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Nutritional Status of Vermicompost Produced from Weed Biomass and Rice Straw as Influenced by Earthworm Species and Seasons

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ABSTRACT

Efficiency of *Eisenia foetida, Amyanthes diffringens* and *Eudrillus eugineae* in vermicomposting of plant biomass viz., rice straw, *Ipomoea carnea*, *Eichhornia* crassipes alone and in mixture was studied during summer and winter seasons. All the species were found efficient in vermicomposting of plant biomass. Time required for composting varied from 50-70 days and 55-75 days during summer and winter seasons, respectively. *E. foetida* was at par with *E. eugineae* as regards to their multiplication rate and composting period. The multiplication rate was lowest with *A. diffringens* which also took relatively longer time for composting. The compost recovery did not change with earthworm species. The highest compost recovery was obtained from *Ipomoea* biomass followed by mixture of rice straw, *Ipomoea* and *Eichhornia* biomass. The compost recovery was lowest with *Eichhornia* biomass. Irrespective of earthworm species, the population at maturity of the compost was increased by 8-12 times over the initial population. Earthworm activity substantially narrowed down the C : N ratio and increased the nutrient content in the compost over the initial value of the respective biomass. Different earthworm species could not show any significant variation in the nutrient content except for nitrogen and phosphorus, which were significantly higher with *E. foetida* and *E. engineae* compared to *A. diffringens*. Vermicompost prepared from *Ipomoea* biomass had the highest nutrient level followed by mixture use of rice straw, *Ipomoea carnea* and *Eichhornia crassipes* biomass. The lowest C : N ratio was recorded in the vermicompost from *Ipomoea* biomass, while the highest was recorded from rice straw.

Key words : Weeds utilization, C : N ratio, compost, nutrient status, soil fertility

INTRODUCTION

Global energy crisis, escalating fertilizer cost and growing environmental concern necessitate the search for alternative sources of plant nutrients. Further, for sustaining soil fertility vis-à-vis soil productivity, integrated use of organic and inorganic sources of plant nutrients is inevitable. In view of acute shortage of conventional sources of organic manures such as animal dung, compost, etc. it is imperative to exploit other sources or organic manures. Of late, vermicomposting as one of the efficient and eco-friendly ways of converting any type of biowastes into quality organic manure (vermicompost) has been gaining popularity all over the world. Huge quantity (5-20 t/ha) of plant biomass such as crop residues, weed biomass, etc. produced in and around farm land have not been scientifically exploited for their manurial potential.

Earthworms are considered as the friend of the farmers since ancient time due to their role in soil ecology. Bhawalkar (1995) designated earthworm as the “Natural Bioreactor” as they harness the beneficial soil micro flora, destroy soil pathogen and convert organic waste to wealth such as biofertilizers, biopesticides, vitamins, enzymes, antibiotics growth hormones and proteinaceous worm biomass. Beneficial effects of earthworm are mainly due to various activities like burrowing, feeding and excretion that affect physical, chemical and biological properties of soil (Edward and Lofty, 1977; Bhatnagar and Palta, 1996). Besides improving crop field status, earthworms can be successfully used for composting of weed biomass, crop residue and other bio-waste into organic manure which is popularly termed as vermicompost. Quality of the vermicompost mainly depends upon the type of raw material and type of earthworm species used (Edward, 1983). The decomposing ability of different species depends highly on agro ecological and environmental conditions of the region (Hallet *et al.*, 1990; Sharma, 2004). Screening of locally available earthworm species and their suitability for vermicomposting during summer and winter seasons is very much required for effective recycling of available bio-waste for production of quality organic manure – vermicompost. Hence, the present study was proposed.

