	**0.524 ± 0.04**	**1.098 ± 0.08**	

Table 2: Significant difference between biomass of the epigeic earthworm, Eudrilus eugeniae cultered in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	0.083	**0.050**	**0.000**
10:1	0.083	-	0.750	**0.000**
15:1	**0.050**	0.750	-	**0.000**
Pure cattle manure (control)	**0.000**	**0.000**	**0.000**	-

Table 3: Biomass (g) of the epigeic earthworm, Eisenia fetida cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.007 ± 0.00	0.008 ± 0.00	0.008 ± 0.00	0.008 ± 0.00	
2	1	0.131 ± 0.10	0.154 ± 0.11	0.028 ± 0.00	0.036 ± 0.01	
3	2	0.063 ± 0.00	0.083 ± 0.00	0.075 ± 0.01	0.146 ± 0.02	

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4	3	0.093 ± 0.01	0.162 ± 0.01	0.170 ± 0.01	0.194 ± 0.00	
5	4	0.115 ± 0.01	0.216 ± 0.01	0.199 ± 0.02	0.344 ± 0.02	
6	5	0.158 ± 0.02	0.225 ± 0.01	0.303 ± 0.04	0.409 ± 0.00	
7	6	0.200 ± 0.02	0.233 ± 0.00	0.333 ± 0.03	0.480 ± 0.02	
8	7	0.230 ± 0.02	0.233 ± 0.02	0.342 ± 0.02	0.457 ± 0.05	
9	8	0.245 ± 0.02	0.247 ± 0.04	0.327 ± 0.02	0.478 ± 0.05	F=36.204
10	9	0.302 ± 0.05	0.274 ± 0.02	0.347 ± 0.02	0.499 ± 0.05	**P=0.000**
11	10	0.204 ± 0.03	0.253 ± 0.04	0.273 ± 0.02	0.471 ± 0.02	
12	11	0.215 ± 0.02	0.265 ± 0.02	0.281 ± 0.02	0.490 ± 0.01	
13	12	0.227 ± 0.02	0.293 ± 0.02	0.368 ± 0.03	0.533 ± 0.04	
14	13	0.341 ± 0.05	0.390 ± 0.01	0.448 ± 0.05	0.568 ± 0.03	
15	14	0.326 ± 0.03	0.404 ± 0.01	0.461 ± .04	0.651 ± 0.03	
16	15	0.329 ± 0.03	0.409 ± 0.01	0.463 ± 0.04	0.669 ± 0.04	
17	16	0.334 ± 0.03	0.413 ± 0.01	0.466 ± 0.04	0.678 ± 0.04	
18	17	0.337 ± 0.01	0.416 ± 0.01	0.477 ± 0.04	0.683 ± 0.04	
19	**Mean ± SE**	**0.214 ± 0.01**	**0.260 ± 0.01**	**0.298 ± 0.02**	**0.433 ± 0.02**	

Table 4: Significant difference in biomass of the epigeic earthworm, Eisenia fetida cultured in cattle manure with Samanea saman in different C:N ratios (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	0.132	**0.007**	**0.000**
10:1	0.132	-	0.088	**0.000**
15:1	**0.007**	0.088	-	**0.000**
Pure cattle manure (control)	**0.000**	**0.000**	**0.000**	-

Table 5: Biomass (g) of the epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.007 ± 0.00	0.006 ± .00	0.006 ± 0.00	0.005 ± 0.00	
2	1	0.014 ± 0.00	0.010 ± 0.00	0.010 ± 0.00	0.024 ± 0.00	
3	2	0.015 ± 0.00	0.019 ± 0.00	0.020 ± 0.00	0.046 ± 0.00	
4	3	0.021 ± 0.00	0.019 ± 0.00	0.021 ± 0.00	0.050 ± 0.01	

