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Biodyanamics of epigeic earthworm *Eudrilus eugeniae* and *Eiseniae fetida* during recycling of poultry waste amended with different organic food sources

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ABSTRACT
Utilizing different epigeic earthworms, is an eco-biotechnological method that transforms energy rich and complex organic substances into a stabilized nutrient rich product Currently, a very meager quantity of the poultry droppings is usually used as fertilizer source and soil conditioner. However, this type of utilization is not pleasing practice in view of the odor from biological degradation. In the present study, potential of vermicomposting technology in the management of poultry droppings (PD) amended with cow dung (CD) and press mud (PM) using epigeic earthworm species Eudrilus eugeniae and Eiseniae fetida under laboratory conditions. Different treatments were maintained for this study and the growth and reproduction potential of Eudrilus eugeniae and Eiseniae fetida were monitored for 75 days after pre-composting. Result revealed that maximum growth (maximum biomass achieved at end, biomass gain and growth rate of worms) and reproductions (total number of cocoon, total hatchling production) were recorded in 1:1:1 ratio of PD, CD and PM feed mixture containing treatments. However, higher proportions of PD in the treatments significantly affected the growth and reproduction of both species worms.
Key words: *Vermicomposting, Earthworms, Growth, Reproduction, Poultry droppings*

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INTRODUCTION

India is one of the largest producers of poultry in the world and the poultry manure availability is estimated to be 12.1 million tons [1]. In poultry industry huge amount of droppings that accumulated in the litter turns it into significance sources odorous gases including amines, amides, mercaptans, and disulphides. These noxious gases can cause respiratory disease in animals and humans [2]. However, poultry droppings along with litter have useful nutrients, and are therefore used as organic fertilizer [3]. However, uncontrolled decomposition and excess applications of poultry droppings to soil can cause environmental problems due to their extremely high levels of nitrogen as ammonia, low pH, and heat generation. Therefore, there is an urgent need to recycle the poultry droppings with eco-friendly method.

Vermicomposting technology can be one of the suitable techniques for the safe treatment of non-toxic organic waste by using earthworms [4]. Growth (biomass increase), reproduction (cocoon and hatchlings number) and life cycle of different species of earthworms using different materials such as sludge and horse manure [5]; sludge's from paper and pulp industries [6]; kitchen wastes [7]; sugar industrial waste press mud and bagasse [8, 9];

paper waste and paper mill sludge [10]; sewage sludge and waste activate sludge [11, 12, 13]; different animal wastes [14]; herbal pharmaceutical industry solid wastes [15] and municipal organic solid waste [16] have been studied. Several epigeic earthworms have been well known species as detritus feeders and can be used potentially to minimize the anthropogenic wastes from diverse sources [17, 18, 19]. Growth and fecundity of *E. eugeniae* were studied by Neuhauser *et al.,* [5] using horse manure and sludge, using a mixture of animal and vegetable waste materials by Suthar [20] and using cattle dung by Vig *et al.,* [21]. Further, Manivannan *et al.* [22] reported the better growth of *E. eugeniae* in press mud and Manivannan, [23] studied and reported the growth, reproduction and life cycle of *E. eugeniae* and *L. mauritii* using pressmud. Recently, Karmegam and Daniel (24) studied the growth and reproduction of *E. eugeniae* in partly degraded leaf litter substrates. However, *E. eugeniae* and *E. fetida* was, and still remains, the favored earthworm species for laboratory trail experiments on poultry droppings through vermicomposting due to its wide tolerance of environmental variables. Hence choosing this species is a first pre-requisite for launching a vermicomposting of poultry droppings amended with press mud and cow dung. Poultry droppings contain a significant fraction of organic material and are a rich source of protein and nitrogen. Therefore, in order to utilize this species successfully effort is being done to examine the role of these earthworm species in vermicomposting of PD amended with PM and CD in order to produce large scale vermicompost production.

MATERIALS AND METHODS

Organic waste and earthworm species

One week old poultry droppings (PD) were collected from Rasi feeds farm, Rasipuram, Namakkal district, Tamil Nadu, India. Two weeks old sugar industry waste press mud (PM) was obtained from effluent treatment plant of E.I.D. Parry Sugar Mill located at Nellikkuppam, Cuddalore District, Tamil Nadu, India. One week old Cow dung (CD) was collected from the agricultural dairy farm, Faculty of Agriculture, Annamalai University, Tamil Nadu, India. Earthworm species *E. eugeniae* and *E. fetida* were cultured and developed outside the laboratory on partially degraded cow dung as feed, respectively. Earthworm's *E. eugeniae* and *E. fetida* were randomly picked from the culture and used for the purpose of this work.

Experimental design

Different treatments were established having 3kg of feed mixture each containing different ratios of PD, CD and PM (Table1). Each treatment was established in triplicate. The feed mixtures were turned manually every day for two weeks in order to stabilize the feed, so that it becomes palatable to earthworms. After 14 days sixty species of worms were introduced in each treatment, separately. The moisture content was maintained at 70 - 80% during the experiment. The treatments were covered with moist jute to prevent moisture loss. The 0 day of the experiment refers to the day of inoculation of earthworms after stabilization of 14 days.

