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Assessment of Earthworm Species for Organic Waste Conversion to Vermicompost Yield and Quality

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ABSTRACT
The three different species of earthworms namely Eisenia fetida, Perionyx excavatus and Lampito mauritti separately and their four combinations were evaluated in banana stem and cow dung as feeding materials for their multiplication, time taken for vermicomposting, yield and NPK content of vermicompost under subtropical environment in Nepal during January to October 2013. Among the 3 species Eisenia solely or in combination with other species showed consistently efficiecy in its reproduction, turnover of vermicompost, yield and NPK content of vermicompost. The multiplication ratio was higher (2.29) in Eisenia followed by Lampito (1.89). Eisenia the shortest turnover time (106 days), higher production of vermicompost (5.1 Kg) and higher total NPK content (2.1, 1.8 and 1.9%) of vermicompost were found in Eisenia followed by Lampito. Perionyx was the least efficient in all aspects. Eisenia dominated the functioning of other two species. The recycling of degradable organic waste into bio-fertilizer through vermicomposting system would potentially address the shortage of organic manure, and substitute import of chemical fertilizers in Nepal.

Key words: Vermicmpost; earthworm species; banana stem; cowdung

INTRODUCTION

Nepalese agriculture is generally subsistence oriented, and largely interdisciplinary and based on forest resources for animal production, which is source of manure for soil fertility maintenance (CBS, NLSS 2004). Average agriculture productivity in Nepal is at the lowest level in South Asia with cereal yields about 2 tons/ha (FAO, 2007). Following the removal of fertilizer subsidies in Nepal, fertilizer prices are much higher than in India (FAO, 2007). The fertilizer use per hectare showed a declining trend from 26 kg in 2003/4 to 21 kg in 2005/6 (FAO, 2007). Hence, fertilizers in Nepal are too expensive to compete in open markets with those agriculture produces from India. Therefore, it is imperative for Nepal to develop alternative fertilizer for the sustainability of soil fertility.

More recently, vermicomposting system has been emerging as a potential technology for recycling organic waste into much needed biofertilizer as vermicast and vermiliquor. Various investigators (Harris *et al.*, 1990; Logsdon 1994; Elvira *et al.*, 1997; Yami and Shrestha, 2005) have established the viability of the vermicompost technology. There are several species of earthworms employed for vermicompostiong under different environments. Earthworm species *E. fetida*, *P. excavatus* and *Eudrilus eugeniae* have appeared as key candidates for organic waste recycling practices (Gajalakshmi *et al.*,2002; Loh *et al.*, 2005; Garg and Kaushik, 2005). *Perionyx excavatus* was able to withstand wider ranges of moisture and temperature than *Metaphire posthuma*, and *Eisenia* species (Shanthi *et al.* 1993). Contrary to this, *Eisenia fetida* has been reported to tolerate wider soil temperature range (42°C to 5^0 C) than *Eudrilus eugeniae* and *Perionyx excavatus* (Reinecke *et al.* 1992). Similrly, *Eisenia fetida* and *Perionyx foveatus* were also found most efficient for vermicomposting under Kathmandu condition (Tamrakar, 2005). Hence, the identification of efficient species of earthworm for particular environment is very important. Uses of earthworm species for recycling of organic waste for the vermicomposting have not been well explored in Nepal. Therefore, the present study aims at the identification of most efficient species of earthworm for waste conversion into quality vermicompost under subtropical environment of Nepal.

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MATERIAL AND METHODS

Three species of earthworms- *Eisenia fetida*, *Perionyx excavatus* and *Lampito mauritti* separately and in following four combinations were evaluated for the multiplication of earthworms, time taken for vermicomposting, yield and quality of vermicompost during January to October 2013 under subtropical environment in Bharatpur, Chitwan, Nepal.

*Eisenia fetida*and *Perionyx excavatus* (500:500)
*Eisenia fetida*and *Lampito mauritti* (500:500)
Perionyx excavatus and *Lampito mauritti* (500:500)
Eisenia fetida, *Perionyx excavatus* and *Lampito mauritti* (334:334:334)

One thousand earthworms of each of 3 species weighing 200 g for experiment I and four combinations each numbering 1000 (200 g) for activity II were introduced in the first tray of 3-tray PVC bin. One kg of fresh banana stem which was abundantly available in the locality was chopped and mixed with one kg partially decomposed cow dung and placed in bins for feeding earthworms. The fresh banana stem containd 0.91% N, 0.83 %, P_2O_5, and 1.0 % K_2O, and similarly cow dung contained 1.8 N %, 0.58 % P_2O_5, and 0.73 % K_2O. Two kilogram of feeding materials (banana stem 50% and cow dung 50%) was added each time into the bins at weekly intervals for 12 times. Once the earthworms completed feeding feedstuff of first tray, they gradually moved into the 2nd and followed by 3rd tray, which allowed the harvesting of the vermi compost matured in the first tray followed by second and third stray. Adequate moisture in the feeding materials was maintained throughout the experiment.