MATERIALS AND METHODS

Four different sets of pot experiments were conducted during summer and winter seasons of 2006-07. The relative efficiency of three earthworm species viz., *Eisenia foetida, Amyanthes diffringes* and *Eudrillus engineae* were evaluated for bio-conversion of rice straw, *Ipomoea carnea*, *Eichhornia crassipes* alone or in mixture. Each set was arranged in completely randomized block design with four replications. The nutrient composition of the substrates used is given in Table 1. The biomass of respective sources was collected and heaped under sun for a week. The biomass was then chopped to 2-3 inches length. Five kg capacity earthen pot with bottom hole was used for the study. A thin layer of ground surface soil of 2 inch thickness was placed at the bottom of each pot so as to create natural conditions for the earthworm. Five hundred grams of the respective biomass and cowdung in 60 : 40 ratios was placed in each earthen pot in alternate layers. Ten adult earthworms were added to the respective pot (Rajkhowa *et al.*, 2005) and covered with hessian cloth so as to create dark conditions in the pots. Sprinkling of water was done as and when necessary to keep the substrate moist. The pots were then kept under a shed made with bamboo and thatch. The population of earthworm was counted with careful hand sorting at the time of harvest of the compost. The maturity of the compost was judged visually with the formation of dark-brown granular structure. The compost was then dried under shade so as to bring the moisture level to about 20%. The compost was then sieved with 2 mm sieve and weighed. Total nitrogen was estimated by following Kjeldahl digestion and distillation method. Di-acid digestion of samples was carried out using concentrated HNO_3 and $HClO_4$ mixed in 9 : 4 ratios. Digested samples were used to determine total potassium, calcium, magnesium using Flame photometer, while phosphorus was determined by using spectrophotometer (Jackson, 1973). The C : N ratio of the samples was determined (Jackson, 1973).

Table 1. Nutrient status in the plant biomass used for vermicomposting

Particulars	*Ipomoea carnea*	*Eichhornia crassipes*	*Oryza sativa*	Cow dung
Nitrogen (%)	1.90	1.50	0.65	0.65
Phosphorus (%)	0.75	0.72	0.12	0.38
Potassium (%)	2.50	2.20	0.96	0.62
Organic carbon (%)	56.40	48.20	40.40	41.80
C : N	29.6 : 1	32.1 : 1	60.2 : 1	60.4 : 1

RESULTS AND DISCUSSION

Efficiency of Earthworm Species

The data on earthworm population, composting time, compost recovery and C : N ratio in the compost prepared from different plant biomass as influenced by earthworm species during summer and winter seasons are given in Table 2. Irrespective of species, the earthworm population at maturity of the compost increased by 8-12 times over the initial value. The highest population build-up was recorded with *E. eugineae* and it was at par with that of *E. foetida*. The lowest population build-up, however, was recorded for *A. diffringens.* In general, the population build-up was slightly lower in winter than during summer season.

The composting time varied from 50-70 and 55-75 days during summer and winter season, respectively, irrespective of earthworm species and plant biomass used. The time required for composting of plant biomass was lowest when *E. eugineae* and *E. foetida* were used for composting indicating the suitability of both the species for vermicomposting under Assam conditions. *A. diffringens* took comparatively more time for decomposing the plant biomass. Time required for composting also varied with the biomass used. *Ipomoea* biomass and mixture of rice straw, *Eichhornia* and *Ipomoea* biomass took comparatively more time for decomposition than the other substrates used. Similar observations were also reported by Bhawalkar (1995), Singh and Rai (1998) and Sannigrahi (2005). Earthworm species like *E. foetida, A. diffringens* and *E. eugineae* decomposed all types of agricultural wastes into compost efficiently (Karthikeyan, 2000). Among the different biomass used, the per cent recovery was comparatively higher in case of *Ipomoea* biomass followed by mixture of rice straw, *Ipomoea* and *Eichhornia* irrespective of earthworm species used. The lowest recovery percentage was recorded from *Eichhornia* which might be due to its low dry matter content. The per cent recovery of compost did not vary significantly due to different earthworm species.

