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Composting of cow dung and crop residues using termite mounds as bulking agent

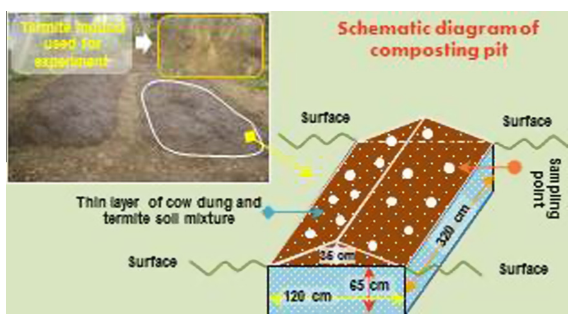
Tanmoy Karak [a,b,*], Indira Sonar [b], Ranjit K. Paul [c], Sampa Das [d], R.K. Boruah [b], Amrit K. Dutta [b], Dilip K. Das [a]

[a] Department of Agricultural Chemistry and Soil Science, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741252, Nadia, West Bengal, India
[b] Upper Assam Advisory Centre, Tea Research Association, Dikom-786101, Assam, India
[c] Indian Agricultural Statistics Research Institute, New Delhi 110012, India
[d] Dibrugarh Polytechnic, Lahowal, Dibrugarh-786010, Assam, India

HIGHLIGHTS

- Composting of crop residues with termite mound is composed and low cost technology.
- Addition of termite mound as composting materials decrease composting time.
- Termite mound addition improves the quality of finished compost.
- Incorporation of termite mound significantly improved NPK in prepared compost.

GRAPHICAL ABSTRACT



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ABSTRACT

The present study reports the suitability of termite mounds as a bulking agent for composting with crop residues and cow dung in pit method. Use of 50 kg termite mound with the crop residues (stover of ground nut: 361.65 kg; soybean: 354.59 kg; potato: 357.67 kg and mustard: 373.19 kg) and cow dung (84.90 kg) formed a good quality compost within 70 days of composting having nitrogen, phosphorus and potassium as 20.19, 3.78 and 32.77 g kg^{-1} respectively with a bulk density of 0.85 g cm^{-3}. Other physico-chemical and germination parameters of the compost were within Indian standard, which had been confirmed by the application of multivariate analysis of variance and multivariate contrast analysis. Principal component analysis was applied in order to gain insight into the characteristic variables. Four composting treatments formed two different groups when hierarchical cluster analysis was applied.

1. Introduction

West Bengal (22°34′0″N, 88°22′0″E), an agriculture-dependent state in eastern India, with its 5.56 million ha of agricultural land is occupying 2.7 per cent of India's total land area. This state targets to bring 20% of the arable land under organic farming. Amongst the districts of West Bengal, Paschim Medinipur (a district situated in the southern point of West Bengal) is quite popular for agricultural production. According to the District Human Development Report (DHDR, 2011), agriculture remains the main stay of economy in Paschim Medinipur and it is ranked 1st, 2nd, 1st and 2nd respectively for ground nut (total production: 38.53 million tons), potato (total production: 2448.13 million tons), soybean (total production: 44.48 million tons) and mustard (total production: 18.12 million tons) production in the state. Amongst the 29 blocks of Paschim Medinipur district, Chandrakona I block (Latitude:

* Corresponding author at: Upper Assam Advisory Centre, Tea Research Association, Dikom-786101, Assam, India. Tel.: +91 9435861567; fax: +91 373 2387556.
E-mail addresses: tanmay.karak@gmail.com, t.karak@tocklai.net (T. Karak).

