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Vermicomposting potentiality of *Perionyx excavatus* for recycling of waste biomass of java citronella - An aromatic oil yielding plant

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ABSTRACT

Laboratory investigation on vermicomposting efficacy of *Perionyx excavatus* for recycling of distillation waste biomass of java citronella (*Cymbopogon winterianus* Jowitt) was carried out in two seasonal trials i.e. summer and winter periods. The experiment was conducted in earthen pots using a mixture of citronella waste material and cowdung in the proportion of 5:1. A control treatment without earthworms was setup for comparison of the results. The vermicompost had shown 5.8 folds reduction in C/N ratio and 5.6 folds enhancement in ash content. The nutrient contents (N, P, K, Ca and Mg) in the vermicompost had increase in the range of 1.2 – 4.1 fold than the initial level. The FT-IR spectra of the vermicompost confirmed increase in nitrogen rich compounds and decrease in aliphatic/aromatic compounds as compared to the initial level of the biowaste materials. The vermicomposting process is influenced by seasonal variation and summer was more productive than winter.

1. Introduction

Cymbopogon winterianus Jowitt (Java citronella) is an important and essential oil yielding aromatic grass cultivated in number of countries including India and the steam volatile essential oils extracted from its leaves are used in perfumery, cosmetics, pharmaceuticals, and flavoring industries (Tanu et al., 2004). Probably, citronella waste biomass is the major residue that is generated during the oil extraction process from the citronella plant in the different citronella oil extraction units. According to an estimate, approximately 200,000 tons dry biomass is generated worldwide per year during essential oil production from aromatic plants (Rolz et al., 1986). A small fraction of this waste biomass is burned to generate steam during the oil extraction process. However, major volume of waste are disposed unscientifically in open space which cause health hazards as they produce a large amount of green house gases such as methane.

In global scale, the anthropogenic methane emission has been accounted as 3–19% and which has been sourced from waste dumping site (Gupta and Garg, 2009). This poses great threat to biosphere by initiating climatic change reactions in the atmosphere. Nevertheless, the safe disposal and meaningful utilization of citronella waste is a great challenge and the present work has been designed to develop a suitable agro-technique to mitigate the problem by using *Perionyx excavatus*, a native earthworm species to India. The vermicomposting efficiency of this epigeic earthworm species has been well established and it exhibits better growth and reproductive performance (Suthar and Singh, 2008). The potentiality of *P. excavatus* had been tested to manage agricultural/industrial waste (Khwairakpam and Bhargava, 2009a), water hyacinth (Gajalakshmi et al., 2001), sewage sludge (Khwairakpam and Bhargava, 2009b), etc. However no attempts have been accomplished till date for vermicomposting of citronella biowaste.

Vermitechnology is one of the suitable agro-techniques that have long been in use for the management of biowaste in many countries round the globe. This technique is primarily based on the activity of earthworms as the biological agent and it provides dual benefit, firstly, management of biowaste and secondly, production of organic manure known as vermicompost. The entire technique is a controlled non-thermophilic decomposition of organic waste by mutual interaction between earthworms and microbes (Pramanik et al., 2009). At present, many of the urban industrial and agro-industrial waste have been successfully converted into organic manure by using this novel technique as being well documented (Sangwan et al., 2008; Khwairakpam and Bhargava, 2009a).

The distillation waste of Java citronella has certain agronomic benefit as it has been used as an organic mulching agent in agricultural crop production (Ram and Kumar, 1997). Even, the production

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of vermicompost from citronella waste biomass was also feasible using exotic verm species *Eudrilus eugeniae* (Deka et al., 2011). However, in the present study two ways have been attempted thus far to break through the application of vermicomposting technology. Firstly, *P. excavatus*, an indigenous earthworm species was employed and studied the efficiency for vermicompost production in two seasonal cycles viz summer and winter. Secondly, to assess the efficiency of the vermicomposting process in terms of degradation of the organic matter content; the C/N ratio, ash content and Fourier-transform infrared (FT-IR) spectra of the end product were also analyzed (Gupta and Garg, 2009).

2. Methods

2.1. P. excavatus, citronella waste material (CWM) and cowdung (CD)

The individuals of *P. excavatus* of different age groups were obtained locally from cowdung dump. The stock culture of the earthworm was maintained in earthen pots using partially decomposed biowaste and cowdung as growth medium in laboratory condition for further use in the vermicomposting experiment. The taxonomic identification of the collected earthworm species was confirmed at Zoological Survey of India, Solan, India. The distillated waste material of citronella was collected from citronella oil industry of Rajapara, Assam, India. Fresh urine free CD was collected locally from a livestock farm at Guwahati, Assam, India. The physico-chemical properties of CWM and CD are reported in the Table 1.