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5	4	0.022 ± 0.00	0.025 ± 0.00	0.024 ± 0.00	0.060 ± 0.00	
6	5	0.023 ± 0.00	0.045 ± 0.01	0.052 ± 0.01	0.068 ± 0.01	
7	6	0.016 ± 0.00	0.039 ± 0.00	0.064 ± 0.01	0.073 ± 0.01	
8	7	0.074 ± 0.00	0.044 ± 0.00	0.052 ± 0.01	0.112 ± 0.01	
9	8	0.024 ± 0.00	0.044 ± 0.01	0.072 ± 0.00	0.082 ± 0.02	F=6.775
10	9	0.031 ± 0.00	0.049 ± 0.01	0.077 ± 0.00	0.092 ± 0.01	**P= 0.014**
11	10	0.031 ± 0.00	0.049 ± 0.01	0.079 ± 0.00	0.095 ± 0.01	
12	11	0.028 ± 0.00	0.033 ± 0.01	0.054 ± 0.00	0.237 ± 0.15	
13	12	0.050 ± 0.01	0.033 ± 0.00	0.063 ± 0.01	0.105 ± 0.03	
14	13	0.050± 0.01	0.113 ± 0.01	0.119 ± 0.22	0.182 ± 0.02	
15	14	0.056 ± 0.01	0.125 ± 0.01	0.129 ± 0.02	0.193 ± 0.03	
16	15	0.061 ± 0.01	0.130 ± 0.01	0.134 ± 0.02	0.196 ± 0.03	
17	16	0.066 ± 0.01	0.136 ± 0.01	0.140 ± 0.02	0.206 ± 0.02	
18	17	0.074 ± 0.01	0.141 ± 0.01	0.146 ± 0.02	0.210 ± 0.02	
19	**Mean ± SE**	**0.036 ± 0.00**	**0.059 ± 0.00**	**0.070 ± 0.00**	**0.113 ± 0.01**	

Table 6: Significant difference between biomass of the epigeic earthworm, Perionyx excavatus cultured in cattle manure with Samanea saman in different C:N ratios (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	0.324	0.155	**0.003**
10:1	0.324	-	0.617	**0.011**
15:1	0.155	0.617	-	**0.025**
Pure cattle manure (control)	**0.003**	**0.011**	**0.025**	-

Table 7: Growth rate (day/g) of the epigeic earthworm, Eudrilus eugeniae cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
2	1	8.87 ± 4.54	4.67 ± 0.74	4.43 ± 0.76	4.02 ± 1.36	
3	2	12.27 ± 6.83	6.52 ± 0.25	7.32 ± 1.00	7.19 ±0.98	
4	3	6.17± 1.31	8.23 ± 0.38	8.59 ± 0.55	9.99 ± 0.17	
5	4	5.55 ± 2.15	9.84 ± 1.57	9.94 ± 0.17	14.49 ± 3.38	
6	5	5.93 ± 1.99	11.98 ± 0.65	9.96 ± 0.86	25.73 ± 5.59	

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7	6	6.45 ± 1.38	10.59 ± 1.03	11.25 ± 0.39	32.47 ± 1.69	
8	7	5.62 ± 0.83	9.83 ± 0.68	10.41 ± 0.45	32.08 ± 1.51	
9	8	5.71 ± 0.93	9.07 ± 0.50	9.64 ± 0.39	28.08 ± 1.41	F=35.410
10	9	5.36 ± 0.80	8.35 ±0.31	8.82 ± 0.28	25.92 ± 1.19	**P=0.000**
11	10	0.03 ± 1.18	7.16 ± 0.21	7.26 ± 0.64	19.11 ± 0.86	
12	11	6.32 ± 0.39	6.53 ± 0.19	6.64 ± 0.59	16.31 ± 1.60	
13	12	5.44 ± 0.53	6.19 ± 0.05	5.97 ± 0.31	15.88 ± 2.55	
14	13	4.32 ± 0.28	8.47 ± 0.56	9.12 ± 0.39	16.71 ± 2.80	
15	14	4.04 ± 0.10	8.10 ± 0.40	9.22 ± 0.32	15.58 ± 2.62	
16	15	3.98 ± 0.25	7.60 ± 0.37	8.63 ± 0.29	14.56 ± 2.44	
17	16	3.70 ± 0.24	7.16 ± 0.36	8.17 ± 0.32	13.42 ± 2.10	
18	17	3.58 ± 0.21	6.77 ± 0.34	7.66 ± 0.25	12.96 ± 2.11	
19	**Mean ± SE**	**5.46 ± 0.53**	**7.61 ± 0.36**	**7.95 ± 0.36**	**16.96 ± 1.29**	