Table 2. Effect of earthworm species on composting time, compost recovery, C : N ratio and earthworm population during summer and winter seasons

Earthworm species	Earthworm population		Composting time		Compost recovery (%)		C : N ratio	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Rice straw								
E. foetida	116	109	55	62	46.2	44.2	18.2	18.2
A. diffringens	81	78	65	69	45.5	44.5	18.2	18.1
E. eugeniae	120	112	55	60	46.4	45.6	18.1	18.1
LSD (P=0.05)	11	15	7	6	NS	NS		
Eichhornia								
E. foetida	119	113	54	58	41.5	40.8	11.2	11.2
A. diffringens	97	90	58	65	39.5	40.5	11.2	11.2
E. eugeniae	113	119	50	55	42.2	42.5	10.8	10.8
LSD (P=0.05)	15	19	7	4	NS	NS		
Ipomoea								
E. foetida	117	107	62	69	52.5	52.1	9.8	9.8
A. diffringens	99	92	70	75	51.6	51.8	10.1	10.1
E. eugeniae	124	113	58	61	53.0	53.2	9.7	9.7
LSD (P=0.05)	17	14	10	11	NS	NS		
Rice straw + *Eichhornia* + *Ipomoea*								
E. foetida	109	106	61	65	48.7	50.2	10.5	10.5
A. diffringens	78	96	67	75	47.6	49.6	11.1	11.1
E. eugeniae	112	117	58	63	49.5	50.8	10.1	10.1
LSD (P=0.05)	15	16	12	9	NS	NS		

NS–Not Significant.

C : N Ratio in the Vermicompost

The C : N ratio is one of the most important parameters that determine the extent of composting and the degree of compost maturity. Vermicomposting substantially narrowed down the C : N ratio of different substrates over their initial value. Irrespective of substrate, the C : N ratio in the vermicompost attained an optimum value (<20) which ensured an acceptable degree of maturity within 60-75 days. Among the different substrates used, the vermicompost prepared from *Ipomoea* biomass had the lowest value of C : N ratio (9.7), while the highest value of C : N ratio (18.1) was recorded with the vermicompost produced from rice straw. The C : N ratio of the vermicompost from *Eichhornia* biomass was comparable to that of mixture of rice straw, *Ipomoea* and *Echhornia* biomass. Earthworm species did not cause significant change in the C : N ratio of the compost. Similarly, no significant change in the C : N ratio in the vermicompost was recorded. Both earthworm activity and initial C : N ratio of the substrates had significant influence on the C : N ratio of the vermicompost. It was reported that the C : N ratio narrowed down as nitrogen remained in the system, while some of the carbon was released as CO_2 (Gaur and Sadasivam, 1993). Earthworm activity stimulates rate of organic matter decomposition by increasing the surface area and aeration of the substrate (Edward, 1983). The intestinal mucus which consists of easily metabolizable compounds is considered to result in a priming effect of earthworms to microbial decomposition (Albanell *et al.*, 1988; Elvira *et al.*, 1996; Vinuslas-Akpa and Loquet, 1997). Further, nitrogen fixing bacteria indirectly help in decreasing C : N ratio by making more nitrogen available from added organic matter (Rasal *et al*., 1988; Shinde *et al*., 1992).

Nutrient Content

The nutrient content in the vermicompost prepared from different substrates (Table 3) increased significantly over the original level in the respective substrate. Several workers (Senapati and Das, 1984; Bhatnagar and Palta, 1996; Venkataratnam, 1998; Sannigrahi and Chakrabortty, 2000) also reported about the improvement in nutrient content in the

Table 3. Nutrient status of vermicompost prepared from different plant biomass as influenced by earthworm species during summer and winter seasons

