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Short communication

Effect of vermicomposting on treated hard stem leftover wastes from pruning of tea plantation: A novel approach

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ABSTRACT

Pruning of tea (*Camellia sinensis* L.) bushes (plants) generates tonnes of plant biomass in each tea garden; however, the hard nature of stems present in pruning litters limits its use in agriculture as an organic amendment. The pruning litters contain more than 1% total nitrogen (N) and the objective of this study was to evaluate the possibility of recycling prunings of tea gardens to nutrient-rich soil amendment through vermicomposting and to modify the vermicomposting technique for replacing the addition of cattle manure with partially decomposed plant (easily available weeds or wastes) residues. In this study, mixing of cattle manure with shredded prunings decreased the rate of vermicomposting and the completion of vermicomposting required one month (30 days) more than the time required for vermicomposting of chopped prunings and cattle manure combination. The extra time required for vermicomposting might be attributed to the decomposition of hard prunings in shredded form. Shredding of prunings significantly ($P \leq 0.05$) decreased total organic C content and that in turn significantly ($P \leq 0.05$) increased total concentrations of nitrogen, phosphorus and potassium in the final vermicompost. Enhanced cellulolytic microbial population and cellulase activity might be attributed to the enhanced decomposition of shredded pruning wastes. The study indicated that partially decomposed plant residues like that of guatemala leaves may be used as alternative of cattle manure during vermicomposting of shredded pruning wastes and total concentrations of nitrogen, phosphorus and potassium in those vermicomposts were significantly at par with those prepared from pruning wastes and cattle manure.

1. Introduction

Tea is the most preferred beverage after water and cultivated under humid sub-tropical climatic conditions (Sitienei et al., 2013). In botanical terms, tea (*Camellia sinensis* L.) is an evergreen shrub. To retain its vegetative stage and also for the convenience of plucking young shoots, tea plants (bushes) are periodically pruned (cut from the top) after every 3–4 years (pruning cycle) (Baruah, 1989). Tea gardens are generally spread over wide area (average size two hundred hectares) and pruning generates huge amount of litters consisting of leaves and stems in those gardens (Fig. 1). The amount of pruning litters depends on the age of tea bushes i.e. on plant physiology, nature of pruning and on tea cultivars. Pruning operations are classified as light pruning (5 cm above the last pruning), medium pruning (45–60 cm above the ground) and heavy pruning or rejuvenation pruning (15–45 cm above the ground). Based on the types of prunings, tea pruning litters may contribute 19,845–24,570 kg ha^{-1} during light pruning, 14,175–16,200 kg ha^{-1} for medium pruning and 41,715–60,210 kg ha^{-1} for rejuvenation pruning (Singha, 2016) and stems contribute as much as ~70% of the whole pruning biomass (Mulky and Sharma, 1993). Those stems of tea plants are very hard in nature and take more than a year to decompose while left on soil of tea gardens (Supplementary Fig. 1). Overall, those tea prunings contain more than 1% nitrogen (N) and recycling of pruning litters through an easy and cost-effective means could open up an enormous organic matter pool for supplementing organic carbon (C) as well as N in soil.

Vermicomposting is a biochemical process of organic matter degradation through the mutual interactions between earthworms and microorganisms (Tajbakhsh et al., 2011). During vermicomposting, organic substrates are modified in their physicochemical properties and the microbial profiles to facilitate proliferation of beneficial microorganisms, which improves chemical and biochemical properties of the final product (Domínguez et al., 2010). Vermicompost has better physical properties, higher nutrient contents in ionic forms and humic substrate contents and rich in

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Fig. 1. Tea bushes were pruned and pruning litters (both leaves and stems) were left on the field for decomposition (average height and average diameter of a pruned tea bushes having physical appearance as these).

bioactive substrates as compared to the initial organic material (Venkatesh and Eevera, 2008; Sinha et al., 2010).