Table 8: Significant difference between growth rate of the epigeic earthworm, Eudrilus euginae cultured in cattle manure with Samanea saman in different C:N ratios (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	0.114	0.075	**0.000**
10:1	0.114	-	0.791	**0.000**
15:1	0.075	0.791	-	**0.000**
Pure cattle manure (control)	**0.000**	**0.000**	**0.000**	-

Table 9: Growth rate (day/g) of the epigeic earthworm, Eisenia fetida cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
2	1	3.24 ± 1.15	4.15 ± 0.56	2.93 ± 0.58	5.77 ± 0.53	
3	2	3.95 ± 0.56	5.34 ± 0.22	4.80 ± 0.76	9.85 ± 1.68	
4	3	4.09 ± 0.50	6.06 ± 0.73	7.72 ± 0.77	8.84 ± 0.36	
5	4	3.83 ± 0.54	7.42 ± 0.67	6.85 ± 0.95	11.97 ± 0.73	

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6	5	4.29 ± 0.66	6.43 ± 0.41	8.43 ± 1.15	11.39 ± 0.17	
7	6	4.58 ± 0.55	5.36 ± 0.23	7.73 ± 0.85	11.23 ± 0.53	
8	7	4.53 ± 0.54	4.59 ± 0.44	6.82 ± 0.53	9.15 ± 1.07	
9	8	4.24 ± 0.45	4.35 ± 0.47	5.59 ± 0.30	8.27 ± 1.13	
10	9	4.67 ±0.81	4.22 ± 0.43	5.38 ± 0.41	7.79 ± 0.89	F=36.041
11	10	2.80 ± 0.49	3.50 ± 0.37	3.78 ± 0.36	6.61 ± 0.35	**P=0.000**
12	11	2.70 ± 0.40	3.34 ± 0.27	3.55 ± 0.32	6.25 ± 0.25	
13	12	2.61 ± 0.30	3.39 ± 0.29	4.29 ± 0.46	6.24 ± 0.52	
14	13	3.66 ± 0.62	4.19 ± 0.17	4.84 ± 0.59	6.11 ± 0.31	
15	14	3.25 ± 0.38	4.04 ± 0.11	4.63 ± 0.48	6.55 ± 0.31	
16	15	3.06 ± 0.35	3.82 ± 0.12	4.34 ± 0.44	6.28 ± 0.40	
17	16	3.08 ± 0.15	3.62 ± 0.11	4.09 ± 0.41	5.97 ± 0.37	
18	17	2.77 ± 0.29	3.43 ± 0.01	3.94 ± 0.42	5.66 ± 0.36	
19	**Mean ± SE**	**3.41 ± 0.18**	**4.29 ± 0.22**	**4.98 ± 0.29**	**7.44 ± 0.39**	

Table 10: Significant difference between growth rate of the epigeic earthworm, Eisenia fetida cultured in Samanea saman with cattle manure in different C:N ratio (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	0.057	**0.004**	**0.000**
10:1	0.057	-	0.122	**0.000**
15:1	**0.004**	0.122	-	**0.000**
Pure cattle manure (control)	**0.000**	**0.000**	**0.000**	-

Table 11: Growth rate (day/g) of the epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.00± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
2	1	1.01 ± 0.31	0.55 ± 0.10	0.52 ± 0.08	2.64 ± 0.88	
3	2	0.57 ± 0.21	0.61 ± 0.27	1.01 ± 0.15	3.41 ± 0.12	
4	3	0.66 ± 0.15	0.61 ± 0.10	0.71 ± 0.21	2.12 ± 0.51	