Growth and reproduction study of *E. eugeniae* and *E. fetida*

Biomass reproduction by *E. eugeniae* and *E. fetida* in each treatment was recorded periodically during experimentation, respectively. The feed in the treatment was turned out then worms and cocoons were separated from the treatment by hand sorting, after which they were counted and weighed after washing with water and then all worms and the feed were returned to their respective treatments. All the results reported in the text are the mean of three replicates and one-way ANOVA was used to analyze the significant differences among different treatments for both worms and Tukey's *t*-test was used as a post hoc analysis to compare the means (SPSS Package). Probability levels of the results used for statistical significance were $P < 0.05$ for the tests.

RESULTS AND DISCUSSION

The significant changes in worm biomass, reproduction and mortality of all the treatments for *E. eugeniae* and *E. fetida* over the experimentation period are illustrated in Table 2 - 6. Statistically *E. eugeniae* and *E. fetida* showed significant difference in biomass production and reproduction potential, i.e., maximum biomass achieved at end (mg worm^{-1}), biomass gain (mg worm^{-1}), growth rate (mg worm^{-1} day^{-1}), total number of cocoon, number of cocoon produced (worm^{-1}), total hatchling number and mean reproduction rate (cocoon worm^{-1} day^{-1}) among different Treatments. *E. eugeniae* showed a maximum and minimum mean individual biomass achieved at end on VT3, VT1 and VT2 treatments, respectively (Table 2). Similarly, *E. fetida* showed a maximum and minimum mean individual biomass gained at end on VT8, VT6 and VT7 treatments, respectively (Table 3). *E. fetida* showed significantly higher mean individual weight gained in VT8, followed by VT6, VT7, VT9 and VT8, respectively. On the other hand, in the present study biomass gain (mg worm^{-1}) and growth rate (mg worm^{-1}) of *E. eugeniae* in VT3 treatment was higher than other treatments studied and the order of net biomass gain and growth rate (mg worm^{-1}) among treatments was: VT3> VT1> VT2> VT5 >VT4 (Table 2 and 3).

Similarly, net biomass gain (mg worm^{-1}) of and growth rate (mg worm^{-1}) of *E. fetida* in VT8 treatment was higher than other treatments studied. The order of net biomass gain and growth rate (mg worm^{-1}) among treatments was: VT8> VT6> VT7> VT10 > VT9 (Table 3 and 4). The findings from the present work, in the context of change in growth and weight of worms with the stocking density corroborates with the findings of other researchers (25, 26). Edwards *et al.* (27) also reported that population density of worms per unit volume or weight of feed was important in affecting the rate of biomass. Neuhauser *et al.* (5) studied impact of population density on biomass growth and reproduction of epigeic species *E. foetida* and they reported that growth of worms was related to the substrate material. Suthar (28) also reported that in addition to the biochemical properties of waste, the microbial biomass and decomposition activities during vermicomposting are also important in determining the worm biomass production. The results clearly suggested that importance of amendment material in vermicomposting may be justified in terms of the physical, chemical and biological nature of the amendment.

Table 1: The composition of selected waste in different experimental treatments

Experimental Treatment	Treatment Description	Ratio
Eudrilus eugeniae		
VT1	Poultry droppings with press mud	1:1
VT2	Poultry droppings with Cow dung	1:1
VT3	Poultry droppings with press mud and Cow dung	1:1:1
VT4	Poultry droppings with press mud	2:1
VT5	Poultry droppings with Cow dung	2:1
Eisenia fetida		
VT6	Poultry droppings with press mud	1:1
VT7	Poultry droppings with Cow dung	1:1
VT8	Poultry droppings with press mud and Cow dung	1:1:1
VT9	Poultry droppings with press mud	2:1
VT10	Poultry droppings with Cow dung	2:1

Table 2: Biomass of *E. eugeniae* during vermicomposting of PD mixed with PM and CD in different treatments

Experimental Treatment	Mean initial biomass/worm (mg)	Biomass gain/worm (mg)	Growth rate/worm/day (mg)
VT1	186 ± 10.3^{a}	961± 80.24^{cd}	12.90 ± 1.23^{c}
VT2	192 ± 15.3^{a}	793 ± 75.53^{c}	10.20 ± 1.56^{b}
VT3	192 ± 11.2^{a}	1059 ± 81.42^{d}	14.20 ± 2.54^{d}
VT4	150 ± 12.1^{a}	635 ± 15.09^{b}	8.50 ± 0.27^{a}
VT5	185 ± 14.4^{a}	636 ± 50.74^{b}	8.50 ± 0.76^{a}

All values are reported as mean ± standard deviation between three replicates; values in the same column with different letters are significantly different (ANOVA; Tukey's test, $p < 0.01$).

