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Influence of poultry waste amended with different organic food sources on growth and reproduction performance of indigenous earthworms *Lampito mauritii* (Kinberg) and *Perionyx excavates* (Perrier)

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ABSTRACT

Disposal of poultry waste (PW) is becoming one of the major areas of concern for a developing country like India. Currently, a very meager quantity of the PW is usually used as fertilizer source and soil conditioner. However, this approach is not pleasing practice in view of the odor from biological degradation. In the present study, potential of vermicomposting technology in the management of PW amended with cow dung (CD) and press mud (PM) using local earthworm species Lampito mauritii and Perionyx excavates under laboratory conditions. A total of six vermicomposters were maintained for this study and the growth and reproduction of L. mauritii and P.excavates were monitored for 60 days after pre-composting (14 days). Result revealed that maximum growth (maximum biomass achieved at end, biomass gain and growth rate) and reproduction (total number of cocoon, total hatchling number and mean reproduction rate) were recorded in 100% cow dung (control) and 1:1:1 ratio of CD+PM+PW feed mixture containing vermicomposters. However, higher percentages of PW in the feed and/or PW alone in different vermicomposters significantly affected the growth and reproduction of both species worms.

Key words: poultry waste, vermicomposting, earthworms, growth, reproduction.

INTRODUCTION

The dramatic development of the poultry industry over the last 20 years created a serious waste disposal problem. 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 [31]. In the poultry farm large amount of droppings that accumulated in the litter turns it into importance sources of contamination *i.e.* odorous gases including amines, amides, mercaptans, sulphides and disulphides. These noxious gases can cause respiratory disease in animals and humans [27]. However, poultry droppings along with litter have useful nutrients, and are therefore used as organic fertilizer [21]. However uncontrolled decomposition and excess applications of PW 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 waste without environmental impact.

Vermicomposting technology can be one of the suitable techniques for the safe treatment of non-toxic organic waste by using earthworms [26]. Through this process inoculated earthworms maintain aerobic condition in the wastes,

convert a portion of the organic material into worm biomass and respiration products and expel the remaining partially stabilized nutrient rich product (vermicompost). Biomass, reproduction and life cycle of different species of earthworms using different materials such as sludge and horse manure [23]; sludge's from paper and pulp industries [4]; kitchen wastes [1]; sugar industrial wastes [19,15,18]; paper waste [6]; sewage sludge [7,14]; animal wastes [17]; waste activate sludge [8]; municipal solid waste [24] and herbal pharmaceutical industry solid wastes [28] have been studied.

Several epigeic earthworm, e.g., *Eisenia fetida*, *Eudrilus eugeniae*, *Perionyx excavates* and *Perionyx sansibaricus* have been identified as detritus feeders and can be used potentially to minimize the anthropogenic wastes from different sources [19,2,7]. Growth and reproduction of *E. eugeniae* were studied by Neuhauser *et al*. [23] using sludge and horse manure, using a mixture of animal and vegetable waste materials by Loehr *et al*. [16] and using cow dung by Kale and Bano [9]. Further, Kale *et al*. [10] reported the better growth of *E. eugeniae* in press mud. Ramalingam [25] studied the growth, reproduction and life cycle of *E. eugeniae* and *L. mauritii* using pressmud. Karmegam and Daniel [12] studied the growth and reproduction of *E. eugeniae* in leaf litter substrates. The indigenous earthworms (*L. mauritii* and *P. excavates*) which were commonly found in Indian soils, has appeared as an efficient tool for organic waste reduction [32]. *L. mauritii and P. excavates* was, and still remains, the favoured earthworm species for laboratory trail experiments on vermicomposting due to its wide tolerance of environmental variables [19]. Hence choosing native species is a first pre-requisite for launching a vermicomposting programme. Poultry waste contains a significant fraction of organic material and is a rich source of protein and nitrogen. Therefore, in order to utilize this species successfully effort is being done to examine the role of local earthworm species *Lampito mauritii* and *Perionyx excavates* in vermicomposting of PW amended with CD and PM in order to produce large scale vermicompost for agronomic purpose.

MATERIALS AND METHODS

Organic waste and earthworm species

Poultry waste (PW) was collected from Indian feeds farm, Perumalkovilmedu, Namakkal district, Tamil Nadu, India. Press mud (PM) was obtained from effluent treatment plant of E.I.D. Parry Sugar Mill located at Nellikkuppam, Tamil Nadu, India. Fresh Cow dung (CD) was collected from the agricultural farm, Faculty of Agriculture, Annamalai University, Tamil Nadu, India. Native earthworm species *Lampito mauritii* (Kinberg) and *Perionyx excavates* (Perrier) of different age groups were cultured and developed outside the laboratory on partially degraded cow dung as feed, respectively. Earthworms *L.mauritii* (30-35 days old) and *P. excavates* (25-30 days) were randomly picked from the culture and used for the purpose of this experiment.