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5	4	0.52 ± 0.10	0.65 ± 0.07	0.62 ± 0.14	1.94 ± 0.23	
6	5	0.44 ± 0.21	1.08 ± 0.31	1.30 ± 0.33	1.79 ± 0.37	F=0.857
7	6	0.20 ± 0.05	0.79 ± 0.20	1.38 ± 0.45	1.60 ±0.34	P=0.501
8	7	0.30 ± 0.05	0.76 ± 0.16	0.94 ± 0.10	2.17 ± 0.38	
9	8	0.30 ± 0.05	0.67 ± 0.22	1.17 ± 0.11	1.36 ± 0.44	
10	9	0.37 ± 0.01	0.67 ± 0.20	1.13 ± 0.09	1.38 ± 0.30	
11	10	0.34 ± 0.08	0.59 ± 0.21	1.03 ± 0.07	1.28 ± 0.26	
12	11	0.26 ± 0.03	0.38 ± 0.12	0.62 ± 0.07	1.76 ± 1.07	
13	12	0.28 ± 0.04	0.31 ± 0.05	0.67 ± 0.19	1.18 ± 0.42	
14	13	0.46 ± 0.12	1.16 ± 0.12	1.24 ± 0.24	1.91 ± 0.34	
15	14	0.50 ± 0.13	1.20 ± 0.12	1.25 ± 0.22	1.91 ± 0.33	
16	15	0.50 ± 0.12	1.17 ± 0.09	1.21 ± 0.19	1.82 ± 0.32	
17	16	0.52 ± 0.10	1.16 ± 0.09	1.19 ± 0.20	1.79 ± 0.28	
18	17	0.55 ± 0.10	1.13 ± 0.08	1.17 ± 0.19	1.72 ± 0.26	
19	**Mean± SE**	**0.43 ± 0.03**	**0.75 ± 0.05**	**0.95 ± 0.06**	**1.77 ± 0.12**	

Table 12: Significant difference between growth rate of the epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	0.707	0.549	0.162
10:1	0.707	-	0.819	0.282
15:1	0.549	0.819	-	0.386
Pure cattle manure (control)	0.162	0.282	0.386	-

Table 12: Sexual maturity (%) of the epigeic earthworm, Eudrilus eugeniae cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
2	1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
3	2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
4	3	26.66 ± 13.33	40.00 ± 20.00	40.00 ± 0.00	66.66 ± 24.03	

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5	4	46.66 ± 5.66	73.33 ± 6.66	73.33 ± 6.66	93.33 ± 6.66	
6	5	60.00 ± 0.00	80.00 ± 0.00	86.66 ± 6.66	100.00 ± 0.00	F=5.778
7	6	93.33 ± 6.66	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	**P=0.021**
8	7	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
9	8	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
10	9	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
11	10	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
12	11	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
13	12	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
14	13	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
15	14	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
16	15	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
17	16	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
18	17	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
19	**Mean ± SE**	**73.70 ± 5.41**	**77.40 ± 5.26**	**77.77 ± 5.19**	**81.11 ± 5.21**	

Table 14: Significant difference between Sexual maturity of the epigeic earthworm, Eudrilus euginae cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1).

C: N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	0.061	**0.043**	**0.003**
10:1	0.061	-	0.833	0.085
15:1	**0.043**	0.833	-	0.119
Pure cattle manure (control)	**0.003**	0.085	0.119	-

Table 14: Sexual maturity (%) of the epigeic earthworm, Eisenia fetida cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
2	1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
3	2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	

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4	3	0.00 ± 0.00	13.33 ± 6.66	26.66 ± 6.66	26.66 ± 6.66	
5	4	6.66 ± 6.66	20.00 ± 11.54	53.33 ± 13.33	40.00 ± 0.00	
6	5	33.33 ± 6.66	46.66 ± 6.66	6.66 ± 17.63	46.66 ±6.66	
7	6	46.66 ± 6.66	66.66 ± 6.66	93.33 ± 6.66	60.00 ± 0.00	
8	7	86.66 ± 6.66	86.66 ± 6.66	93.33 ± 6.66	93.33 ± 6.66	F=5.788
9	8	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	**P=0.021**
10	9	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
11	10	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
12	11	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
13	12	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
14	13	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
15	14	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
16	15	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
17	16	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
18	17	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
19	**Mean ± SE**	**65.18 ± 6.03**	**68.51 ± 5.68**	**74.07 ± 5.40**	**70.37 ± 5.41**	

