Growth and Reproduction of *Perionyx excavatus* (Perrier) During Vermicomposting of Different Plant Residues

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**ABSTRACT**

The data on growth and reproduction of composting earthworms may be beneficial for large scale earthworm production. The growth and reproduction of *Perionyx excavatus* were assessed in limited supplies of four experimental diets-cow dung alone and its mixture with acacia (*Acacia auriculiformis*) leaf litter, bamboo (*Bambusa polymorpha*) leaf litter and terrestrial weed *Mikania micrantha* under laboratory conditions to select suitable diet from our locally available resource for vermiculture. Growth performance of *Perionyx excavatus* was significantly (P<0.05) higher in cow dung (maximum weight mg worm\(^{-1}\) 629 and growth rate mg worm\(^{-1}\) day\(^{-1}\) 22.91). The rate of reproduction (0.3 cocoons worm\(^{-1}\) day\(^{-1}\) and 3.31 juveniles adult\(^{-1}\) week\(^{-1}\)) was significantly higher (P<0.05) in acacia-cow dung mixture. The cocoon production was maximum on the 30th day in all experimental diets (cow dung, acacia-cow dung, bamboo-cow dung, mikania-cow dung). All the diets showed a maximum peak of juvenile production on the 45th day. The lowest rate of biomass increase as well as the rate of reproduction were observed in mikania-cow dung mixture. Present result indicates that cow dung and acacia leaf litter can be used as vermiculture substrate for *P. excavatus*.

**INTRODUCTION**

Vermicomposting is the process of conversion of organic wastes into organic manure called vermicompost through the joint activities of epigeic earthworms and microorganisms. Selection of earthworm species for vermicomposting technology is mainly based on their reproductive potential, growth rate, the range of tolerance to ecological factors and nutrient contents of organic wastes etc. (Hallatt et al. 1992, Reinecke et al. 1992, Singh 2006, Suthar & Ram 2008). Growth and reproduction of *Eisenia fetida* and *Eudrilus eugeniae* have been investigated by various workers (Suthar & Ram 2008, Edwards et al. 1998, Gunadi & Edwards 2003, Garg et al. 2005). Besides earthworm species such as *Perionyx sensibaricus*, *Perionyx bainii*, *Perionyx ceylanensis* and *Perionyx nainianous* have been tested for degradation of organic wastes (Julka et al. 2009). Animal dung (cattle, sheep, horse) have been widely used as vermiculture substrates (Edwards et al. 1998). Other vermiculture substrates include organic wastes from industry such as spent brewery yeast (Butt 1993) and agricultural wastes such as roots of barley (Bostrom & Holmin 1986), ground corn (*Zea mays*) residue (Cook & Linden 1996) and alfalfa leaves (Shipitalo et al. 1988). Native epigeic species *Perionyx excavatus* is a potential candidate for the conversion of organic wastes into useful plant growth media (Edwards et al. 1998, Kale et al. 1982, Chaudhuri 2005). Based on the above facts we aimed to investigate the effects of some locally available organic wastes such as terrestrial weed, *Mikania micrantha*, leaf litter of *Acacia auriculiformis*, leaf litter of *Bambusa polymorpha* mixed with cow dung on the growth and reproduction of oriental epigeic earthworm species, *Perionyx excavatus* in mass culture. The data on growth and reproduction of native species *Perionyx excavatus* may be useful to design vermiculture for large scale production of earthworms using different waste residues. It is mentionable that earthworms are used as fish baits worldwide and earthworm tissue is a good source of protein (vermitin) for poultry, pig and aquarium (Lowe & Butt 2005).

