Dynamic Soil, Dynamic Plant ©2011 Global Science Books

Utilization of Weeds as Substrates for Vermifertilizer

S. Viveka[1] • B. Leena Grace[2*]

[1] Department of Biotechnology, Udaya School of Engineering, Udaya Nagar, Kanya kumari District-629204, Tamil Nadu, India
[2] Department of Biotechnology, Vinayaka Missions University, Salem – 638308 Tamil Nadu, India

Corresponding author: * leenagrace_2002@yahoo.com

ABSTRACT

Aquatic weeds interfere with the normal functioning of water bodies. Among the aquatic weeds, water hyacinth is considered to be the most obnoxious weed ranked eighth in the world. *Ipomoea carnea* is a cosmopolitan species of weed in disturbed habitats. Compost is known to improve crop production by improving soil fertility and soil physical properties. Earthworms make important contributions in the decomposition of organic material. In the present study, *Lampito mauritii*, an indigenous earthworm, was utilized for the decomposition of commonly available aquatic weeds *viz*., *Eichhornia crassipes* and *I. carnea* for the production of good quality vermicompost. After the completion of vermicomposting the cocoons, juveniles, non-clitellated and adult earthworms were separated and counted. Physico-chemical parameters of the compost were analyzed in the initial and final stages of vermicomposting. Bacterial and fungal density and their generic and species level identification analysis were also carried out. The pH value increased in the final stage and was 7.2. The EC improved from initial (0.82,0.85) to final stages (1.43,0.99) in both *Eichhornia*- and *Ipomoea*-based composts. The temperature in the final stage of *Eichhornia*- and *Ipomoea*-based vermicompost was 28.9 and 28.7°C, respectively. Bulk density decreased significantly with increasing water holding capacity and porosity. N, P, K and organic carbon values were higher in both *Eichhornia*- and *Ipomoea*-based vermicompost than the initial state. Bacterial density of *Eichhornia* and *Ipomoea* composts was 2.16×10^7 and 2.83×10^7 CFU/g, respectively. The fungal density of *Eichhornia* and *Ipomoea* composts were 2.76×10^4 and 2.30×10^4CFU/g, respectively. *E. crassipes* and *I. carnea*, both weeds, could be effectively utilized as substrates for vermicomposting.

Keywords: earthworms, *Eichhornia crassipes*, *Ipomoea carnea*, *Lampito mauritii*, vermicompost

INTRODUCTION

Organic farming is a production system which largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and live stock feed additives. It relies on crop relations, crop residues, animal manures, legumes, green manures, off- farm organic wastes and aspects of biological pest control to maintain soil productivity to supply plant nutrients and to control insects, weeds and pests (Lampkin 1990; Rajasekaran 1995). Composting is one of the recycling methods for converting organic residues into nutrients for growing food crops. Not all organic wastes can be applied or ploughed directly as such into the soil because of their variation in decomposition and C: N ratio. Farming practices which involve heavy application of chemical fertilizers may cause depletion of certain nutrients in the soil and accumulation of certain others in excess resulting in a nutrient imbalance, in turn affecting soil productivity. In agricultural production, organic manure definitely plays a key role because it possesses many desirable soil properties and exerts a beneficial effect on the physical, chemical and biological characteristics of the soil to achieve sustainability (Goyal *et al.* 1991). Vermiculture is a biotechnology-based technique that helps to partially solve pollution problems since earthworms are effective converters of wastes. Earthworms are used to dispose waste materials, including compost (Sannigrahi and Chakrabortty 2000). Prabha *et al.* (2008) reported that vermicompost application stimulated root growth of *Ipomoea carnea* which facilitates nutrient absorption and thereby favouring higher yield.

Aquatic weeds are thought to adversely impact the environment (Lee 1985). They also dock certain plant pathogens which adversely affect agricultural crops (Edwards and Bohlen 1996). *Ipomoea carnea* Jacq is a cosmopolitan species of weed within disturbed habitats. The water content with toxic industrial wastes and decaying organic matter in the soil appear to favour growth of the weeds (Chaphekar and Bhalerao 1988). The present study aimed to investigate the possibility of using an earthworm, *Lampito mauritii*, as a potential organism for decomposing two locally abundant weed species *viz*. *Eichhornia crassipes* and *Ipomoea carnea*.

