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Delayed nutrient application affects mineralisation rate during composting of plant residues

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Abstract

The hypothesis that delayed addition of nutrient rich material to compost would influence the mineralisation pattern was investigated by studying N turnover in compost based on wheat straw and clover-grass hay. After $7\frac{1}{2}$ weeks of composting almost twice as much N was mineralised when the addition of some of the N-rich clover-grass hay was postponed, suggesting that this influenced the microbial succession. The delayed addition resulted in a second temperature peak and a decline in the pH. Despite the altered conditions no significant effect was observed on the weight loss or loss of C and N. In conclusion, compost processes can in a simple way be affected by delayed substrate application leading to a higher nutrient availability without altering other parameters significantly.

Keywords: Composting; Nitrogen mineralisation; Growing medium; Plant residues; Decomposition

1. Introduction

Composting experiments have been performed intensively during the last decades. Primarily the studies have focused on rural and urban wastes, often with the aim of reducing volume and avoiding nutrient losses (Witter and Lopez-Real, 1988; Martins and Dewes, 1992; Sánchez-Monedero et al., 2001). More recently, the focus has also been on composting of plant residues to produce growing media (Jensen et al., 2001; Prasad and Maher, 2001; Garcia-Gomez et al., 2002). Major topics in composting research have been process control and characterisation of maturity or stability criteria. Control of a composting process and the properties of the end product can be achieved by at least two different strategies. One strategy is to adjust process parameters, such as moisture level, temperature or oxygen content (Beck-Friis et al., 2001; Smårs et al., 2002). Another is to alter the starting conditions by changing the composition or type of material used so that C/N ratio or fibre composition is changed (Eklind and Kirchmann, 2000a,b; Eiland et al., 2001). A third strategy, which to our knowledge has not yet been subject to experiments, is to influence the composting process by altering the time of addition of parts of the material to be composted; normally all the material to be composted is included right from the start.

Nitrogen has often been recognised as a limiting factor for microbial growth and activity during the decomposition of plant residues (Recous et al., 1995), especially in materials with a high C/N ratio such as wheat straw. However, experiments on the effect of additional N supply on the decomposition of plant residues showed different results, ranging from positive to negative effects on the decomposition rate (Fog, 1988). Resource quality, microclimatic conditions and decomposer efficiency are major factors regulating

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composition and activity of decomposer communities and hence the process of decomposition and nutrient release (Neely et al., 1991; Ågren et al., 2001). Thus, the effect of added N on decomposition may depend on the plant material as degradation is influenced by nutrient content and anatomical structure of the material. Parameters such as N source and the time scale of the decomposition process also influence the effect of added N.

Recous et al. (1995) found that the ratio of N immobilised to C mineralised decreased with time, and suggested that there was a high N demand during the first stages of decomposition when soluble and easily degradable C compounds were mineralised, while the N demand was lower when the more recalcitrant C compounds were decomposed.

Since much C from plant residues such as straw materials is only slowly available to microorganisms, leading to low growth efficiency, a limited amount of N may be required during decomposition, and recycling of N may then be adequate to meet the N requirements (Bremer et al., 1991). Microorganisms, especially fungi, have a considerable capacity to adapt to N deficient conditions. A large amount of N initially could consequently result in immobilisation. This greater N immobilisation may depend on (1) synthesis of microbial biomass with a lower C/N ratio; (2) higher N losses; or (3) reduced N mineralisation or re-mineralisation, which may have been related to reduced microbial activity (Bremer et al., 1991).

When composting material with the purpose of creating a growing medium it is important to understand the mineralisation and immobilisation processes, as nutrient release is controlling plant growth. Availability of nutrients from organic composts is often limited despite a high initial nutrient input, and considerable nutrient losses frequently occur during the composting period, primarily due to gaseous emissions. As nutrients are a limited resource in organic production a more efficient nutrient use is desirable. Many horticultural plants are very nutrient demanding and compost used as fertiliser should provide a high nutrient level from the start. It was hypothesised that such high efficiency composts could be prepared by splitting the addition of the nutrient rich material during the composting process. The first addition at the start of the composting process should be sufficient to support the turnover of the readily available carbohydrates. The remaining nutrient rich material should be added later in the process when the turnover of the wheat straw would already be proceeding. Decomposition of the newly added material would then result in less N immobilisation compared to compost produced by a single addition at the beginning of the process.

The objective of this study was to test this hypothesis, by comparing turnover and N release in composts prepared in the above mentioned way with composts prepared with all the material present initially.

2. Methods

2.1. Experimental design and materials

Compost was made of wheat straw as structural component and clover-grass hay as a nutrient rich component. The wheat straw was air dried after harvest, whereas the clover-grass hay was shredded into pieces of <20 mm and oven dried after harvest. Total C and N of the materials were determined, the wheat straw having a C/N ratio of approximately 100 kg/kg and the clover-grass hay a C/N ratio of 15 kg/kg. Initial C/N ratio of the composts was calculated based on the amount of organic material and the total C and N content of the materials.

Two experiments were set up as summarised in Table 1. Experiment I had three different treatments with three replicates in each. Treatment 1 was a mixture of clover-grass hay and wheat straw giving a C/N ratio of 25. Treatment 2 had only one third of the clover-grass hay from the beginning and thus an initial C/N ratio of 38. Treatment 3 had even less, only one sixth of the clover-grass hay initially, which resulted in a C/N ratio of 50. After three weeks of composting, when temperature

Table 1
The setup for experiments I and II including amounts of material added to each compost box in the different treatments, and the initial C/N mass ratios and water contents of the mixtures

	Wheat straw (kg)	Clover-grass initial (kg)	Clover-grass 3 weeks (kg)	C/N	Water (%)
Experiment I					
Treatment 1: all material present initially	32	48	0	25	78
Treatment 2: 1/3 clover-grass initially, 2/3 after 3 weeks	32	16	32	38	79
Treatment 3: 1/6 clover-grass initially, 5/6 after 3 weeks	32	8	40	50	77
Experiment II					
Treatment 1: all material present initially	35.5	21.5	0	35	54
Treatment 2: 1/4 clover-grass initially, 3/4 after 3 weeks	35.5	5.5	16	60	52