**MATERIALS AND METHODS**

A study on growth and reproduction of Indian vermicomposting earthworm, *Perionyx excavatus* was carried out in a well-aerated room on four different diets such as cow dung (C), cow dung mixed with terrestrial climbing weed, *Mikania micrantha* (M) (often found to form hazardous bush around the roadside lamp posts forming shades against the light in Tripura), leaf litter of *Acacia auriculiformis* (A) and bamboo (*Bambusa polymorpha*) (B). Urine free cow dung, *M. micrantha*, leaf litter of *Acacia* and *Bambusa* were collected from Tripura University campus and its neighbouring areas. The leaf litter and plant biomass of *M. micrantha* were air-
dried. The air-dried plant substrates were crushed to get small fractions. Four vermicomposting treatments were established by using earthen pot (2.5 L capacity, diameter 25 cm and depth 15 cm) having 300 g of dry feed mixtures in each pot. One treatment contained only C (300 g) as control and rest three experimental treatments were prepared by mixing the different plant substrates (A, B and M) with C in 7:3 ratios (dry weight), i.e. 210 g A and 90 g C (AC) in 7:3 ratio, 210 g B and 90 g C (BC) in 7:3 ratio, 210 g M and 90 g C (MC) in 7:3 ratio. Before setting up the experiment, the authors made pilot studies using different ratios of C with weed (M) and leaf litters (A and B) on a dry weight basis. It was observed that weeds (M) and leaf litter (A and B) Vs. C when mixed with C at 7:3 ratio, were suitable for earthworm inoculation and their subsequent activity. *P. excavatus* generally inhabits cow dung pits and prefers cow dung as its best food of choice compared to other diets. Each treatment had three replicates. Among these diets mixtures, AC was unpalatable to earthworms up to 21 days. So these feed mixtures (C, AC, BC, and MC) were pre-composted for 3 weeks to make palatable to earthworms. After pre-composting each culture pot of the four vermicomposting sets was inoculated with 30 adults of *P. excavatus* [cumulative weight 9.99±0.09 g (Mean ± SE)]. The containers were covered tightly with jute cloth to prevent the escape of earthworms and entry of light inside. The taxonomic identification of the earthworm species was confirmed at Zoological Survey of India, Solan. The moisture content of the incubation media was maintained at 50 to 60% (Chaudhuri 2007) by using hand sprayer at maximum room temperature ranging in between 29°C to 31°C. The earthworms were not supplied with additional food during 45 days experiment.

Cocoon and juvenile produced were collected fortnightly from the culture media with the aid of a hand lens. The live biomass of earthworms (mg worm⁻¹), net weight gain (mg worm⁻¹), growth rate (mg worm⁻¹ day⁻¹) and the rate of reproduction in terms of the cocoon (worm⁻¹ day⁻¹) and juvenile generation (adult⁻¹ week⁻¹) were measured at 15 days interval by hand sorting of the culture media. The rate of growth (mg worm⁻¹ day⁻¹), the rate of cocoon production (worm⁻¹ day⁻¹) and rate of juvenile production (adult⁻¹ week⁻¹) were calculated by the following formulae-

\[ i. \text{ Rate of growth (mg worm}^{-1} \text{ day}^{-1}) = \frac{\text{Maximum worm weight} - \text{Initial worm weight}}{\text{No. of days to attain maximum weight}} \]

\[ ii. \text{ Rate of cocoon production (worm}^{-1} \text{ day}^{-1}) = \frac{\text{Maximum number of cocoons}}{\text{No. of adult at 0 day} \times \text{Total number of days to attain maximum number of cocoons}} \]

\[ iii. \text{ Rate of juvenile production (adult}^{-1} \text{ week}^{-1}) = \frac{\text{Maximum number of juveniles}}{\text{No. of adult at 0 day} \times \text{Total number of days to attain the maximum number of juvenile population}} \times 7 \]

Initial substrates materials were analysed for pH (1:2.5 suspensions of the material and distilled water), electrical conductivity (distilled water suspension of each waste mixture in the ratio of 1:10 (W/V), total carbon (Walkley & Black 1934), total Nitrogen (Jackson 1975), available phosphorus (Kuo 1996) and available potassium (Jones 2001). The data were subjected for analysis of variance (ANOVA) followed by Tukey’s post hoc test using OriginPro 2016. All the results reported in the text are the mean of three replicates.