MATERIALS AND METHODS

Two commonly available aquatic weeds, *E. crassipes* and *I. carnea*, were procured from Mannarkoil, between Ambasamudrum and Vakaikulam near Alwarkurichi at the southern part of Tamil Nadu, India. The collected weeds were chopped into small pieces of approximately 10 cm in size. The chopped biomass was sun dried to remove excess moisture and to make it free of pathogens. Before vermicomposting, *Eichhornia* and *Ipomoea* biomasses were pretreated with cow dung slurry (CDS). For the pretreatment the raw materials were sprayed with 25-35% CD inoculum daily for a total of 15 days for *Eichhornia* and 30 days for *Ipomoea.* During the process of vermicomposting, the *Eichhornia* biomass was pretreated with CDS for 15 days since it enhances initial degradation and easy palatability and digestion by the earthworms (Demirbas 2010). The *Ipomoea* biomass was resistant to degradation. Therefore the biomass was treated with CDS for 30 days; due to the long composting process the weeds were easily acceptable for the earthworms.

After pretreatment, 50 kg of weed biomass was mixed with fresh CD in a 1: 1 ratio. All the processed resources were poured into a pit with dimension 1.0 × 0.5 × 1.0 m. Water was sprinkled inside the pit area daily to maintain the moisture content at 40-50%. Five hundred clitellate (adult) *Lampito mauritii* were taken from our vermibiotech laboratory, Sri Paramakalyani Center for Environmental Sciences, Alwarkurichi, Manonmanium Sundaranar University. They were introduced into each vermipit (3 replications). In addition, coconut leaves were spread over the pit for

Received: 7 July, 2011. Accepted: 2 August, 2011.

Original Research Paper

Table 1 Proximate composition of the *Eichhornia* and *Ipomoea* plants prior to utilization for composting.

Name of organic wastes used	pH	EC mS/cm	Lignin %	Cellulose %	N%	P%	K%	Ca%	Mg%	S%	Fe%	Cu%	Zn%	Organic carbon %
Eichhornia	5.8	0.38	30.6	26.7	1.16	0.094	0.13	1.02	0.15	0.69	1.57	0.01	0.09	30.0
Ipomoea	5.9	0.38	32.8	28.1	1.19	0.084	0.68	1.18	0.08	0.35	2.09	0.01	0.03	31.2

Table IA One-way analysis of variance showing that there are no significant differences between the organic wastes (*Eichhornia* and *Ipomoea*) and their proximate composition at the 5% level.

Source of variation	SS	df	MS	*F*	*P*-value	*F* crit
Between groups	1.193157	1	1.193157	0.007744	0.930552	4.225201
Within groups	4006.023	26	154.0778			
Total	4007.216	27				

Table 2 Physical properties of *Eichhornia* and *Ipomoea* composts (all values = mean ± SE).

Stages	pH	EC (mS/cm)	Temperature °C	Porosity %	Bulk density %	Water holding capacity %	Moisture content %
Eichhornia							
Initial	6.06 ± 0.03	0.82 ± 0.01	29.53 ± 0.22	33.37 ± 0.94	0.83 ± 0.01	58.40 ± 0.87	34.27 ± 0.66
Final	7.22 ± 0.03	1.43 ± 0.005	28.90 ± 0.42	66.57 ± 0.27	0.51 ± 0.01	138.07 ± 0.70	63.07 ± 0.53
Ipomoea							
Initial	6.12 ± 0.06	0.85 ± 0.02	29.43 ± 0.29	30.60 ± 0.75	0.87 ± 0.01	35.83 ± 0.84	23.40 ± 0.55
Final	7.22 ± 0.03	0.39 ± 0.01	28.73 ± 0.41	60.00 ± 0.47	0.49 ± 0.01	143.67 ± 0.86	63.63 ± 0.35

Table 2A Two-way analysis of variance showing that there are no significant differences between the initial and final stages of *Eichhornia* and *Ipomoea* composts and their physical properties at the 5% level.

Source of variation	SS	df	MS	*F*	*P*-value	*F* crit
Between groups	1.05123	1	1.05123	0.006799	0.934968	4.259677
Within groups	3710.729	24	154.6137			
Total	3711.78	25				

mulching. The content of the pit was mixed well once in seven days without disturbing the worms maintaining the temperature of the pit at 20–30°C which led to uniform maturation of the compost. After the completion of vermicomposting, the cocoons, juveniles, non-clitellated and adult earthworms were separated and counted.