RESULTS AND DISCUSSION

Effect of earthworm species

Time taken for vermicomposting: Vermicompost was prepared significantly earlier for *Eisenia* (106 days), followed by *Lampito* (109 days) (Table 1). The longest time (112 days) was taken by *Perionyx* for the turn over of vermicomposting. Hence, *Eisenia fetida* was found most efficient in recycling organic waste into vermicompost.

Multiplication of earthworm: The multiplication of *Eisenia* was significantly higher (2232) followed by *Lampito* (1951) (Table 1). The least density was recorded for *Perionyx* species (1579). Similarly, the highest multiplication ratio was also noted for *Eisenia* (2.2) followed by *Lampito* (1.9) and the least was recorded for *Perionyx* species (1.6).

Yield and conversion: Vermicompost yield was significantly higher from *Eisenia* (5.1.kg), followed by *Lampito* (4.6 kg) and the lowest from *Perionyx* species (4.4 kg) (Table 2). The conversion ratio of vermicompost to the feeding material was also significantly higher for *Eisenia* (0.89), followed by Perionyx (0.79) and *Lampito* (0.77). This calculation revealed that one kilogram of waste (mixture of cow dung and banana stump) produced 210g, 190g and 180g of vermicompost by *Eisenia*, *Lampito* and *Perionyx* respectively.

Table 1. Days required for vermicomposting, earthworm population and multiplication ratio under different species of earthworm, Bharatpur, Chitwan, 2013

Treatments	Parameters		
	Duration for Vermicomposting (days)	Earthworm population (nos}	Multiplication ratio
Eisenia	106[c]	2232[a]	2.29[a]
Perionyx	112[a]	1579[c]	1.62[c]
Lampitio	109[b]	1951[b]	1.98[b]
LSD	2.034**	166.3**	0.197**
SEM (±)	0.6237	50.98	0.11
CV (%)	1.0	4.57	4.5
Grand mean	109	1932.67	1.93

Table 2. Yield of vermicompost (DW) and conversion ratio, Bharatpur, Chitwan, 2013

Treatments	Parameter	
	Vermicompost (DW)	Dry conversion ratio
Eisenia fetita	5.1[a]	0.89[a]
Perionyx excavatus	4.4[c]	0.79[b]
Lampitio maurittii	4.6[b]	0.77[c]
LSD	0.059**	0.007**
SEM (±)	0.018	0.022
CV (%)	0.70	0.5
Grand mean	4.74	0.81

Nutrient contents of vermicompost: A significantly greater nitrogen (N) content was recorded from *Eisenia* species (2.1%), followed by *Lampito* species (1.9%) and the lowest from *Perionyx* species (1.8%) (Table 3).

Table 3. NPK content of vermicompost obtained from the different species of earthworm, Bharatpur, Chitwan 2013

Treatments	Nutrient concentration (%)		
	Nitrogen	Phosphorous	Potassium
Eisenia fetida	2.1[a]	1.8[a]	1.9[a]
Perionyx excavatus	1.8[c]	1.1[c]	1.4[c]
Lampitio maurittii	1.9[b]	1.6[b]	1.6[b]
LSD	0.059**	0.12**	0.178**
SEM (±)	0.018	0.036	0.055
CV (%)	1.7	4.5	5.79
Grand mean	1.95	1.456	1.678

Similarly, significantly greater total phosphorus content was also recorded from *Eisenia* species (1.8%), followed *Lampito* species (1.6%). The lowest phosphorus content was from *Perionyx* species (1.1%). Likewise potassium content of vermicompost was 1.9, 1.4 and 1.6 % from *Eisenia*, *Perionyx* and *Lampito* respectively. The NPK content was consistently higher in the vermicompost from *Eisenia* which was also consistently followed by *Lampito*.

Effects of (combination) mixture of species

Duration for vermicomposting: The recycling of organic waste to vermicompost was significantly earlier for combination of *Eisenia* + *Lampito* (102 days), followed by *Eisana* + *Perionyx* (107 days) (Table 4). The delayed vermicompost maturity was recorded from combination of *Lampito* + *Perionyx* species (112 days). The performance of the combination of *Lampito and Perionyx was* found very poor for the time taken in vermicomposting.

Multiplication of earthworm: Earthworm population was also significantly high from *Eisenia* + *Lampito* mixture (1678), followed by *Eisenia* + *Perionyx* (1589). The least earthworm population was from *Lampito* + *Perionyx* species (1498). Multiplication ratio also varied in the similar pattern of population with species.