**RESULTS**

Table 1 shows the composition of food substrates provide to earthworms. The pH values of the food substrates were alkaline side of neutral (6.3 - 7.63). The highest electrical conductivity (990 µMho/cm), nitrogen (3.08%), available phosphorus (163.71 mg/100g) and available potassium (7321.33 mg/100g) was recorded in MC. The maximum carbon content (20.37%) was in MC and minimum (17.14%) was in C.

The differential growth (mg worm⁻¹) response of *P. excavatus* on various experimental diets over a period of 45 days is represented in Fig. 1. *P. excavatus* had the highest individual live weight (629 mg worm⁻¹) in C with a net weight gain of 296.18 mg worm⁻¹ and growth rate of 22.91 mg worm⁻¹ day⁻¹ (Table 2). In fact, maximum weight gain, net weight gain and growth rate were significantly higher (P < 0.05) in C compared to the other diets (Table 2). Highest growth rate (worm⁻¹ day⁻¹) in C was followed by that in BC, MC, and AC. In AC, lowest net weight gain (52.02 mg worm⁻¹) and lowest growth rate (3.47 mg worm⁻¹ day⁻¹) were recorded. *P. excavatus* had early biomass gain in C, BC, and AC on the 15th day, whereas the highest individual biomass was achieved on the 30th day in MC (Table 2). After attaining highest biomass a gradual decline was observed up
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Fig. 1: Changes in biomass production of *P. excavatus* in different experimental diets; Abbreviation: C- cow dung, AC- acacia-cow dung, BC- bamboo- cow dung, MC- mikania- cow dung.

Fig. 2: Dynamics of cocoons production of *P. excavatus* in different experimental diets; Abbreviation: C- cow dung, AC- acacia-cow dung, BC- bamboo- cow dung, MC- mikania- cow dung.

Fig. 3: Patterns juveniles production of *P. excavatus* in different experimental diets; Abbreviation: C- cow dung, AC- acacia-cow dung, BC- bamboo- cow dung, MC- mikania- cow dung.

Table 1: Some analytical characteristics of experimental diets (Mean±SE).

|                     | C          | AC              | BC            | MC           |
|---------------------|------------|-----------------|---------------|--------------|
| pH                  | 7.42 ± 0.14| 6.3 ± 0.005     | 6.75 ± 0.003  | 7.63 ± 0.11  |
| Electrical Conductivity( μMho/cm ) | 580.66 ± 0.66 | 570 ± 0.00     | 720 ± 0.00   | 990 ± 0.01   |
| Organic Carbon (%)  | 17.14 ± 0.58| 19.83 ± 0.04    | 19.52 ± 0.76  | 20.37 ± 0.54 |
| Available Phosphorus (mg/100g) | 147.39 ± 5.08 | 26.15 ± 0.17   | 48.97 ± 0.8   | 163.71 ± 2.5 |
| Available Potassium (mg/100g) | 1000 ± 14.43 | 1087 ± 7.21    | 937.33 ± 7.21 | 7321.33 ± 14.2 |
| Total Nitrogen (%)  | 1.26 ± 0.006| 1.82 ± 0.003    | 1.62 ± 0.003  | 3.08 ± 0.05  |

Abbreviation: C- cow dung, AC- acacia-cow dung, BC- bamboo- cow dung, MC- mikania- cow dung.

The reproduction potential of *P. excavatus* in terms of their cocoons production (worm⁻¹ day⁻¹) and juvenile production (worm⁻¹ week⁻¹) among different experimental diets are...
summarized in Table 3 (a, b). The rate of cocoon production was highest (P < 0.05) in AC followed by C, BC and least in MC (Table 3a). *P. excavatus* had an earlier peak of cocoon production (4.84 worm\(^{-1}\)) on the 15\(^{th}\) day in AC (Fig. 2). However, cocoon production (worm\(^{-1}\)) in general was highest in all the experimental diets on the 30\(^{th}\) day (Fig. 2). The cocoon production was ceased after 30\(^{th}\) day in all experimental diets (Fig. 2). The rate of juvenile production (adult\(^{-1}\) week\(^{-1}\)) also differed (P < 0.05) among the four different food substrates (Table 3b). All the treatments (C, AC, BC, and MC) showed a maximum peak of juvenile production on the 45\(^{th}\) day (Fig. 3) i.e. 15 days after the peak of cocoon production (Fig. 2). The appearance of the juveniles was first encountered in C and AC (i.e. on the 15\(^{th}\) day) and later in BC and MC (i.e. 30\(^{th}\) day) (Table 3b). The highest number (total number) and rate of juvenile production (adult\(^{-1}\) week\(^{-1}\)) were on the 45\(^{th}\) day and were in the following order AC > BC > C > MC (Fig. 3). Growth and reproduction rate of some epigeic earthworm species are given in Table 4.