Table 3: Biomass of *E. fetida* during vermicomposting of PD mixed with PM and CD in different treatments

Experimental Treatment	Mean initial biomass/worm (mg)	Biomass gain/worm (mg)	Growth rate/worm/day (mg)
VT6	155 ± 15.4^{a}	740 ± 34.05^{cd}	9.90 ± 0.53^{b}
VT7	150 ± 15.3^{a}	668 ± 26.08^{c}	8.90 ± 0.40^{b}
VT8	154 ± 11.6^{a}	798 ± 22.05^{d}	10.65 ± 0.45^{c}
VT9	151 ± 14.5 ^{a}	354 ± 16.07^{a}	4.80 ± 0.35^{a}
VT10	191 ± 18.4^{a}	420 ± 41.24^{b}	5.70 ± 0.35^{a}

All values are reported as mean ± standard deviation between three replicates; values in the same column with different letters are significantly different (ANOVA; Tukey's test, $p < 0.01$).

Table 4: Reproduction rate of *E. eugeniae* during vermicomposting of PD mixed with PM and CD in different treatments

Experimental Treatment	Total no. of cocoons obtained at the end	Total no. of hatchlings obtained at the end
VT1	158 ± 22.0^{bc}	25 ± 4.5^{bc}
VT2	163 ± 15.0^{c}	30 ± 3.3^{bc}
VT3	222 ± 21.0^{d}	60 ± 3.2^{c}
VT4	30 ± 3.0^{a}	4 ± 2.4^{a}
VT5	72 ± 21.0^{b}	19 ± 4.3^{b}

All values are reported as mean ± standard deviation between three replicates; values in the same column with different letters are significantly different (ANOVA; Tukey's test, $p < 0.01$).

Table 5: Reproduction rate of *E. fetida* during vermicomposting of PD mixed with PM and CD in different treatments

Experimental Treatment	Total no. of cocoons obtained at the end	Total no. of hatchlings obtained at the end
VT6	197± 15.2^{b}	37 ± 6.1^{bc}
VT7	205 ± 21.2^{c}	54 ± 5.9^{c}
VT8	285 ± 20.4^{d}	84 ± 11.2^{d}
VT9	31 ± 4.5^{a}	8 ± 0.8^{a}
VT10	55± 12.5^{bc}	21± 4.5^{b}

All values are reported as mean ± standard deviation between three replicates; values in the same column with different letters are significantly different (ANOVA; Tukey's test, $p < 0.01$).

Table 6: Total mortality (%) of *E. eugeniae* and *E.fetida* during vermicomposting of PD mixed with PM and CD in different treatments

Experimental Treatment	*E. eugeniae*	Experimental Treatment	*E.fetida*
VT1	7.9 ± 2.5a^{b}	VT6	4.5 ± 2.5^{ab}
VT2	3.2 ± 0.5^{a}	VT7	2.7 ± 0.4^{a}
VT3	1.4 ± 0^{a}	VT8	1.2 ± 0^{a}
VT4	35.4 ± 9.6^{c}	VT9	40.5 ± 8.4^{c}
VT5	30.4 ± 5.8	VT10	30.5 ± 6.4^{c}

All values are reported as mean ± standard deviation between three replicates; values in the same column with different letters are significantly different (ANOVA; Tukey's test, $p < 0.01$).

The total cocoon numbers varied among treatments and maximum and minimum cocoons obtained at the end were in VT3 and VT1 treatment for *E. eugeniae* and VT8 and VT6 treatment for *E. fetida*, respectively. Similarly, the maximum number of hatchlings was observed in VT3 and VT1 treatment for *E. eugeniae* and VT8 and VT6 treatment for

E. fetida, respectively (Tables 4 and 5). The variation in cocoon numbers and number of hatchings in the treatments for *E. eugeniae* and *E. fetida* were significant ($p<0.05$), respectively. In the present study *E. eugeniae* and *E. fetida* showed a statistically different pattern of mortality among different vermicomposting treatments, respectively. The maximum worm mortality was recorded in the treatments for both species of worms which indicate some growth retarding substances in it (Table 6). However, mortality was lower in those waste mixtures which had less PD concentrations for both worms. Meharaj and Manivannan (23) have also reported some earthworms mortality during the vermicomposting of biogas plant slurry mixed with crop residues. The different mortality rates during vermicomposting may be due to the difference in the quality and chemical composition of waste mixtures used. The survival rate of earthworms also depends upon the rate of food consumption during acclimatization of worms in the waste mixtures during initial period vermicomposting. Moreover, changes in pH of substrate, higher C:N ratio of initial substrate and production of toxics or foul smelling gases maybe some of the factors responsible earthworms mortality (22). The growth and reproduction of the *E. eugeniae* and *E. fetida* was best when allowed to feed PD amended with PM and CD in1:1:1 ratio.

CONCLUSION

From this study it was observed that addition organic amendment i.e, CD and PM with PD was efficient to support various growth parameters, i.e., biomass production, growth rate, cocoon and hatchlings production for *E. eugeniae* and *E. fetida*. Hence, it was concluded that if CD and PM are amended in proper quantities (1:1:1: ratio), it would be most effective to support a sustainable harvest of earthworms for large scale vermicomposting practices. In addition, results of this study also revealed that among the two species of epigeic worms, *E. eugeniae* exhibits healthier biomass production, growth rate, cocoons and hatchlings production than *E. feida.*

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