Earthworm species	Nutrient content (g/kg)											
	Summer						Winter					
	N	P	K	Ca	Mg	S	N	P	K	Ca	Mg	S
Rice straw												
E. foetida	13.2	10.5	11.6	7.3	1.3	1.8	13.2	9.5	11.8	7.6	1.3	1.7
A. diffringens	13.0	9.8	11.5	7.4	1.2	1.7	12.9	9.1	10.8	7.5	1.2	1.6
E. eugineae	13.8	10.6	11.8	7.9	1.4	1.8	13.6	9.7	12.0	8.1	1.3	1.7
LSD (P=0.05)	0.6	0.4	NS	NS	NS	NS	0.5	0.3	0.9	NS	NS	NS
Eichhornia												
E. foetida	19.5	12.9	21.5	9.5	2.9	3.8	19.6	12.8	21.6	9.6	2.8	3.9
A. diffringens	19.0	12.5	21.4	9.5	2.8	3.7	18.9	12.3	21.3	9.3	2.7	3.8
E. eugineae	20.2	13.0	21.9	9.8	2.9	3.8	20.1	12.9	21.7	9.9	2.8	3.9
LSD (P=0.05)	0.9	NS	NS	NS	NS	NS	0.9	NS	NS	NS	NS	NS
Ipomoea												
E. foetida	24.2	18.1	25.5	11.2	4.5	5.1	23.9	18.2	25.7	11.1	4.6	5.0
A. diffringens	23.1	17.6	25.0	11.0	4.5	4.8	22.5	17.9	25.0	11.0	4.6	4.9
E. eugineae	24.5	18.2	26.2	11.2	4.6	5.1	23.9	18.4	26.0	11.1	4.7	5.3
LSD (P=0.05)	1.1	0.3	NS	NS	NS	NS	1.0	0.3	1.0	NS	NS	NS
Rice straw + *Eichhornia* + *Ipomoea*												
E. foetida	20.1	13.6	20.5	11.3	4.1	5.3	19.3	13.2	20.0	11.1	4.6	5.1
A. diffringens	19.2	13.1	19.8	10.2	4.0	4.7	19.1	13.0	19.8	10.9	4.0	4.8
E. eugineae	20.0	13.9	21.2	11.5	4.6	5.2	19.5	13.7	20.2	11.4	4.6	5.3
LSD (P=0.05)	0.7	0.3	NS	NS	NS	NS	0.9	0.4	0.5	NS	NS	NS

NS–Not Significant.

vermicompost due to earthworm activity. Different earthworm species did not cause significant variation in nutrient content except nitrogen and phosphorus. This is in conformity with the findings of Sannigrahi (2005). Variation in nutrient content was significant as regards to different substrates used which might be due to variation in the inherent nutrient content in the substrate. Irrespective of earthworm species and composting season, the nitrogen content in vermicompost from rice straw ranged from 1.29 to 1.38%, P 0.91 to 1.06% and K 1.14 to 1.20% showing comparatively lower nutrient content over the other substrates used. The highest nutrient content was recorded in the vermicompost prepared from *Ipomoea* biomass in which N content ranged from 2.25 to 2.45%, P 1.76 to 1.84% and K 2.50 to 2.61%. The nutrient content in the vermicompost prepared from *Eichhornia* biomass was comparable to vermicompost prepared from mixture of rice straw, *Ipomoea* and *Eichhornia* biomass. The increase in nutrient content in the vermicompost was due to loss of a part of organic carbon as carbondioxide during decomposition and production of mucus and nitrogenous excrements by earthworm resulting in the overall increase in the mineral contents. Vermicompost also contained different enzymes like proteases, amylase, lipase, cellulose, chitinase, etc. and beneficial microorganisms. The earthworm tissue contains 50-75% proteins, 7-10% fats, calcium, phosphorus and other minerals. These are added to vermicompost after the death of matured earthworms. All these factors might have increased the nutrient content in the vermicompost. Similar results were also reported by Sannigrahi (2005). Nutrient content in the vermicompost did not vary significantly with the season of production.

From the above study, it can be concluded that different plant biomass such as rice straw, *I. carnea*, *E. crassipes*, etc. can be effectively utilized for the production of nutrient rich vermicompost. The earthworm species viz., *E. eugineae*, *E. foetida* and *A. diffringens* are equally effective for vermicomposting plant biomass during summer and winter seasons under the prevailing agro-climatic conditions of Assam.

