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Vermicomposting of distillation waste of citronella plant (*Cymbopogon winterianus* Jowitt.) employing *Eudrilus eugeniae*

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ABSTRACT

Laboratory experiment on vermicomposting of distillation waste of java citronella (*Cymbopogon winterianus* Jowitt.) was carried out employing *Eudrilus eugeniae*, in two seasonal trials, covering summer and winter periods. Two vermicomposting treatments were conducted in earthen pots, one with citronella plant waste only (CW) and the other, a mixture of citronella waste and cowdung in the proportion 5:1 (CW + CD). Vermicomposting of citronella waste resulted reduction in C/N ratio (83.5–87.7%), enhancement of ash content and a number of macro and micronutrients. The FT-IR spectroscopy of the vermicompost revealed the reduction in aliphatic and aromatic compound as well as increase in amide group after the 105 days stabilization process. The vermicompost output was significantly enhanced in CW + CD treatment than CW treatment. Even, nutrient content of the vermicompost was also higher in CW + CD treatment than CW alone indicating the positive role of cowdung in improvement of quantity and quality.

1. Introduction

Java citronella (*Cymbopogon winterianus* Jowitt.) belonging to family Poaceae is an important aromatic crop cultivated in a number of countries and on steam distillation the shoot biomass of the plant yields an essential oil, widely used in fragrance and flavour industries (Rao, 2000). The technology of extracting citronella oil can be classified as a clean agrobased technology. In India, agro-industrial sector contributes huge potential resource of plant nutrients in the form of wastes, which is either thrown away or buried or burnt causing environmental pollution (Suthar, 2007). India is one of the important producers of java citronella essential oil (Rao, 2000). The biomass of citronella produced as wastes during the oil extraction process from the citronella plant in the different citronella oil extraction unit are disposed off in the field which occupied some portion of cultivated land where it is dumped year after year and decomposed in the field. This unscientific disposal method causes loss of nutrients and economy. Further, these unattended waste biomass undergo anaerobic decomposition during rains and causes environmental pollution by releasing significant amount of methane. Waste dumping sites contribute about 3–19% emission of total anthropogenic methane globally (Gupta and Garg, 2009).

Vermitechnology is a suitable technology for management of many biodegradable materials through the activity of earthworms as the biological agent. The first advantage of use of earthworms in waste management is the reduction in composting period and secondly production of organic manure known as vermicompost. Vermicomposting is the technique of controlled non-thermophilic decomposition of organic wastes by mutual interaction between earthworms and microbes (Pramanik et al., 2009). The use of earthworms for vermiconversion of waste materials including urban, industrial and agro-industrial to produce biofertilizers has already been reported (Sangwan et al., 2008; Khwairakpam and Bhargava, 2009a). However, a little importance has been given for biomanagement of distillation waste product of citronella plant; although there is a scope to measure the potentiality of earthworms for conversion of this biowaste to utilizable product.

The vermicomposting efficacy and biology of *Eudrilus eugeniae* is well documented in literature. Gajalakshmi et al. (2001) reported that *E. eugeniae* is a manure worm, used for vermicomposting due to its voracious appetite, high rate of growth and reproductive ability. Various authors suggested *E. eugeniae* for vermicomposting of different organic material (Pattnaik and Reddy, 2010; Padmavathiamma et al., 2008). However, type and combination of biowaste, seasonal and other abiotic factors are also crucial for vermicomposting operation of a particular earthworm species.

The present study deals with the vermiconversion of distillation waste of citronella plant into vermicompost by using *E. eugeniae*. During the study, the waste biomass of citronella plant was

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supplemented with cowdung (Yadav and Garg, 2009; Kaushik and Garg, 2003) for evaluation of the role of cowdung in decomposition as well as quality and quantity of the output. Besides, attempts have been made to have a comparative efficiency study of the earthworm species in vermicompost production during summer and winter period. The C/N ratio, ash content and Fourier-transform infrared (FT-IR) spectra analysis of the end product has been carried out, which are reliable indicators to test the efficiency of vermicomposting process in terms of degradation of the organic matter content (Gupta and Garg, 2009).

2. Methods

2.1. Earthworms cultures

E. eugeniae was obtained from the vermicomposting unit of Central Silk Board, Boko, Assam, India. 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.

2.2. Citronella waste (CW) and cowdung (CD)

The distillated waste material of citronella was collected from citronella oil industry of Rajapara, Assam, India. The biowastes were air dried and cut into small pieces for the experiment. Fresh urine free CD was collected locally from a livestock farm at Guwahati, Assam, India. The physico-chemical properties of CW and CD are reported in the Table 1.