Experimental design

Six vermicomposters (cement tank) were established having 3kg of feed mixture each containing CD, PM and PW alone (control) and CD, PM mixed with PW in different rations (Table1). Each vermicomposter was established in triplicate. The feed mixtures were turned manually every day for 14 days in order to stabilize the feed so that it becomes palatable to worms. After 14 days fifty species of worms were introduced in each vermicomposter, separately. The moisture content was maintained at 65-75% during the experiment. The vermicomposter were covered with moist jute to prevent moisture loss. The 0 day (Initial) refers to the day of inoculation of earthworms after stabilization of 14 days.

Growth and reproduction study

Biomass gain, cocoon and hatchlings production by *L.mauritii* and *P. excavates* in each vermicomposter were recorded periodically during experimentation, respectively. The feed in the vermicomposter was turned out then earthworms and cocoons were separated from the feed by hand sorting, after which they were counted and weighed after washing with water. Then all earthworms and the feed (but not cocoons) were returned to their respective vermicomposter. All the results reported in the text are the mean of three replicates. One-way ANOVA was used to analyze the significant differences among different vermicomposters. Tukey's *t*-test was used as a post hoc analysis to compare the means (SPSS Package). The probability levels used for statistical significance were $P < 0.05$ for the tests.

RESULTS AND DISCUSSION

The changes in worm biomass, reproduction and mortality of all vermicomposter for *L. mauritii* and *P. excavatus* over the experimentation period are illustrated in Table 2-6. Statistically *L. mauritii* and *P.excavatus* 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 vermicomposters. Both species showed maximum and minimum mean individual biomass achieved at end in CD and PW alone vermicomposter, respectively. However, *L. mauritii* showed significantly higher individual weight in CD (1249±138.27mg) followed by CD+PM+PW (1144±167.18 mg), CD+PW (994±95.15mg), PM (909±113.15mg), PM+PW (816±61.06mg) and PW (606±68.03mg); and *P. excavatus* showed significantly higher individual weight in CD (947±39.23mg), followed by CD+PM+PW (946±38.0mg), CD+PW (894±57.06mg), PM (813±42.28mg), PM+PW (790±28.14mg) and PW (501±28.12mg) during the experimentation (Table 2).

Table 1: Description of vermicomposters used for experimentations (*Lampito mauritii* and *Perionyx excavates*)

Vermicomposter	Ratio	Description
CD (control)	-	100% cow dung
PM (control)	-	100% press mud
PW	-	100% poultry waste
CD+PW	1:1	1 part cow dung + 1 part poultry waste
PM+PW	1:1	1 part press mud + 1 part poultry waste
CD+PM+PW	1:1:1	1 part cow dung +1 part press mud+ 1 part poultry waste

Table 2: Biomass of *L. mauritii* and *P. excavates* during vermicomposting of PW amended with CD and PM

Vermicomposter	Mean initial biomass/worm (mg)		Maximum biomass achieved/worm (mg) at the end	
	L. mauritii	*P. excavatus*	*L. mauritii*	*P. excavatus*
CD	195 ± 13.1^{a}	154 ± 11.1^{a}	1249 ± 138.27^{bc}	947 ± 39.23^{bc}
PM	191 ± 11.2^{a}	149 ± 16.0^{a}	909 ± 113.15^{b}	813 ± 42.28^{b}
PW	194 ± 19.2^{a}	152 ± 15.5^{a}	606 ± 68.03^{a}	501 ± 28.12^{a}
CD+PW(1:1 ratio)	190 ± 20.1^{a}	156 ± 19.67^{a}	994 ± 95.15^{b}	894 ± 57.06^{b}
PM+PW(1:1 ratio)	188 ± 15.2^{a}	153 ± 11.3^{a}	816 ± 61.06^{ab}	790 ± 28.14^{ab}
CD+PM+PW(1:1:1ratio)	188 ± 18.1^{a}	152 ± 17.3^{a}	1144 ± 167.18^{bc}	946 ± 38.01^{bc}

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

Table 3: Biomass gain and growth rate of *L. mauritii* and *P. excavates* during vermicomposting of PW amended with CD and PM