Physical parameters such as pH, EC, temperature, porosity, bulk density, water holding capacity and moisture content of the compost were analyzed in the initial and final stage (Muthuvel and Udaya Soorian 1999). The chemical parameters analysed included lignin (gravimetric method; MACS Manual 1984), cellulose (calorimetric method; Updegraff 1969), nitrogen (Kjeldahl method; Tandon 1993), phosphorus (colorimetric method; Tandon 1993), potassium (flame photometric method; Tandon 1993), calcium (titrimetric method; Tandon 1993), magnesium (titrimetric method; Tandon 1993), organic carbon (ISI Bulletin 1982), sulphur (turbidimetry method; Tandon 1993), iron (spectrophotometric method; Model CL-27; Jackson 1973), zinc and copper (atomic absorption spectrophotometric method; Tandon 1993).

Bacterial and fungal density and identification analysis were carried out following the method suggested by Allen (1953) and Williams *et al.* (1989). For statistical analysis the significance of deviations were tested by ANOVA at the 5% level.

RESULTS AND DISCUSSION

Physico-chemical parameters of vermicompost

The proximate composition of the *Eichhornia* and *Ipomoea* weeds prior to composting were shown in **Table 1**. The physical and chemical properties of the vermicompost utilizing *Eichhornia* and *Ipomoea* as a weed base during initial and final stage of vermicompost are indicated in **Tables 2** and **3**, respectively. All values were expressed as mean ± standard error (**Tables 2, 3, 5**) and the data of **Tables 2** and **3** were subjected to two-way ANOVA that shows there are no significant differences between the organic wastes (*Eichhornia* and *Ipomoea*)/compost and their proximate composition and physicochemical properties at the 5% level (**Tables 2A, 3A**). The one way analysis of variance for **Tables 1** and **5** shows there is no significant difference between the *Eichhornia* and *Ipomoea* post compost earthworm population at 5% level (**Table 1A, 5A**).

The results of the present study showed that the pH values amplified in the final stage and it was 7.2. The analysis of worm casts showed a neutral P^H (Kale and Bano 1998). The EC was improved from initial to final stage in both *Eichhornia* and *Ipomoea* vermicompost. The temperature noticed in the final stage of *Eichhornia* and *Ipomoea* based vermicompost was 28.9 and 28.7°C, respectively. The results of the bulk density decreased significantly with increasing water holding capacity and porosity. Biosynthesis of organic manure decreased the bulk density, increased the pore volume and water holding capacity. Gupta *et al.* (2007) investigated that water hyacinth could be potentially useful as raw substrate in vermicomposting if mixed with up to 25% in cow dung on dry weight basis.

The chemical composition of the vermicompost utilizing *Eichhornia* and *Ipomoea* as a base is reported in **Table 3**. From the present study it is observed that the lignin and cellulose are degraded in the compost which made easy for the plants for absorption. The percentage of lignin and cellulose was reduced during the final stage. The present study also exposed a significant increase in the proportion of micro and macro nutrients, after vermicomposting.

The percentage of nitrogen, phosphorous and potassium increased in the vermicomposting period by the earthworm species *Lampito mauritii*. In contrast, C/N decreased day by day (Tripathi and Bhardwaj 2004).The chemical analysis showed that N, P, K and organic carbon values were higher in vermicompost than biodigested slurry. The N, P, K contents of vermicompost was relatively higher than aerobic and anaerobic composts. C: N ratio of the compost decreased significantly with increasing nitrogen content. The potentiality of *Lampito mauritii* was assessed in terms of efficiency and sustainability of vermicomposting by water hyacinth. Gajalakshmi *et al.* (2001) reported that when *Lampito mauritii* was used for composting with water hyacinth: cowdung (6:1) as feed, vermicasts were produced with a steady increase of output and the earthworms grew well by increasing their weights.

Table 3 Chemical composition of *Eichhornia* and *Ipomoea* composts (all values = mean ± SE).

Stages	Lignin %	Cellulose %	N %	P %	K %	Ca %	Mg %
Eichhornia							
Initial	28.83 ± 0.19	25.33 ± 0.28	1.25 ± 0.05	0.18 ± 0.01	0.20 ± 0.01	1.18 ± 0.03	0.16 ± 0.005
Final	18.17 ± 0.10	15.23 ± 0.19	2.38 ± 0.01	1.19 ± 0.02	1.57 ± 0.01	2.15 ± 0.02	0.47 ± 0.01
Ipomoea							
Initial	29.90 ±0.46	25.07 ± 0.24	1.21 ± 0.05	0.23 ± 0.03	0.79 ± 0.04	1.16 ± 0.04	0.10 ± 0.01
Final	19.63 ± 0.26	16.27 ± 0.20	2.12 ± 0.03	1.29 ± 0.03	2.13 ± 0.02	1.39 ± 0.01	0.22 ± 0.01