Though vermicomposting is an eco-friendly process for recycling most of the organic wastes; the standard vermicomposting method was not effective to degrade tea pruning wastes. Previously, an attempt was made in experimental farm of Tocklai Tea Research Institute, Jorhat, Assam, India to decompose pruning wastes (both leaves and stems) and cattle manure combination (1:1 proportion) through vermicomposting. However, after five (5) months, vermicomposting experiment leads to the decomposition of cattle manure and leaves portion only leaving stems almost unchanged (Supplementary Fig. 2). Therefore, earthworms possibly could not degrade and ingest hard stems and that in turn limited decomposition of those stems during vermicomposting. Safique et al. (2015) observed that incubation of hard pruning stems in shredded form improved chemical properties in soil due to their decomposition within 4 month study period. The hypothesis of this study was that shredding enhances microbial activity by enormously increasing surface area of pruning wastes and that in turn might enhance the rate of its decomposition. The aim of this study was to recycle the whole pruning wastes through vermicomposting i.e. to make the hard stem portion of pruning wastes palatable to earthworms.

The activity of microorganism-originated cellulase enzyme changes at different stages of vermicomposting (Pramanik, 2010a) and external inoculation of cellulolytic microorganisms with organic substrates improves nutrient status and microbial properties of final vermicompost (Pramanik, 2010b). During vermicomposting, cattle manure is mixed with organic wastes for enhancing activity of microorganisms especially of cellulolytic group and also for providing favourable environment to the earthworms (Lalander et al., 2015). Pramanik (2010a) observed that partial decomposition of organic substrates before vermicomposting enhanced the rate of vermicomposting by hastening the activity of cellulolytic microorganisms. In this study, an attempt was made to recycle prunings in the shredded form through vermicomposting. Partially decomposed plant residues or garden wastes (in this study, guatemala grass) was tried as an alternative of initial cattle manure mixing with organic substrates. Guatemala grass (*Tripsacum andersonii*) is a weed in humid sub-tropical regions (Randolph, 1970) like Northeast India and is specially grown in tea gardens as nitrogen (N)-rich green manure. This guatemala may be replaced by any similar type plant residues for making partially decomposed organic substrates. The objectives of this study was to evaluate the possibility of recycling prunings of tea gardes to nutrient-rich soil amendment through vermicomposting and to modify the vermicomposting technique for replacing the addition of cattle manure with partially decomposed plant (easily available weeds or wastes) residues.

Table 1
Some chemical properties of initial organic substrates used for vermicomposting.

Parameters	Pruning litters	Cattle manure	Guatemala leaves
Total organic C (mg g^{-1})	416.7 ± 23.0	249.1 ± 16.7	317.4 ± 28.7
Total N (mg g^{-1})	16.1 ± 3.7	6.1 ± 0.9	8.8 ± 1.0
C/N ratio	25.9	40.8	36.1
Total P (mg g^{-1})	5.3 ± 0.8	6.7 ± 0.4	5.9 ± 0.4
Total K (mg g^{-1})	8.4 ± 1.5	4.9 ± 0.3	6.3 ± 0.5

2. Materials and methods

2.1. Materials used and experimental set up

A vermicomposting experiment was setup in the vermicomposting unit of Tocklai Tea Research Institute (TTRI), Jorhat, Assam, India to evaluate the suitability of tested method for recycling pruning wastes. Pruning wastes were collected from the experimental tea garden of TTRI and dried in the sunshine for three (3) days. The dried pruning wastes will be referred as 'prunings' hereafter. One portion of the prunings was chopped into ≥5 cm pieces, while other portion was shredded or ground mechanically (less than 5 mm size). During this study, cattle manure, collected from nearby dairy farm, was air-dried and mixed with both chopped (T_1) and shredded (T_2) prunings (prunings: manure = 4:1, w/w basis). Freshly cut guatemala leaves were chopped and dipped into sufficient amount of tap water (leaves: water = 1: 5, w/v basis) for decomposition. Some chemical properties of cattle manure, prunings and guatemala leaves were presented in Table 1. After fifteen (15) days, the partially decomposed guatemala leaves were mixed with shredded (T_3) prunings (prunings: manure = 4:1, w/w basis) for vermicomposting. Five kilogram of all three (3) treatments was kept in three replications in a suitable size earthen pot and vermi-