available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/ecoleng

Bioconversion of post harvest crop residues and cattle shed manure into value-added products using earthworm *Eudrilus eugeniae* Kinberg

*Surindra Suthar**

Department of Zoology, J. N. Vyas University, Jodhpur 342001, India

ARTICLE INFO

Article history:
Received 7 September 2007
Received in revised form
17 October 2007
Accepted 5 November 2007

Keywords:
Crop residues
Cattle shed wastes
Earthworm
Vermicomposting
Eudrilus eugeniae
Cocoon
Vermicompost
C:N ratio

ABSTRACT

The post-harvest residues of some local crops, e.g. wheat (*Triticum aestivum*), millets (*Penniseum typhoides* and *Sorghum vulgare*), and a pulse (*Vigna radiata*) were subjected to recycle through vermicomposting by using the epigeic earthworm *Eudrilus eugeniae* Kinberg, under laboratory conditions. The crop residues were amended with animal dung; and three types of vermibeds were prepared: (i) millet straw (*S. vulgare* + *Pennisenum typhoides* in equal quantity) + sheep manure (1:2 ratio) (MS), (ii) pulse bran (*Vigna radiata*) + wheat straw (*Triticum aestivum*) + cow dung (1:1:2 ratio) (PWC), and (iii) mixed crop residues (mixing of all types crop residues, used in this study) + cow dung in 1:1 ratio (MCR + CD). The fourth treatment was cattle shed manure (CSM). At the end, ready vermicompost showed lower organic C content and higher concentrations of other important plant nutrients. Organic C content decreased in the order: MCR + CD (27.6%) > PWC (22.8%) > CMS (22.6%) > MS (19.4%). The ready vermicompost obtained from MCR + CD vermibed showed the maximum increase (% of initial level) in content of total N (143.4%), available P (111.1%) and exchangeable K (100.0%). The end product showed reduction in C:N ration between the ranges of 60.7% (CSM) and 70.3% (MCR + CD), at the end. The composting earthworm *E. eugeniae* exhibited the highest values of biological parameters: maximum mean individual biomass (1261.25 ± 7.0 mg), biomass gain (955.84 ± 11.03 mg), growth rate (10.62 ± 0.10 mg wt. worm^{-1} day^{-1}), cocoon numbers (87.67 ± 6.51), and reproduction rate (0.66 ± 0.01 cocoons worm^{-1} day^{-1}) in CSM container, while MS vermibeds showed the lowest values of these parameters. During experimentation, the maximum mortality for *E. eugeniae* was recorded in MS (16.67 ± 7.63%) followed by CSM > PWC > MCR + CD. Results indicated that the C:N ratio of the substrate drastically influenced the growth parameters of *E. eugeniae*, and it showed the close relations with maximum individual biomass gain (R^2 = 0.96), individual growth rate (R^2 = 0.82), and reproduction rate (cocoon worm^{-1} day^{-1}) (R^2 = 0.72), in different treatments. This study clearly indicates that vermicomposting of crop residues and cattle shed wastes can not only produce a value-added product (vermicomposting) but at the same time acts as best culture medium for large-scale production of earthworms.

1. Introduction

Agriculture, food processing, pulp and paper, or any cellulose-based industry produces massive quantities of solid and liquid waste materials. Disposal and environmental friendly man-

* Fax: +91 154 2475960.
E-mail address: sutharss_soilbiology@yahoo.co.in.
0925-8574/$ – see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.ecoleng.2007.11.002

agement of these industrial wastes has become a serious global problem. Therefore, much attention has been paid in recent years to develop low-inputted efficient technologies to convert these nutrient-rich organic wastes into value-added products for sustainable land practices. Decomposition of complex organic waste resources into odor free humus like substances through the action of worm is termed vermicomposting. However, vermicomposting is stabilization of organic material involving the joint action of earthworms and microorganisms. Although microbes are responsible for biochemical degradation of organic matter, earthworms are the important drivers of the process, conditioning the substrate and altering the biological activity (Dominguez, 2004). Several epigeic earthworms have been identified as detritus feeders which can be reared on large numbers in organic wastes (Taylor et al., 2003). Some of these epigeics, e.g. *Eisenia fetida* (Savigny), *Perionyx excavatus* (Perrier), and *Eudrilus eugeniae* Kinberg, have appeared as the key candidates for organic waste recycling industries (Kale et al., 1982; Butt, 1993; Butt et al., 1995; Loh et al., 2005; Garg et al., 2006; Suthar, 2007a,b,c).