Table 4. Days required for vermicomposting, earthworm population and multiplication ratio as affected by combinations of different species, Bharatpur, Chitwan, 2013

Treatments	Parameters		
	Duration (days)	Earthworm population (#)	Multiplication ratio
Eisenia + *Perionyx*	107^{c}	1589^{b}	1.59^{b}
Eisenia + *Lampito*	102^{d}	1678^{a}	1.68^{a}
Lampito + *Perionyx*	112^{a}	1498^{c}	1.50^{c}
Eisenia + *Perionyx* + *Lampito*	110^{b}	1534^{c}	1.53^{c}
LSD	1.16**	43.56**	0.051**
SEM (±)	0.372	13.99	0.049
CV (%)	0.60	1.53	1.62
Grand mean	107.92	1588.42	1.58

Yield and conversion ratio: The vermicompost yield was significantly high from *Eisenia* + *Lampito* (5.1 kg) than from Eisenia + *Perionyx* (4.8 kg) and the lowest yield was found from *Perionyx* + *Lampito* (4.4 kg) which was significantly lower than that of the mixture of 3 species (4.6 kg) (Table 5). Similarly, the dry weight conversion ratio was also significantly higher in combinations of *Eisenia and Perionyx* (0.87) followed by *Eisenia and Perionyx* (0.83). The dry matter conversion ratio was lowest in *Lampito and Perionyx* (0.76).

Table 5. Yield of vermicompost (DW) and conversion ratio, Bharatpur, Chitwan, 2012

Treatments	Parameter	
	Vermicompost (DW)	Conversion ratio
Eisenia + *Perionyx*	4.8^{b}	0.83^{b}
Eisenia + *Lampito*	5.1^{a}	0.87^{a}
Lampito + *Perionyx*	4.4^{d}	0.76^{d}
T_4 *Eisenia* + *Perionyx* + *Lampito*	4.6^{c}	0.8^{c}
LSD	0.056**	0.017**
SEM (±)	0.018	0.01
CV (%)	0.61	1.062
Grand mean	4.70	0.815

Nutrient content of vermicompost: A significantly greater total nitrogen content (1.9%, was recorded from *Eisenia and Lampito* species followed by *Eisenia* and *Perionyx* species (1.7%) and the lowest total nitrogen content was from *Lampito* and *Perionyx* species (1.3%). A significantly greater total phosphorus content was also recorded from *Eisenia and Lampito* combination (1.6%), followed by *Eisenia and Perionyx* (1.4%). The total phospohorus content was significantly low at both in *Lampito and Perionyx* and combination of 3 species (*Eisenia*, *Perionyx* and *Lampito*). The similar trend was also found with respect to potassium.

Table 6. Change in NPK content under the combinations of earthworm species, Bharatpur, Chitwan, 2013

Treatments	Nutrient concentration (%)		
	Nitrogen	Phosphorous	Potassium
Eisenia + *Perionyx*	1.7[b]	1.4[b]	1.5[b]
Eisenia + *Lampito*	1.9[a]	1.6[a]	1.7[a]
Lampito + *Perionyx*	1.3[c]	1.1[c]	1.3[c]
T_4 *Eisenia*+ *Perionyx*+ *Lampito*	1.4[c]	1.2[c]	1.3[c]
LSD	0.139**	0.179**	0.056**
SEM (±)	0.044	0.057	0.018
CV (%)	5.33	7.21	2.68
Grand mean	1.5	1.367	1.392

Eisenia species of earthworm either alone or in combination with other species was the most efficient for recycling organic waste into vermicompost. It is obvious that *Eisenia* dominates the functioning of other species under wider range of tempertraures and intake more food as well. It shows consistently the superiority in terms of time taken for vermicomposting, its reproduction, yield and NPK content of vermicompost. It may be attributed to its voracious feeding nature under a wider range of temperature. It consumes 3 to 4 times to its body weight than *Eudrilus eugeniae* and *Perionyx excavatus* (Reinecke *et al*., 1992, Edwards and Bater, 1992). The differences in growth and eventually their multiplication rate differ with species (Dominguez *et al.*, 2000, Chaudhari and Battacharjee 2002). Similar to present finding, Reinecke *et al.* (1992) reported that *Eisenia* had a wider tolerance for temperature than *Eudrilus eugeniae* and *P. excavatus*. However, Shanthi *et al.* (1993) reported that *Perionyx excavatus* was able to withstand greater range of temperature and moisture than *Eisenia* species in degradation of vegetable. The NPK conversion efficiency in the *Eisenia* is significantly greater than other two species. The higher nutrient conversion efficiency can be attributed to the fact that the total NPK assimilation in the growth of the worm for *Eisenia* is smaller compared to the other two species. This explanation is also supported by the fact that the individual weight of the *Eisenia* is smaller in relation to other tested species. Also the vermicomposts produced - using different species of earthworms show variation in nutrient composition. The species of earthworm influences not only the size of earthworm population but also the rate of growth and fecundity (Dominguez *et al.*, 2000, Chaudhari and Battacharjee 2002).

CONCLUSION

There is significant diversity among earthworm species in terms of time required for vermicomposting, nutrient content of vermicompost, and population growth of earthworms. Hence, it is imperative to select appropriate earthworms for vermicomposting for particular environmental domins.The recycling of degradable organic waste into bio-

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fertilizer through vermicomposting system has great potential for producing alternative fertilizers in Nepal which would address the shortage of organic manure, and substitute import of chemical fertilizers.

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