**DISCUSSION**

The palatability of earthworms for organic wastes is influenced by its physico-chemical characteristics and nutrient contents that affect the efficiency of earthworms in the decomposition process and their growth in the organic wastes (Chaudhuri 2002, Suthar 2007a). Individual live weight (629 mg worm\(^{-1}\)), growth rate (22.91 mg worm\(^{-1}\) day\(^{-1}\)) and net weight gain (296.18 mg worm\(^{-1}\)) of *P. excavatus*, were maximum in C. The highest growth rate of *P. excavatus* in C was because a minimum of only 15 days was required to attain its highest biomass and net weight gain. According to Loh et al. (2005) cow dung is a most preferred diet of earthworms irrespective of the species which could be due to easily assimilable organic matter and presence of low growth retarding factors in it (Suthar 2007a). Maximum individual biomass of *P. excavatus* (600 mg worm\(^{-1}\)) in animal dung was reported by Hallat et al. (1990) supports our observation of maximum mean individual live weight of *P. excavatus* (629 mg worm\(^{-1}\) on the 15\(^{th}\) day) in C. Nitrogen-rich diets promote...

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**Table 2: Growth of *P. excavatus* in different experimental diets (Mean±SE).**

| Substrates | Mean initial weight (mg worm\(^{-1}\)) | Mean maximum weight (mg worm\(^{-1}\)) | Maximum weight achieved on | Net weight gain (mg worm\(^{-1}\)) | Growth rate (mg worm\(^{-1}\) day\(^{-1}\)) |
|------------|----------------------------------------|----------------------------------------|---------------------------|----------------------------------|--------------------------------------|
| C          | 333.31 ± 0.12\(^a\)                    | 629 ± 22.31\(^a\)                     | 15\(^{th}\) day           | 296.18 ± 23.11\(^a\)             | 22.91 ± 1.93\(^a\)                  |
| AC         | 333.33 ± 0.30\(^a\)                    | 385.86 ± 14.87\(^b\)                 | 15\(^{th}\) day           | 52.02 ± 0.84\(^b\)               | 3.47 ± 0.99\(^b\)                  |
| BC         | 333.3 ± 0.14\(^c\)                     | 471.52 ± 23.18\(^c\)                 | 15\(^{th}\) day           | 138.18 ± 23.18\(^c\)             | 12.6 ± 1.54\(^c\)                  |
| MC         | 333.37 ± 0.36\(^a\)                    | 570 ± 10.32\(^d\)                    | 30\(^{th}\) day           | 236.66 ± 20.2\(^d\)              | 9.47 ± 1.13\(^d\)                  |

Abbreviation: C- cow dung, AC- acacia-cow dung, BC- bamboo- cow dung, MC- mikania- cow dung. Different letters correspond to a significant difference (P < 0.05).

**Table 3: Rate of reproduction of *P. excavatus* in different experimental diets (Mean±SE).**

(a) Cocoon production of *P. excavatus* in different experimental diets.

| Substrates | Cocoon production started in | Total no. of cocoons produced after 45 days | No. of cocoons produced (worm\(^{-1}\)) | Rate of cocoon production (worm\(^{-1}\) day\(^{-1}\)) |
|------------|-----------------------------|--------------------------------------------|----------------------------------------|-----------------------------------------------------|
| C          | 15\(^{th}\) day             | 205 ± 32.5\(^a\)                          | 6.84 ± 0.9\(^a\)                      | 0.25 ± 0.008\(^a\)                                  |
| AC         | 15\(^{th}\) day             | 107 ± 22.8\(^b\)                          | 3.05 ± 0.7\(^b\)                      | 0.3 ± 0.25\(^b\)                                   |
| BC         | 15\(^{th}\) day             | 136 ± 21.9\(^b\)                          | 3.9 ± 0.6\(^b\)                      | 0.23 ± 0.11\(^b\)                                  |
| MC         | 15\(^{th}\) day             | 81 ± 21.3\(^c\)                           | 2.2 ± 0.6\(^c\)                      | 0.13 ± 0.01\(^c\)                                  |