2.2. Experimental setup

The citronella waste material (CWM) were dried in air, cut into small pieces and mixed with cowdung (CD)on dry weight basis in a ratio of 5:1 for the experiment (Deka et al.,2011). This mixture (i.e. CWM + CD) were predecomposed for 15 days so that it becomes palatable for the earthworms (Sangwan et al., 2008). The vermicomposting experiment was conducted by using earthen pots of 2 L capacity (diameter 15 cm, depth 20 cm). The pots were filled with 1.5 cm thick sterilized soil layer at the bottom as soil is considered as an important supporting material for vermicomposting (Deka et al., 2011; Yadav et al., 2010). The experiment was setup by taking 500 g CWM + CD mixture (on dry weight basis) in each pot and no extra feeds were provided during the study. In each earthen pot, 15 individuals (average weight of 8.6–9.2 g) of 40 days old earthworms were introduced from the stock culture. All the experimental pots were kept in a dark room at an ambient temperature. The moisture level in the pots was maintained at 65–70% throughout the study (Suthar and Singh, 2008). To avoid moisture loss and protect the earthworms from other predators the experimental pots were placed on water filled trays and covered with jute sheets. The water level was also maintained in the trays as and when it was necessary. The experiment was conducted both in summer and winter seasons to study the seasonal impact on vermicompost production. The mean ambient temperature during the experimental period was recorded 29.5 °C and 20.8 °C in summer and winter, respectively. The average duration of the experiment was of 105 days. A control treatment was also kept with a same setup but without earthworms. Three replications were setup for statistical analysis of the results. The vermicompost was harvested after the appearance of black granular structure on the surface of the composting medium. Watering of the composting medium was discontinued four days before the harvesting. Vermicompost output percentage as against each seasonal period was calculated on dry weight basis taking generated vermicompost and the raw material used in the experiment. Population of earthworm and their biomass as well as cocoons were measured at the end of the experiment as per the method outlined by Gupta and Garg (2008).

Table 1
Chemical composition of the raw materials used for vermicomposting.

Parameters	CD	CWM
pH	7.01 ± 0.61	6.74 ± 0.92
Conductivity (mS/ds)	0.967 ± 0.14	0.304 ± 0.01
Ash content (g/kg dw)	238.7 ± 2.7	141.3 ± 2.1
TOC (g/kg dw)	416 ± 1.8	190.4 ± 1.6
TKN (g/kg dw)	8.1 ± 0.5	4.3 ± 0.4
Available P (mg/kg dw)	2500 ± 3.0	407.8 ± 1.8
Total K (mg/kg dw)	3650 ± 2.1	183.4 ± 1.4
Total Na (mg/kg dw)	200 ± 1.6	41.5 ± 1.5
Total Ca (mg/kg dw)	8978 ± 1.7	5.36 ± 0.38
Total Mg (mg/kg dw)	4669 ± 1.6	2.72 ± 0.73
Manganese (mg/kg dw)	489.7 ± 1.7	189 ± 1.8
Iron (mg/kg dw)	1823.4 ± 1.8	1200.5 ± 2.5
Zinc (mg/kg dw)	112.6 ± 1.8	110.8 ± 1.6
Copper (mg/kg dw)	251.5 ± 1.5	8.7 ± 1.6
C: N ratio	51.35 ± 1.75	44.27 ± 1.9

Mean value ± SD.
CWM = citronella waste material; CD = cowdung; dw = dry weight.

2.3. Physico-chemical and FTIR analysis

The vermicompost generated in the two seasonal trials were mixed properly for analysis of pH, conductivity, ash content, total organic carbon (TOC), total kjeldhal nitrogen (TKN), available phosphorus (P), total potassium (K), total calcium (Ca), total magnesium (Mg) and heavy metals (Mn, Cu, Fe and Zn). For chemical analysis all the samples i.e. the compost, vermicompost, waste material and cowdung were separately dried in air at room temperature and powdered in stainless steel blender. The pH and conductivity value were measured in 1:5 (w/v) water suspensions using digital pH (Elico Li 127) and conductivity meter (Elico CM 180) respectively. The ash content was measured following the method of Nelson and Sommers (1982). Total Organic Carbon was measured by Walkey and Black titration method described by Jackson (1975). Micro Kjeldhal method (Jackson, 1975) was used for measuring nitrogen. The C:N value was calculated from the measured values of total organic carbon and nitrogen. Available phosphorus was determined by using the spectrophotometer (Shimadzu UV 1601) following the stannous chloride method (APHA, 1998). Total sodium and potassium was determined by acid digestion method using flame photometer with standard solution (APHA, 1998). For analysis of Ca, Mg, Mn, Cu, Zn and Fe samples were digested in microwave digester [Milestone, Ethos 900] and then analyzed by Atomic Absorption Spectrophotometer (Shimadzu AA 7000). All the samples were analyzed in triplicate and average results were recorded. The results were reproducible within ±5% error limit. The Fourier-transform infrared (FT-IR) spectra of the samples were carried out by using FTIR spectrophotometer (Bruker Vector 22) according to the method as employed by Gupta and Garg (2009). Samples (5 mg each) were mixed with 400 mg KBr, homogenized in an agate mortar and pressed into a pellet. Infrared spectra were recorded in mid infrared area (wave number ranged 4000–400 cm^{-1}).

2.4. Statistical analysis

Paired sample *t*-test was used to analyze the significant differences in vermicompost production, earthworm population and biomass in two seasonal periods. The same test was also used to compare initial biowaste mixture (CWM + CD) as well as compost (without earthworm) and vermicompost generated from this mixture for their different chemical parameters.