	S %	Fe %	Cu %	Zn %	Organic carbon %	C:N ratio
Eichhornia						
Initial	0.73 ± 0.005	2.22 ± 0.02	0.013 ± 0.001	0.11 ± 0.005	28.90 ± 0.42	24.42 ± 0.16
Final	0.83 ± 0.01	3.67 ± 0.02	0.025 ± 0.001	0.34 ± 0.005	40.13 ± 0.38	22.14 ± 0.03
Ipomoea						
Initial	0.44 ± 0.01	2.25 ± 0.02	0.014 ± 0.001	0.12 ± 0.01	30.40 ± 0.35	24.71 ± 0.12
Final	0.69 ± 0.01	3.44 ± 0.03	0.038 ± 0.001	0.42 ± 0.01	40.27 ± 0.29	22.99 ± 0.02

Table 3A Two-way analysis of variance shows that there are no significant differences between the initial and final stages of *Eichhornia and Ipomoea* composts and their chemical composition at the 5% level.

Source of variation	SS	df	MS	*F*	*P*-value	*F* crit
Between groups	3334.276	1	3334.276	0.00302	0.95752	5.317655
Within groups	8831414	8	1103927			
Total	8834748	9				

Table 4 Density and identification of microbes in *Eichhornia* and *Ipomoea* composts.

Medium	Load		Identification	
	Bacterial density CFU/g	Fungal density CFU/g	Bacteria	Fungi
Eichhornia compost	2.16×10^7	2.76×10^4	*Bacillus* sp., *Staphylococcus* sp., *Pseudomonas* sp., *Achromobacter* sp., *Vibrio* sp., *Aeromonas*	*Aspergillus flavus*, *Aspergillus nidulan*, *Fusarium* sp., *Mucor variens*, *Rhizopus* sp., *Fusidium* sp., *Absidia ramosa.*
Ipomoea compost	2.83×10^7	2.30×10^4	*Bacillus* sp., *Staphylococcus* sp., *Micrococci* sp., *Pseudomonas* sp	*Rhizopus* sp., *Mucor* sp., *Aspergillus* sp., *Fusarium* sp., *Chaetomium globosum*, *Fusidium* sp., *Absidia ramosa.*

Table 5 Post-compost earthworm populations (all values = mean ± SE).

Medium	No. of worms introduced	Cocoons	Juveniles	Non-clitellates	Adults
Eichhornia compost	500	1525.3 ± 13.2	2762.3 ± 10.0	252.6 ± 6.0	602.6 ± 4.5
Ipomoea compost	500	1635.6 ± 11.5	2826.6 ± 11.6	250.6 ± 6.6	612.6 ± 6.0

Table 5A One-way analysis of variance shows that there are no significant differences between the *Eichhornia* and *Ipomoea* post-compost and earthworm populations at the 5% level.

Source of variation	SS	df	MS	*F*	*P*-value	*F* crit
Between groups	1450.243	1	1450.243	0.977367	0.342365	4.747225
Within groups	17805.92	12	1483.827			
Total	19256.16	13				

Microbial analysis of vermicompost

The bacterial and fungal densities of both vermicompost are reported in **Table 4**. Earthworm casts usually have greater populations of bacteria, fungi and actinomycetes and more enzyme activity, larger concentrations of available nutrients and greater structural stability than the surrounding soil aggregates. Aira *et al.* (2007) studied the relationships between earthworm activity, microbial biomass and the activation and dynamics of several enzyme activities. They reported that the correlations between microbial biomass and enzymes which signify an increase of intracellular enzyme activity. The differences in overall enzyme activity agree with the variation found in extracellular enzyme activity suggesting certain dependence on substrate availability. Aira and Domínguez (2008) found that earthworms increased microbial biomass and were more active in reactors fed with 3 kg of slurry.

Earthworm casts are rich in ammonia and partially digested organic matter and provide a good substrate for the growth of microorganisms. The earthworm *Lampito mauritii* can increase the microbial population and densities during vermicomposting of *Eichhornia* and *Ipomoea* biomass which in turn can be used for increasing the microbial population of the soil.

Post compost earthworm population

After the completion of vermicomposting, the collected worms represented cocoons, juveniles, non-clitellates and adults are illustrated in **Table 5**. Greater biomass and number of these different stages of earthworms are the good indication of successful composting. Comparison between the vermicomposts prepared by using *Eichhornia* and *Ipomoea* showed that high increase of earthworm population was noticed in *Ipomoea*. It may be due to the good taste which accelerated the palatability. Recycling of aquatic weeds into valuable biomanure can reduce the use of agricultural chemicals and help to protect the environment with sustainable agriculture.