(b) Juveniles production from the cocoons of *P. excavatus*.

| Substrates | Emergence of juveniles on | Total no. of juvenile production after 45 days | Rate of juvenile production (adult\(^{-1}\) week\(^{-1}\)) |
|------------|---------------------------|-----------------------------------------------|----------------------------------------------------------|
| C          | 15\(^{th}\) day           | 156 ± 39.5\(^a\)                            | 1.39 ± 0.07\(^a\)                                         |
| AC         | 15\(^{th}\) day           | 284 ± 23.2\(^b\)                            | 3.31 ± 0.03\(^b\)                                         |
| BC         | 30\(^{th}\) day           | 387 ± 23.8\(^c\)                            | 2.22 ± 0.027\(^c\)                                         |
| MC         | 30\(^{th}\) day           | 78 ± 10.2\(^d\)                             | 0.66 ± 0.11\(^d\)                                         |

Abbreviation: C- cow dung, AC- acacia-cow dung, BC- bamboo- cow dung, MC- mikania- cow dung. Different letters correspond to a significant difference (P<0.05).
in rapid growth and reproduction in earthworms (Evans & Guild 1948). Despite high nitrogen (3.08 mg/100g) content in MC, *P. excavatus* showed a delay in the increase in biomass production in MC, probably due to its high pH (7.63) and electrical conductivity (990 μMho/cm). Presence of high content of soluble salts as indicated by the highest electrical conductivity in MC might harm earthworm feeding activity. Moreover, the antifungal and antimicrobial properties of essential oils of mikania (Baral et al. 2011) perhaps prevent the microflora to release the locked-up nutrients during the initial stage of waste decomposition. So during the first 15 days, earthworm growth was retarded in MC instead of a sudden rise as found in other diets. But with the progress of decomposition, those growth retarding substances in the wastes probably declined so that palatability and release of locked up nutrients gradually increased in MC at a later stage leading to highest weight gain by *P. excavatus* in MC on the 30th day. Lowest growth rate (3.47 mg worm⁻¹ day⁻¹) with lowest net weight gain (52.02 mg worm⁻¹) of *P. excavatus* in the AC was probably due to high lignin and rich polyphenol content of *Acacia* that suppressed the growth rate of earthworms through their effects on their feeding activities (Ganesh et al. 2009). Polyphenol content in the leaf has an inverse relationship with the palatability of earthworms (Edwards & Bohlen 1996). Low biomass values of earthworms under 3-10 years old rubber plantations due to excess flavonoid, lignin, and polyphenol contents of rubber leaves as reported by Chaudhuri et al. (2013) support our present findings. The growth rate of *P. excavatus* in different experimental diets (C, AC, BC, and MC) ranging in between 3.47 mg worm⁻¹ day⁻¹ (AC) to 22.91 mg worm⁻¹ day⁻¹ (C) is much higher than those of *P. ceylanensis* (1.34-1.79 mg