Vermicomposter	Biomass gain/worm (mg) at the end		Growth rate/worm/day (mg)at the end	
	L. mauritii	*P. excavatus*	*L. mauritii*	*P. excavatus*
CD	1056 ± 65.51^{cd}	793 ± 30.19^{cd}	17.65 ± 1.27^{c}	13.21 ± 0.50^{c}
PM	718 ± 52.35^{bc}	663 ± 18.57^{bc}	11.96 ± 1.02^{b}	11.08 ± 0.32^{b}
PW	412 ± 34.52^{a}	347 ± 21.42^{a}	6.86 ± 0.71^{a}	5.83 ± 0.36^{a}
CD+PW(1:1 ratio)	804 ± 49.43^{c}	739 ± 30.25^{c}	13.40 ± 0.92^{bc}	12.30 ± 0.59^{bc}
PM+PW(1:1 ratio)	628 ± 33.22^{b}	637 ± 21.17^{b}	10.46 ± 0.65^{ab}	10.65 ± 0.42^{ab}
CD+PM+PW(1:1:1ratio)	956 ± 90.57^{cd}	794 ± 27.56^{cd}	15.993 ± 1.53^{c}	13.24 ± 0.57^{c}

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

Table 4: Reproduction rate of *L. mauritii* and *P. excavates* during vermicomposting of PW amended with CD and PM

Vermicomposter	Total no. of cocoons obtained at the end		Total no. of hatchlings obtained at the end	
	L. mauritii	*P. excavatus*	*L. mauritii*	*P. excavatus*
CD	226.2 ± 17.0^{c}	281.9 ± 18.5^{c}	68.1 ± 6.1^{c}	84.6 ± 8.1^{d}
PM	157.1 ± 23.0^{bc}	163.8 ± 20.2^{bc}	27.4 ± 4.2^{bc}	31.9 ± 5.3^{bc}
PW	32.3 ± 2.0^{a}	31.6 ± 8.5^{a}	3.9 ± 5.1^{a}	6.8 ± 1.2^{a}
CD+PW(1:1 ratio)	164.5 ± 19.0^{bc}	208.7 ± 13.6^{c}	32.1 ± 4.3^{bc}	58.1 ± 9.2^{c}
PM+PW(1:1 ratio)	111.7 ± 24.0^{b}	94.2 ± 11.1^{b}	17.9 ± 5.1^{b}	23.9 ± 2.2^{b}
CD+PM+PW(1:1:1ratio)	219.4 ± 39.2^{c}	281.2 ± 18.2^{c}	62.8 ± 5.6^{c}	79.7 ± 11.9^{d}

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

However, biomass gain (mg worm^{-1}) of *L. mauritii* and *P.excavatus* in CD vermicomposter was higher than other vermicomposters studied. The order of biomass gain among vermicomposters was: CD > CD+PM+PW > CD+PW > PM > PM+PW > PW for both species of worms. The maximum growth rate (mg worm^{-1} day^{-1}) for *L. mauritii* was in CD (17.65±1.27mg) followed by CD+PM+PW (15.93±1.53mg), CD+PW (13.40±0.92mg), PM (11.96±1.02mg), PM+PW (10.46±0.65mg) and PW (6.86±0.71mg) (Table 2) and for *P.excavatus* was in CD (13.21±0.50mg)

followed by CD+PM+PW (13.24±0.57mg) CD+PW (12.30±0.59mg), PM (11.08±0.32mg), PM+PW (10.65±0.42mg) and PW (5.83±0.36mg) (Table 3). However difference among CD and CD+PM+PW vermicomposters for *L.mauritii* and *P.excavatus* in respect to maximum biomass achieved (mg worm^{-1}), biomass gain (mg worm^{-1}) and growth rate (mg worm^{-1} day^{-1}) were not statistically significant.

Maximum biomass in the vermicomposters may be due to the more palatability and acceptability of feed by earthworms and the minimum biomass in the vermicomposter with higher proportion of PW was possibly due to the presence of some growth-retarding substances in it. The findings from the present work, in the context of change in individual weight of worms with the stocking density corroborates with the findings of other researchers [22,20]. It is suggested that decrease in individual weight of worms at high stocking densities may be due to the exhaustion of foods below maintenance level in the vermicomposters towards the end of vermicomposting period. The growth rate (mg biomass gained/worm/day) has been considered a good comparative index to compare the growth of earthworms in different feeds [3]. Hence, the difference in growth rate among different vermicomposters in the present study seems to be closely related to substrate quality.

Table 5: Reproduction rate of *L. mauritii* and *P. excavates* during vermicomposting of PW amended with C and PM

Vermicomposter	No. of cocoon produced worm^{-1}		Reproduction rate (No. of cocoon worm^{-1} day^{-1})	
	L. mauritii	*P. excavatus*	*L. mauritii*	*P. excavatus*
CD	4.54 ± 0.08^{d}	5.64 ± 0.4^{c}	0.07 ± 0^{d}	0.09 ± 0^{d}
PM	3.16 ± 0.04^{c}	3.28 ± 0.4^{b}	0.05 ± 0^{c}	0.05 ± 0^{c}
PW	0.64 ± 0.01^{a}	0.64 ± 0.18^{a}	0.01 ± 0^{a}	0.01 ± 0^{a}
CD+PW(1:1 ratio)	3.30 ± 0.03^{c}	4.16 ± 0.28^{bc}	0.05 ± 0^{c}	0.06 ± 0^{cd}
PM+PW(1:1 ratio)	2.24 ± 0.03^{b}	1.88 ± 0.22^{ab}	0.03 ± 0^{b}	0.03 ± 0^{b}
CD+PM+PW(1:1:1ratio)	4.38 ± 0.06^{d}	5.6 ± 0.36^{c}	0.07 ± 0^{d}	0.09 ± 0^{d}