REFERENCES

Aira M, Domínguez J (2008) Optimizing vermicomposting of animal wastes: Effects of rate of manure application on carbon loss and microbial stabilization. *Journal of Environmental Management* **88 (4)**, 1525-1529

Aira M, Monroy F, Domínguez J (2007) Earthworms strongly modify microbial biomass and activity triggering enzymatic activities during vermicomposting independently of the application rates of pig slurry. *Science of the Total Environment* **385 (1-3)**, 252-261

Allen GN (1953) Experiment *in Soil Bacteriology*, Burger's Publication Co. Minneapolis, Minn., USA, 127 pp

Chaphekar SB, Bhalerao SA (1988) *Ipomoea carnea* Jacq. in Bombay urban area. *International Journal of Ecology and Environmental Science* **14 (2-3)**, 175-183

Demirbas A (2010) Products from lignocellulosic materials via degradation processes. *Energy Sources* **30**, 27-37

Edwards CA, Bohlen PJ (1996) *Biology and Ecology of Earthworms*, Chapman and Hall, London, 426 pp

Gajalakshmi S, Ramasamy EV, Abbasi SA (2001) Potential of two epigeic and two anecic earthworm species in vermicomposting of water hyacinth. *Bioresource Technology* **76 (3)**, 177-181

Goyal S, Mishra MM, HoodaI S, Singh R (1991) Organic manure on physico chemical properties of soil. *Soil Biology and Biochemistry* **24**, 1081-1082

ISI Bulletin (1982) Manak Baavan Bhadur Shah Zafar Marg, New Delhi

Jackson ML (1973) *Soil Chemical Analysis*, Prentice-Hall, New Delhi, 498 pp

Kale RD, Bano K (1998) Earthworm cultivation and culturing techniques for production of Vee comp 83 E UAS, Vee Meal 83 P UAS. *Mysore Journal of Agricultural Sciences* **22**, 339-344

Karmegam N, Daniel T (2000) Effect of bio-digested slurry and vermicompost on the growth and yield of cowpea, *Vigna unguiculata* (L.) Walp. variety C1. *Environment and Ecology* **18 (2)**, 367-370

Lampkin N (1990) *Organic Farming*, Farming Press, I Pswich, UK,701 pp

Lee KE (1985) *Earthworms, Their Ecology and Relationship with Soils and Land Use*, Academic Press, London. UK, 79 pp

MACS Manual (1984) *Laboratory Manual on Microbiological Aspects of Biogas Production*, Maharashtra Association for the Cultivation of Science, Pune, pp 56-57

Muthuvel P, Udayasoorian C (1999) *Soil, Plant, Water and Agrochemical Analysis*, Tamil Nadu Agricultural University, Coimbatore, 52 pp

Pawer AD, Divakar BJ, Sain M (1979) A note - *Oxya nitidula* feeding on water hyacinth. *Indian Journal of Plant Protection* **7 (2)**, 13-15

Prabha KP, Li L-Y, Kumari UR (2008) An experimental study of vermibiowaste composting for agricultural soil improvement. *Bioresource Technology* **99 (6)**, 1672-1681

Rajasekaran K (1995) Organic agriculture. *Kisan World* **22**, 27-29

Renuka G, Kumar PM, Kumar NR, Singh NS, Garg VK (2007) Development of a water hyacinth based vermireactor using an epigeic earthworm *Eisenia foetida* . *Bioresource Technology* **98 (13)**, 2605-2610

Sannigrahi AK, Chakrabortty S (2000) Impact of composting techniques on the availability of NPK and Microbial population in composts. *Environment and Ecology* **18 (4)**, 888-890

Singh J, Bhat SS, Sudharshan MR, Singh J, Bhat S (1997) Performance of Scotch Bonnet Chilli in Karnataka and its response to vermicompost. *Journal of Indian Cocoa, Arecanut and Spices* **21 (1)**, 9-10

Tandon HLS (1993) *Methods of Analysis of Soils, Plant, Waters and Fertilizers*, Fertilizer Development and Consultation Organization, New Delhi, 228 pp

Tripathi G, Bhardwaj P (2004) Comparative studies on biomass production, life cycles and composting efficiency of *Eisenia fetida* (Savigny) and *Lampito marutii* (Kinberg). *Bioresource Technology* **92 (3)**, 275-283

Updegraff DM (1969) Semimicro determination of cellulose in biological materials. *Anaytical Biochemistry* **32**, 420-424

Williams ST, Sharpe ME, Holt JG (1989) *Bergey's Manual of Systematic Bacteriology* (Vol IV), Williams and Wilkins, NY, pp 2299-2648