| Earthworm species | Culture materials | Growth rate (mg worm⁻¹ day⁻¹) | Reproduction rate | References |
|-------------------|------------------|-----------------------------|-------------------|-----------|
| *P. excavatus*     | Cowdung          | 22.91                       | 0.25              | Present study |
|                   | Acacia leaf litter-Cowdung | 3.47                       | 0.3               | Present study |
|                   | Bamboo leaf litter-Cowdung | 12.6                       | 0.23              | Present study |
|                   | *Mikania micrantha*-Cowdung | 9.47                       | 0.13              | Present study |
|                   | Cowdung          | 2.86                        | -                 | Chaudhuri & Bhattacharjee (2002) |
|                   | Cowdung-Kitchen wastes | 2.47                       | -                 | Chaudhuri & Bhattacharjee (2002) |
|                   | Cowdung- Straw   | 4.75                        | -                 | Chaudhuri & Bhattacharjee (2002) |
|                   | Cowdung- Leaf litter | 4.02                       | -                 | Chaudhuri & Bhattacharjee (2002) |
|                   | Rubber leaf litter | 5.04                        | -                 | Chaudhuri et al. (2003) |
|                   | Presssmud-Cowdung | 4.81                        | 0.79              | Birundha et al. (2013) |
| *P. ceylanensis*   | Cowdung          | 1.34                        | 0.94              | Karmegam & Daniel (2009) |
| *P. sansibaricus*  | Kitchen waste- *Mangifera indica* leaf litter | 3.77                       | 0.25              | Suthar (2007a) |
| *Eisenia fetida*   | Cattle solid wastes | 8.00                       | 0.22              | Suthar (2009) |
|                   | Cowdung          | 16.3                        | 0.39              | Garg et al. (2005) |
|                   | Goat waste       | 16.5                        | 0.32              | Garg et al. (2005) |
|                   | Sheep wastes     | 26.2                        | 0.44              | Garg et al. (2005) |
|                   | Rubber leaf litter | 6.2                         | -                 | Chaudhuri et al. (2003) |
| *Eudrilus eugeniae*| *Diospyros meaonxylon* leaf litter | 68.00                       | 0.54              | Kadam (2015) |
| *Lumbricus rubellus*| Rubber leaf litter | 28.8                       | -                 | Chaudhuri et al. (2003) |
| *Dendrobaena rubida*| Cowdung          | 8.02                        | 0.77              | Elvira et al. (1996) |
| *Dichogaster modiglianii*| Cowdung         | 3.84                        | 0.2               | Elvira et al. (1996) |
|                   | Pasture soil     | -                           | 0.19              | Bhattacharjee & Chaudhuri (2002) |
worm\(^{-1}\) day\(^{-1}\)\) and the growth rate recorded for \(P.\ excavatus\) and \(P.\ sansibaricus\) by various workers that ranged from 3.5 to 8.0 mg worm\(^{-1}\) day\(^{-1}\) (Reinecke et al. 1992, Suthar & Ram 2008, Karmegam & Daniel 2009, Suthar 2009) but lower than the growth rate of other vermicomposting species viz. \(E.\ eugeniae\) and \(E.\ fetida\) as mentioned in Table 4 (Garg et al. 2005, Kadam 2015).