REFERENCES

Albanell, E., J. Plaixats and T. Cabrero, 1988. Chemical changes during vermicomposting (*Exsenia foetida*) of sheep manure mixed with cotton industrial wastes. *Biology and Fertility of Soils* **6** : 266-269.

Bhatnagar, R. K. and R. K. Palta, 1996. *Earthworm Vermiculture and Vermincomposting.* Kalyani Publishers, New Delhi. pp. 6-49.

Bhawalkar, M. S. 1995. Sustainable agriculture through vermiculture. *Ind. Farmers Times* **13** : 13-14.

Edward, C. A. 1983. Earthworms, organic waste and food. *Span* **26** : 106-108.

Edward, C. A. and J. R. Lofty, 1977. *Biology of Worms.* Chapman and Hall, Holland. p. 333.

Elvira, C., M. Gaicoechea, L. Sampedro, S. Mate and R. Nogales, 1996. Bioconversion of solid paper pulp mill sludges by earthworms. *Bioresource Technol.* **57** : 173-177.

Gaur, A. C. and K. V. Sadisivam, 1993. Theory and practical considerations of composting organic wastes. In : *Organics in Soil Health and Crop Production*, Thompson, P. K. (ed.). pp.1-20.

Hallet, L., A. J. Reineek and S. A. Vitjeon, 1990. Life cycle of the oriental compost worms, *Perionyx excavatus* (Oligochaeta). *South Afr. J. Zool.* **25** : 41-45.

Jackson, M. L. 1973. *Soil Chemical Analysis.* Prentice Hall of India Pvt. Ltd., New Delhi.

Karthikeyan, S. 2000. Compost maturity indices. In : Short Course on Vermiculture and Vermicomposting Technology. Tamil Nadu Agricultural University, Coimbatore. p. 98.

Rajkhowa, D. J., A. K. Gogoi and N. T. Yaduraju, 2005. Success story on weed utilization for vermicomposting. *Technical Bulletin No. 6*, National Research Centre for Weed Science, Jabalpur. pp. 1-12

Rasal, P. H., H. B. Kalbhar, V. V. Shingte and P. L. Patil, 1988. Development of technology for rapid composting and enrichment. In : *Biofertilizers–Potentialities and Problems*, Sen, S. P. and Patel, P. (eds.). pp. 254-258.

Sannigrahi, A. K. 2005. Efficiency of *Perionyx excavatus* of vermicomposting of thatch grass (*Imperata cylindrical*) in comparison to *Eigenia foetida* in Assam. *J. I. S. S. S.* **53** : 237-239.

Sannigrahi, A. K. and S. Chakrabortty, 2000. Impact of composting techniques on the availability of NPK and microbial population in composts. *Environ. and Ecol.* **18** : 888-890.

Senapati, B. K. and M. C. Das, 1984. Functional role of earthworms in decomposer sub-system. *Trop. Ecol.* **25** : 54-73.

Sharma, A. K. 2004. *Biofertilizers for Sustainable Agriculture, 4th edn.* Published by Agrobios (India), Jodhpur. p. 66.

Shinde, P. H., R. K. Naik, R. B. Nazirker, S. K. Dadam and V. M. Khaire, 1992. Evaluation of vermicompost. Proc. National Seminar on Organic Farming. M. P. K. V., Pune. pp. 54-55.

Singh, J. and S. N. Rai, 1998. Vermicomposting : a prospective boon for sustainable agriculture in India. *Farmers and Parliament* **33** : 17-18, 26.

Venkataratnam, L. 1998. Vermiculture : a profitable new agri-business. *Health Action* **11** : 32-33.

Vinuslas-Akpa, M. and M. Loquet, 1997. Organic matter transformations in lingo cellulosic waste products composted on vermicomposted (*Eisenia foetida* anderi) : Chemical analysis and 13C CPMAS NMR spectroscopy. *Soil Biol. and Biochem.* **28** : 751-758.