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22°57′10″N & 21°36′35″S; Longitude: 88°12′40″E & 86°33′50″W; net cultivated area 17,000 ha having sandy soil: 60 ha; loam: 1800 ha; sandy loam: 7940 ha; sandy clay loam: 1200 ha; clay loam: 4000 ha and clay: 2000 ha) is the region having highest agricultural production that contributes 34% of the total production of this district (DHDR, 2011). Due to having undulating topography and laterite soil (about 400 ha) it is not so suitable for large-scale common crop cultivation, but is suitable for cashew nut (*Anacardium occidentale* L.) cultivation. Cashew nut is a high priced popular dry fruit throughout the world but this crop is commonly known as "poor man's crop, rich man's food" (Mohod et al., 2010). Present status of total NPK fertilizer application in this block is about 120,000 matric tons per year. Farmers frequently face serious problem in purchasing costly chemical fertilizers for cashew nut production to reap optimum return (DHDR, 2011). Moreover, growers have highly variable flows of incomes and expenditures coupled with the seasonal nature of agricultural activities. For small farmers with little capital, therefore, the availability of fund plays the most crucial role that is required for buying more marketed inputs (e.g., chemical fertilizers) to smoothly manage the production and sometimes for investing in infrastructure (e.g., digging wells) that normally becomes beyond their capability (DHDR, 2011). As a result, growers are bound to find their own ways using this sort of *age-old composting* technique to obtain optimum return. But this survey and available literature reveal that availability of cow-dung, a traditional raw material is threatened by its alternative use as fuel (Nisanka et al., 1992). On the other hand other organic raw materials such as crop residues and green manure are rapidly declining due to their use as fuel and fodder too (Gottumukkala et al., 2013). Therefore, it is of paramount importance to find out alternative cost-saving materials having no other uses in daily life. Use of selected agricultural residues such as stovers of groundnut (*Arachis hypogaea* L), soybean (*Glycine max* (L.) Merr.), potato (*Solanum tuberosum* L.) and mustard (*Brassica juncea* L.) can be of use as composting materials, as these residues have no direct available economical uses. Karak et al. (2013a) reveal that use of potato and mustard stovers along with pond sediment as composting materials can increase nutrient contents in finished compost. As the studied block is under drought prone region and availability of pond sediment is mere difficult, therefore, it is essential to find out alternative source of pond sediment. In that region having abundance of large forests areas, Termite (*Neotermes aburiensis*) mound is very common where termite operates as decomposer, which is also known as "ecosystem engineers" (Dangerfield et al., 1998; Mathew et al., 2013). It is documented that termite mound is rich in different plant nutrients (Semhi et al., 2008; Seymour et al., 2014) and can be safely used for different purposes like use in growing rice paddy cultivation, vegetable beds and charcoal kilns (Miyagawa et al., 2011). Termite mound due to its higher density can be used as a bulking agent to speed up composting of agricultural waste as well as to enhance density of the matured compost. Cashew growers need an enormous amount of compost right from the starting of cultivation to the optimum production period (30–40 years) with balanced plant nutrients. In view of the time requirement for compost maturity and cost benefit analysis, preparation and application of compost is mostly considered as a time consuming and non-profitable business by the rural farming community in West Bengal, which again involves high cost on transporting to field without immediate cash returns. In order to overcome these disadvantages, it is essential to improve the quality of compost, especially in relation to N and K contents. Sewage sludge and municipal solid waste can be used as bulking agent but presence of heavy metals in these materials increases chance of significant accumulation of heavy metals in soils and plants treated with such compost. This limits the use of such bulking agents for preparation of compost in India (Karak et al., 2012, 2013a,b). As composts prepared from different organic wastes differ in their quality and maturity period, measures adopted during compost production should ensure optimum physico-chemical properties, adequate degree of stability and the desired level of maturity. Maturity and stability indicators used in this composting study include physical parameters like temperature, volume reduction and bulk density, chemical parameters like pH, electrical conductivity (EC), total organic carbon (TOC), oxidisable carbon (OXC), water-soluble carbon (WSC), total nitrogen (TN), NO_3^--N, NH_4^+-N, total potassium (K), total phosphorus (P), heavy metals (e.g., Cr, Cd, Ni and Pb) and bio-assays such as germination index (Karak et al., 2013a). Furthermore, assessment of compost quality produced from easily available bio-waste in and around tea garden by physico-chemical, phytotoxicity and exploratory data analysis is reported (Karak et al., 2014). However, there is no information available on changes occurring to these parameters during composting of agricultural waste blended with termite mound.

Therefore, the working hypothesis of this present study is that, co-composting of a freely available agricultural waste mixture with termite mound may result in production of a compost well fulfilling Indian standard prescribed by Fertilizer Control Order of India (FCOI, 1989). Therefore, the present paper sets out the objective to evaluate and compare the performances of different agricultural waste mixtures and cow dung with termite mound (using pit composting method), by assessing the changes in different physico-chemical properties and bioassay of the composting feeds during composting and at maturation in the light of statistical approach.

2. Methods

2.1. Feed stock used in composting, treatments and experimental set-up

Groundnut (*Arachis hypogaea* L), soybean (*Glycine max* (L.) Merr.), potato (*Solanum tuberosum* L.) and mustard (*Brassica juncea* L.) plants were harvested from the agricultural fields located at Chandrakona 1 block of Paschim Medinipur, West Bengal, India. The whole plants, including the roots were chopped in 1.5–2 cm pieces after removing pods (for groundnut), seeds (for soybean and mustard) and tuber (for potato). Four composting modes (each mode was a combination of pit i.e. below ground + windrow i.e. above ground composting piles) with three replications were prepared for this study. All sets of experiments were conducted at the below and above-ground closed-heap composting process. Therefore, the composting pile was a combination of a rectanguloid (below ground) and a triangular prism (upper ground). The dimensions of below ground pit were 3.20 m × 1.20 m × 0.65 m (length × *breadth* × depth) and the dimensions of the above ground heap were triangular prism with the dimension 3.20 m × 1.20 m × 0.35 m (length × base × height). For all pits, polythene sheet of 100 gauge was placed at the base as well as in the wall of the pit to prevent leaching. Total volume of composting pit was 3.2 m^3 and composting was done during the month of December–February, 2011. Details of pit composition were as follows:

Pit 1 (Control): Weight (kg) ratio – ground nut:soybean:potato:mustard:cow dung:Termite mound:: 361.65:354.59:357.67:373.19:84.90:0; Pit 2: Weight (kg) ratio – ground nut:soybean:potato:mustard:cow-dung:Termite mound:: 361.65:354.59:357.67:373.19:84.90:20; Pit 3: Weight (kg) ratio – ground nut:soybean:potato:mustard:cow-dung:Termite mound:: 361.65:354.59:357.67:373.19:84.90:50; Pit 4: Weight (kg) ratio – ground nut:soybean:potato:mustard:cow-dung:Termite mound:: 361.65:354.59:357.67:373.19:84.90:100. The composting feeds were mixed with pond water and moisture was adjusted to 60% of water holding capacity, as it was considered optimal for biological activity during composting (Karak et al., 2014). To regulate the optimum moisture