Earthworms begin reproduction after attainment of a certain level of biomass (Chaudhuri et al. 2002). Thus, in all experimental diets (C, AC, BC and MC) following attainment of maximum biomass on the 15\(^{th}\) day, the highest level of cocoon production and juvenile production was observed on the 30\(^{th}\) day and 45\(^{th}\) day respectively. The reason behind the occurrence of the peak of cocoon production earlier than the juvenile production was because after a certain period of incubation (13-14 days development time) hatchlings were produced. Thus cocoon development time of 15 days and more than one hatchling emergence per cocoon (Bhattacharjee & Chaudhuri 2002) were responsible for the dramatic rise in juvenile production on the 45\(^{th}\) day in all of the diets (C, AC, BC, and MC). Interestingly, despite lowest biomass and growth rate of \(P.\ excavatus\) in AC, the rate of reproduction in terms of cocoon production (0.3 worm\(^{-1}\) day\(^{-1}\)) or juvenile production (3.31 adult\(^{-1}\) week\(^{-1}\)) in it was very high. The rate of reproduction in terms of cocoon production in AC was much higher than that in \(P.\ sansibaricus\) (0.22 cocoon worm\(^{-1}\) day\(^{-1}\) and 0.25 cocoon worm\(^{-1}\) day\(^{-1}\)) reared in cattle solid wastes and kitchen waste mixed with \(M.\ indica\) leaf litter respectively (Table 4). High biomass value with a lower rate of reproduction of \(P.\ excavatus\) in the kitchen wastes was earlier recorded (Table 4). Thus a good biomass supporting medium may not be a good medium for reproduction (Haimi 1990, Dominguez et al. 1997). Besides, the biochemical qualities of the food substrates, microbial biomass, and decomposition activities are some of the important factors that determine the onset of cocoon production in earthworms (Dominguez et al. 2003, Suthar 2006). Thus high polyphenol and lignin-containing substrates which exerted negative impacts on the growth rate of earthworm, \(P.\ excavatus\) in AC were probably not the inhibitory factor for the reproduction of \(P.\ excavatus\). Juvenile production (3.31 juvenile adult\(^{-1}\) week\(^{-1}\)) in \(P.\ excavatus\) cultured in AC is higher than that in \(E.\ fetida\) (1.3 juvenile adult\(^{-1}\) week\(^{-1}\)) and 1.4 juvenile adult\(^{-1}\) week\(^{-1}\) in \(E.\ eugeniae\) reared in rubber leaf litter (Chaudhuri et al. 2006) (Table 4). According to Suthar (2007b), the nitrogen content of the culture media has a positive effect on the rate of cocoon production in earthworms and their further development through influencing dietary need of protein. Despite having rich nitrogen contents (3.08%) in MC, \(P.\ excavatus\) had the lowest rate of reproduction (rate of cocoon production 0.13 worm\(^{-1}\) day\(^{-1}\) and rate of juvenile production 0.66 adult\(^{-1}\) week\(^{-1}\)) in MC. Microbial communities act as a good food source of earthworms (Suthar 2008). The rich content of phytochemicals along with various essential oil having antifungal and antimicrobial activities (Baral et al. 2011, Rufatto et al. 2012) probably inhibited the rate of reproduction of \(P.\ excavatus\) in MC at the initial stage of the experiment. For this reason, no juveniles were produced on the 15\(^{th}\) day and only a few juveniles (0.14 adult\(^{-1}\)) appeared on the 30\(^{th}\) day in the MC. Suthar & Sharma (2013) also reported a negative effect of high phytochemicals on the cocoon production of \(E.\ fetida\). However, 0.66 juvenile generation adult\(^{-1}\) week\(^{-1}\) in \(P.\ excavatus\) reared in MC was much lesser than 1.3 juvenile adult\(^{-1}\) week\(^{-1}\) and 1.4 juvenile adult\(^{-1}\) week\(^{-1}\) in \(E.\ fetida\) and \(E.\ eugeniae\) cultured in rubber leaf litter (Table 4). The lowest rate of cocoon production by \(P.\ excavatus\) (0.25 and 0.23 worm\(^{-1}\) day\(^{-1}\)) despite having highest mean numbers of cocoons per worm in C (6.84) and BC (3.05 worm\(^{-1}\)) was since the time required to achieve the maximum number of cocoons were longer.

**CONCLUSION**

The present work was conducted to assess the growth and reproduction of \(P.\ excavatus\) during vermicomposting of cow dung and its mixture with different plant residues (leaf litter of \(Acacia\ auriculiformis\), \(Bambusa\ polymorpha\), \(Mikania\ micrantha\)) under laboratory conditions. Maximum biomass gain (P < 0.05) and significantly higher (P < 0.05) growth rate of \(P.\ excavatus\) were observed in cow dung. Reproduction performance (rate of cocoon production worm\(^{-1}\) day\(^{-1}\) and juvenile production worm\(^{-1}\) week\(^{-1}\)) of \(P.\ excavatus\) was highest in (P < 0.05) acacia- cow dung mixture. Thus it can be concluded from the present study that cow dung and acacia leaf litter can be used as vermiculture substrate for \(P.\ excavatus\).

**ACKNOWLEDGMENT**

The authors express their gratefulness to DBT (Sanction Order No. BT/PR24972/NER/95/932/2017), New Delhi for funding the investigation and Dr. Niladri Paul, Assistant Professor, College of Agriculture, Lembucherra, Tripura for providing lab facilities to analyze the chemical parameters of the wastes materials.

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