Table 16: Significant difference between Sexual maturity of the epigeic earthworm, Eisenia fetida cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	0.219	**0.004**	**0.038**
10:1	0.219	-	**0.028**	0.286
15:1	**0.004**	**0.028**	-	0.166
Pure cattle manure (control)	**0.038**	0.286	0.166	-

Table 16: Sexual maturity (%) of the epigeic earthworm, Perionyx excavates cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
2	1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	

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3	2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
4	3	6.66 ± 6.66	20.00 ± 0.00	40.00 ± 0.00	26.66 ±6.66	
5	4	40.66 ± 0.00	46.66± 6.66	53.33 ± 6.66	46.66± 6.66	
6	5	60.00 ± 0.00	53.33±6.66	60.00±0.00	60.00 ± 0.00	
7	6	73.33 ± 6.66	73.33 ± 6.66	73.33 ± 6.66	73.33 ± 6.66	
8	7	93.33 ± 6.66	93.33 ± 6.66	93.33 ± 6.66	93.33 ± 6.66	F=1.225
9	8	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	P=0.362
10	9	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
11	10	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
12	11	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
13	12	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
14	13	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
15	14	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
16	15	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
17	16	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
18	17	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	
19	**Mean ± SE**	**70.74 ± 5.56**	**71.48 ± 5.40**	**73.33 ± 5.18**	**72.22 ± 5.32**	

Table 18: Significant difference between Sexual maturity of the epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	0.667	0.111	0.296
10:1	0.667	-	0.217	0.521
15:1	0.111	0.217	-	0.521
Pure cattle manure (control)	0.296	0.521	0.521	-

Table 18: Rate of cocoon production (worm/week) of the epigeic earthworm, Eudrilus eugeniae cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
2	1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
3	2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
4	3	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
5	4	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	

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6	5	0.00 ± 0.00	0.00 ± 0.00	0.13 ± 0.13	1.66 ± 0.88	
7	6	0.06 ± 0.06	1.00 ± 0.34	1.73 ± 0.35	2.73 ± 1.45	
8	7	0.86 ± 0.26	1.40 ±0.23	2.73 ± 0.74	3.93 ± 0.78	
9	8	0.93 ± 0.26	2.06 ± 0.33	3.73 ± 0.58	4.66 ± 0.74	F=9.257
10	9	0.80 ± 0.11	2.80 ± 1.00	3.73 ± 0.66	3.93 ± 1.17	**P=0.006**
11	10	1.06 ± 0.17	2.66 ± 0.56	3.46 ± 0.13	3.73 ± 0.76	
12	11	1.53 ± 0.26	2.40 ± 0.41	3.53 ± 1.22	4.00 ± 1.11	
13	12	1.06 ± 0.13	2.13 ± 0.26	2.20 ± 1.33	3.33 ± 1.20	
14	13	1.40 ± 0.23	2.06 ± 0.35	2.93 ± 0.63	3.60 ± 0.52	
15	14	1.66 ± 0.17	2.73 ± 0.56	2.86 ± 0.67	4.46 ± 0.85	
16	15	1.46 ± 0.46	2.93 ± 0.96	3.40 ± 1.20	5.20 ± 0.60	
17	16	1.46 ± 0.46	3.46 ± 0.96	3.73 ± 1.15	4.26 ± 0.69	
18	17	1.60 ± 0.20	3.86 ± 0.86	4.80 ± 0.52	4.40 ± 1.30	
19	CCN* for 17 weeks	13.88 ± 2.77	29.49 ± 6.82	38.96 ± 9.31	49.89 ± 12.05	
20	**X cocoon rate(worm/week) ± SE**	**1.15 ± 0.23**	**2.45 ± 0.56**	**2.99 ± 0.71**	**3.83 ± 0.92**	