However, agriculture by-products, e.g. animal dung, farmyard manure, and crop residues, are potential sources of plant nutrients. According to a conservative estimation, around 600–700 million tonnes (mt) of agricultural waste (including 272 mt of crop residues) are available in India every year, but most of it remains unutilized. This huge quantity of wastes can be converted into nutrient-rich bio-fertilizer (vermicompost) for sustainable land restoration practices. It is interesting that a great proportion of the crop nutrient input during cultivation returned in the form of the plant residues. Estimation showed that 30–35% of applied N & P and 70–80% for K remained in the crop residues of food crops. Such nutrient-rich crop residues must be 'prepared' before they are used as a fertilizer, and earthworms are suitable candidates for the same. According to Lorimor et al. (2001), compared to conventional composting system (as commonly used in India to manage crop residues and other related wastes), vermicomposting often results in mass reduction, shorter time for processing, high levels of humus with reduced phytotoxicity. Since organic matter is transferred differently in compost and vermicompost, it can be partly explained by the mutualistic relationship between ingested microorganisms and intestinal mucus (Trigo and Lavelle, 1993).

The composting efficiency and biology of tropical earthworm species, i.e. *E. eugeniae* Kinberg, is well documented in literature. Several workers have reported the vermicomposting potential of *E. eugeniae* by using a variety of waste materials such as animal dung (Reinecke et al., 1992; Kale, 1998; Dominguez et al., 2001); industrial waste (Senappa et al., 1995), etc. The crop residues, which are produced in a huge quantity, have not been previously tested as feeding substances for *E. eugeniae*. Therefore, there are vast opportunities to explore the composting potential of this species to manage the crop residues and other agriculture by-products.

The objectives of this study were to test the efficiency of a tropical earthworm *E. eugeniae* to recycle cattle shed manure and post-harvest residues of some local crops after mixing with cattle dung in different ratios. The assessment of biomass production and reproduction patterns of *E. eugeniae* in these substrate materials was also considered.

2. Materials and methods

2.1. Earthworm culture and organic waste collection

Originally, *E. eugeniae* used in this study were obtained from Prof. Radha D. Kale, Department of Zoology, University of Agriculture Science, Bangalore. The worms were cultured in a cemented tank containing partially decomposed cow dung mixed with leaf litter (*Mangifera indica*), under laboratory conditions. For the vermicomposting trial, post-harvesting residues, e.g. chopped straw of wheat (*Triticum aestivum*), millets (*Pennisenum typhoides* and *Sorghum vulgare*) and pulse (*Vigna radiata*), were collected from Jhanwargarh Krishi Farm, Jhalamand village, Jodhpur, India. The cattle shed manure (consisted of animal excreta, discarded cattle feed, etc.) was collected from the cattle yards of a dairy farm, near Kakani road, Jodhpur, India. One-week-old cow dung and sheep manure were used as bulking agent to produce four different feeding/bedding materials for laboratory trial. Urine-free cow dung (7.82 pH, 298 g kg^{-1} organic carbon, 5.72 g kg^{-1} total nitrogen, 2.32 g kg^{-1} phosphorous, and 5.62 g kg^{-1} potassium) was collected from Borana Dairy Farm, Ghanchi Colony, Jodhpur, India. One-week-old urine-free sheep manure (8.12 pH, 306 g kg^{-1} organic carbon, 12.02 g kg^{-1} total nitrogen, 5.42 g kg^{-1} phosphorous, and 10.56 g kg^{-1} potassium) was collected from a sheep farm, Jhalamand village, Jodhpur, India.

2.2. Preparation of vermibeds and composting trial

The crop residues were dried at 60 °C in a hot air oven, chopped and sieved (<2 mm). The crop residues were amended with cattle dung in different ratio in order to produce three feed mixtures (dry weight proportion in plastic containers). One treatment was composed of pure cattle shed manure. The

Table 1 – Composition of treatment bedding used in this study

Treatment	Composition (A + B)		
	(A) *Crop residues*	(B) *Animal dung*	Ratio of A and B
MS (millet straw + sheep manure)	*Sorghum vulgare* + *Pennisenum typhoides*	Sheep manure	1:2
PWC (pulse bran + wheat straw + cow dung)	*Vigna radiata* + *Triticum aestivum*	Cow dung	1:2
MCR + CD (mixed crop residues + cow dung)	Mixing of all types crop residue used in this study	Cow dung	1:1
CSM (cattle shed manure)	Discarded cattle feed (chopped green fodder and dry wheat straw) and animal dung	–	–