2.3. Experimental setup

The vermicomposting experiment was setup in earthen pots of 2 L capacity (diameter 15 cm, depth 20 cm). Two treatments were taken for vermicomposting of CW materials; one with CW alone; while the other with a mixture of CW and CD in the ratio of 5:1. The earthen pots were filled with 1.5 cm thick sterilized soil layer at the bottom as soil is considered as important supporting material for vermicomposting (Yadav et al., 2010). Some relevant parameters of the bedding soil before and after vermicomposting process were analyzed to study the leaching of nutrients during the process of vermicomposting. The experiment was conducted by taking 500 g raw materials (on dry weight basis) in earthen pot for each treatment trial and no extra feed was provided during the study. Before starting of the experiment, citronella wastes (CW) and the citronella wastes with cowdung mixture (CW + CD) were precomposted for 15 days so that it becomes palatable to the earthworms (Sangwan et al., 2008). To each earthen pot, 15 numbers (average weight of 7.8–8.4 g) of 40 days old earthworms were introduced from the stock culture after pre-composting of the raw materials. The experiment was conducted in dark room in ambient temperature. The moisture levels in the experimental pots were maintained at 70 ± 10% (Yadav and Garg, 2009). To avoid moisture loss and protect the earthworms from predators, the experimental pots were placed on water filled trays and covered with jute sheets. The water levels in the trays were maintained whenever necessary. The experiment was conducted both in summer and winter seasons to study the seasonal impact on vermicompost production. The average duration of the experiment was 105 days. A control treatment was also kept with same setup without earthworms. Three replications were made in each treatment for statistical analysis of the results. The vermicompost was harvested after 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 from each treatment was calculated on dry weight basis for each seasonal period. Population of earthworm and their biomass as well as cocoons were measured at the end of the experiment as per the method given by Gupta and Garg (2008).

Table 1
Physico-chemical characteristics of the raw material used in the experiment.

Parameters	CD	CW	CW + CD (5:1)
pH	7.01 ± 0.61b	6.74 ± 0.92a	6.80 ± 0.90a
Conductivity (dS m^{-1})	0.967 ± 0.14d	0.304 ± 0.01c	0.309 ± 0.01c
Ash content (g/kg)	238.7 ± 2.7e	141.3 ± 2.1f	141.9 ± 1.9f
TOC (g/kg)	416 ± 1.8g	190.4 ± 1.6h	190.6 ± 1.6h
TKN (g/kg)	8.1 ± 0.5i	4.3 ± 0.4j	4.4 ± 0.5j
Available P (mg/kg)	2500 ± 3.0m	407.8 ± 1.8k	408.2 ± 1.2k
Total K (mg/kg)	3650 ± 2.1n	183.4 ± 1.4p	184.2 ± 0.9p
Total Na (mg/kg)	200 ± 1.6q	41.5 ± 1.5r	42 ± 1.3r
Total Ca (mg/kg)	8978 ± 1.7t	5.36 ± 0.38s	5.41 ± 0.52s
Total Mg (mg/kg)	4669 ± 1.6ab	2.72 ± 0.73bc	2.91 ± 0.91bc
C:N ratio	51.35 ± 1.75nk	44.27 ± 1.9mn	43.32 ± 1.54mn
Manganese (mg/kg)	489.7 ± 1.7gh	189 ± 1.8jk	190.3 ± 1.3jk
Iron (mg/kg)	1823.4 ± 1.8bh	1200.5 ± 2.5hd	1211.9 ± 2.9hd
Zinc (mg/kg)	112.6 ± 1.8x	110.8 ± 1.6y	111.3 ± 2.3y
Copper (mg/kg)	251.5 ± 1.5v	8.7 ± 1.6z	9.8 ± 0.5z

CW = citronella waste.
CD = cowdung.
CW + CD = mixture of citronella waste and cowdung at 5:1 ratio.
Mean values followed by different letters are statistically significant (Pair *t* test $P < 0.05$, two tail).

2.4. Physico-chemical and FTIR analysis

No separate analysis for the compost and vermicompost obtained in two seasonal trials was carried out in this study; instead the vermicompost generated in the two seasonal trials for each treatment were mixed properly for the chemical analysis. For analysis of chemical parameters; the compost, vermicompost, waste materials and cowdung samples were air dried separately in room temperature and ground in stainless steel blender. The samples were analyzed in triplicate and average results were recorded which were reproducible within ±5% error limit. 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 Somme's (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. Sulfuric acid (0.002 N) solution was used for extraction of phosphorus from the sample. 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). Textural properties and water holding capacity (WHC) of bedding soil was determined following the standard methods (Richards, 1954). The Fourier-transform infrared (FT-IR) spectra of the samples were carried out in FTIR spectrophotometer (Bruker Vector 22) following the method given by Gupta and Garg (2009). Sample (5 mg) 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}).