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

Table 6: Total mortality (%) of *L. mauritii* and *E. fetida* during vermicomposting of PW amended with CD and PM

Vermicomposter	*L. mauritii*	*E. fetida*
CD	1.6 ± 0^{a}	1.4 ± 0^{a}
PM	13.4 ± 6.0^{ab}	10.2 ± 2.1^{ab}
PW	84.7 ± 10.5^{c}	79.2 ± 13.2^{c}
CD+PW(1:1 ratio)	11.2 ± 4.6^{ab}	3.7 ± 2.6^{a}
PM+PW(1:1 ratio)	52.7 ± 14.3^{b}	46.3 ± 10.2^{b}
CD+PM+PW(1:1:1ratio)	4.8 ± 0.5^{a}	1.8 ± 0.5^{a}

All values are reported as mean ±standard deviation between six 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 vermicomposters and maximum and minimum cocoons obtained at the end were in CD (226.2±21.0) and PW (32.3±2.0) vermicomposter for *L. mauritii* and CD (281.9±18.5) and PW (31.6±8.5) vermicomposter for *P.excavatus*, respectively. Cocoon production (worm^{-1}) and reproduction rate (cocoon worm^{-1} day^{-1}) varied significantly among different vermicomposters ($p<0.05$). The number of cocoon produced (worm^{-1}) was highest 4.54 ± 0.08 in CD vermicomposter for *L. mauritii* and 5.64 ± 0.4 in CD vermicomposter for *P.excavatus* and minimum 0.64±0.01 in PW for *L. mauritii* and 0.64 ±0.18 in PW for *P.excavatus*, respectively. Statistically, the difference between CD and CD+PM+PW in *L.mauritii* and CD and CD+PM+PW in *P.excavatus* for number of cocoon production (worm^{-1}) was not significant (Table 4). The maximum reproduction rate was recorded in CD and CD+PM+PW vermicomposters and minimum reproduction rate was recorded in PW vermicomposter for both species of worms. Nonetheless, CD and CD+PM+PW vermicomposters did not show a statistically significant difference for reproduction rate (Table 5). The maximum number of hatchlings was observed in CD followed by CD+PM+PW, CD+PW, PM, PM+PW and PW for *L. mauritti* and *P.excavatus*, respectively (Table 4). The results suggested that higher proportions of PW or PW alone with cow dung or press mud were not suitable for cocoon production. It may be concluded that production of cocoons in the feed mixtures could be related to the biochemical quality of the feed, which was one of the important factors and in addition to the biochemical properties of waste, the microbial biomass and decomposition activities during vermicomposting are also important in determining the cocoon production [11]. Suthar [29] summarized that chemical nature of feeding stock may be of a primary importance for rearing of earthworm or organic waste resources. So, the difference in cocoon production could be due to variation in quality of the substrate.

L. mauritti and *P.excavatus* showed a statistically different pattern of worm mortality among different vermicomposters (Table 6). However, difference among CD and CD+PM+PW vermicomposters in respect to total worm mortality was not statistically significant ($p<0.01$) for both species of worms. The survival of earthworms in feed mixtures is drastically influenced by the chemical environment and ambient climatic variability. The food consumption rate in earthworms during initial critical period (period of acclimatization of earthworms in waste system) also determines the survival rate of earthworms in vermbeds. C:N ratio of initial feedstuff may also be a limiting factor the feed consumption rate in earthworms [5, 30] and consequently affects earthworm survival in vermibeds. Kaushik and Garg [13] reported that pre-composting is essential to avoid the earthworm mortality. Hence, it has been found that mixing of CD and PM in PW before vermicomposting reduced the rate of worm mortality during decomposition process.

CONCLUSION

In this study the vermicomposting of PW amended with CD and PM with *L. mauritii* and *P. excavatus* has been examined for its suitability for growth and reproduction of earthworms. Mixing of certain organic amendments as bulking agent in PW creates suitable microcosms for the earthworms. Among the vermicomposters 1:1:1 ratio of PW, CD and PM was optimum waste mixtures for the growth and reproduction of *L. mauritii* and *P. excavatus* and hence PW can be recommended as feed materials in vermicomposting facilities.

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