CCN* = Cumulative Cocoon Number

Table 20: Significant difference between Cocoon production of the epigeic earthworm, Eudrilus euginae cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	0.089	**0.014**	**0.001**
10:1	0.089	-	0.274	**0.013**
15:1	**0.014**	0.274	-	0.077
Pure cattle manure (control)	**0.001**	**0.013**	0.077	-

Table 20: Rate of cocoon production (worm/week) of the epigeic earthworm, Eisenia fetida cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
2	1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
3	2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
4	3	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	

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5	4	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
6	5	0.00 ± 0.00	0.41 ± 0.41	0.83 ± 0.83	2.12 ± 0.24	
7	6	0.00 ± 0.00	1.31 ± 0.36	2.58 ± 0.71	4.36 ± 1.29	
8	7	0.13 ± 0.13	2.73 ± 0.76	2.25 ± 0.62	4.98 ± 1.90	
9	8	0.80 ± 0.20	1.83 ± 0.16	2.66 ±1.16	4.93 ± 0.45	F=24.400
10	9	0.65 ± 0.08	1.08 ± 0.14	2.56 ± 0.47	4.16 ± 0.50	**P=0.000**
11	10	1.60 ± 0.65	2.35 ± 0.35	2.61 ± 0.49	5.10 ± 0.20	
12	11	1.81 ± 0.59	2.45 ± 0.85	2.56 ± 0.92	6.38 ± 0.49	
13	12	2.10 ± 0.37	1.80 ± 0.61	3.06 ± 0.40	4.61 ± 0.93	
14	13	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	4.05 ± 0.81	
15	14	1.63 ± 0.18	3.16 ± 0.44	4.76 ± 0.68	4.33 ± 0.90	
16	15	1.03 ± 0.36	2.15 ± 0.52	4.81 ± 1.67	4.37 ± 1.17	
17	16	1.53 ± 0.63	2.68 ± 0.49	3.88 ± 0.99	5.16 ± 0.97	
18	17	1.25 ± 0.25	1.96 ± 0.28	2.80 ± 0.20	6.45 ± 1.10	
19	CCN* for 17 weeks	12.53 ± 3.44	23.91 ± 5.37	35.36 ± 9.14	61.00 ± 10.95	
20	**X cocoon rate(worm/week) ± SE**	**1.13 ± 0.31**	**1.83 ± 0.41**	**2.72 ±0.70**	**4.69 ± 0.84**	

Table 22: Significant difference between Cocoon production of the epigeic earthworm, Eisenia fetida cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	0.089	**0.005**	**0.000**
10:1	0.089	-	0.088	**0.000**
15:1	**0.005**	0.088	-	**0.003**
Pure cattle manure (control)	**0.000**	**0.000**	**0.000**	-

Table 22: Rate of cocoon production (worm/week) of the epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
2	1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
3	2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
4	3	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
5	4	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	

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6	5	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
7	6	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.55 ± 0.55	
8	7	0.00 ± 0.00	1.13 ± 0.27	1.66 ± 0.33	2.77 ± 0.48	
9	8	0.69 ± 0.38	2.44 ± 0.61	3.33 ± 0.00	3.19 ± 0.60	F=9.751
10	9	0.88 ± 0.11	2.47 ± 0.46	3.66 ± 0.33	3.33 ± 0.19	**P=0.005**
11	10	0.88± 0.39	2.41 ± 0.30	3.66 ± 0.00	3.83 ± 0.78	
12	11	1.66 ± 0.33	2.41 ± 0.61	2.88 ± 0.11	2.91 ± 0.65	
13	12	1.63 ± 0.89	2.16 ± 0.44	2.55 ± 0.11	2.86 ± 0.82	
14	13	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.88 ± 0.48	
15	14	1.58 ± 0.41	1.44 ± 0.11	2.44 ± 0.29	2.05 ± 0.27	
16	15	1.77 ± 0.48	2.55 ± 0.29	2.33 ± 0.33	2.44 ± 0.22	
17	16	1.53 ± 0.29	2.22 ± 0.40	2.21 ± 0.29	2.08 ± 0.50	
18	17	1.33 ± 0.33	2.66 ± 0.19	3.55 ± 0.29	3.22 ± 0.97	
19	CCN* for 17 weeks	11.95 ± 3.61	21.89 ± 3.68	28.27 ± 2.08	31.11 ± 6.51	
20	**X cocoon rate(worm/week) ± SE**	**1.195 ± 0.361**	**1.99 ± 0.33**	**2.57 ± 0.18**	**2.59 ± 0.54**	

Table 24: Significant difference between Cocoon production of the epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	**0.033**	**0.003**	**0.001**
10:1	**0.033**	-	0.135	**0.043**
15:1	**0.003**	0.135	-	0.481
Pure cattle manure (control)	**0.001**	**0.043**	0.481	-

Table 23: Rate of cocoon production (worm/week) of the epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1), with their significant F and P-values. Values are in Mean ± SE.

Sl. No.	**Week**	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**	**Significant difference F and P- values**
1	IW	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
2	1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
3	2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
4	3	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	

5	4	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
6	5	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
7	6	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.55 ± 0.55	
8	7	0.00 ± 0.00	1.13 ± 0.27	1.66 ± 0.33	2.77 ± 0.48	
9	8	0.69 ± 0.38	2.44 ± 0.61	3.33 ± 0.00	3.19 ± 0.60	F=9.751
10	9	0.88 ± 0.11	2.47 ± 0.46	3.66 ± 0.33	3.33 ± 0.19	**P=0.005**
11	10	0.88± 0.39	2.41 ± 0.30	3.66 ± 0.00	3.83 ± 0.78	
12	11	1.66±0.33	2.41 ± 0.61	2.88 ± 0.11	2.91 ± 0.65	
13	12	1.63 ± 0.89	2.16 ± 0.44	2.55 ± 0.11	2.86 ± 0.82	
14	13	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.88 ± 0.48	
15	14	1.58 ± 0.41	1.44 ± 0.11	2.44 ± 0.29	2.05 ± 0.27	
16	15	1.77 ± 0.48	2.55 ± 0.29	2.33 ± 0.33	2.44 ± 0.22	
17	16	1.53 ± 0.29	2.22 ± 0.40	2.21 ± 0.29	2.08 ± 0.50	
18	17	1.33 ± 0.33	2.66 ± 0.19	3.55 ± 0.29	3.22 ± 0.97	
19	CCN* for 17 weeks	11.95 ± 3.61	21.89 ± 3.68	28.27 ± 2.08	31.11 ± 6.51	
20	**X cocoon rate(worm/week) ± SE**	1.195 ± 0.361	1.99 ± 0.33	**2.57 ± 0.18**	**2.59 ± 0.54**	

CCN* = Cumulative Cocoon Number

Table 24: Significant difference between Cocoon production of the epigeic earthworm, Perionyx excavatus cultured in Samanea saman with cattle manure in different C:N ratios (5:1, 10:1 and 15:1).

C:N ratio	**5:1**	**10:1**	**15:1**	**Pure cattle manure (control)**
5:1	-	**0.033**	**0.003**	**0.001**
10:1	**0.033**	-	0.135	**0.043**
15:1	**0.003**	0.135	-	0.481
Pure cattle manure (control)	**0.001**	**0.043**	0.481	-

SUMMARY AND CONCLUSION

The results revealed that Eudrilus eugeniae showed better growth and reproduction in Control cattle manure followed by Eisenia fetida and least in Perionyx excavatus. In case of Eisenia fetida and Perionyx excavates, early maturation was noticed in 15:1 C:N ratio. Eudrilus eugeniae showed 100% survivability followed by 80% in Eisenia fetida and only 58.3% in Perionyx excavatus. Thus, different C:N ratio influenced the growth and reproduction of these three epigeic earthworms.

Hence, based on the results obtained in the present study it is clear that Control-CM serves as better feed material as compared to altered C:N ratio with the feed material (Samanea saman). Among all three species, it is recommended that Eudrilus eugeniae can be best cultured in cattle manure for successful Vermitechnology as compared to rest of the two species as it showed better results for overall growth and reproduction.

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