Ecological Engineering 82 (2015) 252–257

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Short communication

Nitrogen addition alters carbon and nitrogen dynamics during decay of different quality residues

Chunming Jiang *, Wantai Yu **, Qiang Ma, Yonggang Xu, Hua Zhou

State Key Laboratory of Forest and Soil Ecology, Soil Nutrients Recycling Group, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110016, PR China

ARTICLE INFO

Article history:
Received 13 November 2014
Received in revised form 31 March 2015
Accepted 28 April 2015
Available online 16 May 2015

Keywords:
Residue decomposition
Added nitrogen effect
Carbon and nitrogen dynamics
Stable isotope signature

ABSTRACT

With the increasing of anthropogenic nitrogen (N) deposition, understanding the underlying mechanisms of external N effect on residue decomposition is critical to improving our prediction of the ecosystem carbon (C) sequestration. An experiment of decay subjected to N addition was conducted by 360 days incubation under laboratory condition, using leaf residues collected from Chinese fir (*Cuninghamia lanceolata*) (*Cl*) and eucalyptus (*Eucalyptus urophylla*) (*Eu*). Decay of needle leaf (*Cl*) was slower and more limited by N than broadleaf (*Eu*). Added N significantly accelerated initial decay, and then the N effect tended to be negative. The switched time point coincided with the C concentration peak, implying C quality might affect the external N impacts. More importantly, our results, together with previous decay studies using multiple residues, illuminated that both the positive and negative N effects became evident as residue quality tended to be low. We supposed that this phenomenon might be attributed to the fact that the specific microbe (fungi, which possessed higher N and C use efficiency than bacteria) gradually exerted a more dominant role in decay with the residue quality varying from high to low, and this shape of microbe would mediate the N impacts. For the isotope signatures, the supplied N caused elevated residue ^{15}N in the early stage, and the increased magnitude was much greater for the hardly-degradable residue (*Cl*). These ^{15}N dynamics patterns revealed enhanced initial microorganism activity by added N, and also probably confirmed the microbe-mediated effect we presumed. Overall, our research delivered very helpful implications for nutrient management and ecosystem restoration under heightened N scenario in the future.

1. Introduction

Nitrogen (N) deposition has been sharply increasing for the past century due to the intensification of human activities (Galloway et al., 2004; Hobbie, 2008), which would impact carbon (C) and N cycling of terrestrial ecosystems (Jiang et al., 2010). Decomposition of plant residue is a key link of ecosystem C and N cycles, not only affecting the nutrient availability to plants and microbes but also C sequestration of terrestrial ecosystems (Balasubramanian et al., 2012; Jauregui et al., 2013; Pu et al., 2014). Since residue decomposition is generally limited by N availability, the impacts of external N have been causing great concerns and numerous studies have been conducted. Knorr et al. (2005) synthesized previous researches and summarize that the N effect on decomposition could be stimulatory, neutral, or even negative. The general conclusion in this meta-analysis was that added N could promote initial decay, and in the subsequent stage (when recalcitrant substrates had been accumulated), the decomposition was decelerated by the external N. For residues with contrasting qualities, the altered degree of decay by N remained controversial. Hobbie (2008) and Mo et al. (2008) believed that the stimulating effect and depressing effect of N were both more pronounced for high-quality residue. However, some other experiments supported the inverse patterns (Vestgarden, 2001; Perakis et al., 2012). These intriguing results urged us to establish a generic relationship between the residue qualities and their responses to N addition, then to explore the underlying mechanisms.

Microorganisms exerted a major role in residue decay. On the other hand, the decomposers were also shaped by the residue to adapt its initial quality (Sariyildiz and Anderson, 2003a,b). It had been widely accepted that fungi rather than bacteria gradually became the fundamental decomposer with the residue quality being poor (Grigulis et al., 2013). Whether such differentiation of decomposer groups contributed to the generic rule of N

* Corresponding author. Tel.: +86 24 8937 0421; fax: +86 24 8397 0366.
** Corresponding author.
E-mail addresses: jchmjchm@163.com (C. Jiang), jchm1980@126.com (W. Yu).

http://dx.doi.org/10.1016/j.ecoleng.2015.04.093
0925-8574/

effects on decay of different quality residues required further analysis. Variation of residue C and N stable isotopes during decay was partly attributed to preferential microbial use of light isotopes (Connin et al., 2001; Fernandez et al., 2003; Asada et al., 2005), which might help to probe the microbial mechanisms. To date, employing these isotope signatures to reveal the potential microbe mechanisms associated with the N effect on decay has not been done to the best of our knowledge.

Therefore, using two contrasting leaf materials, we conducted a decay experiment subjected to N addition. Firstly, we characterized and compared the C and N dynamics of the two leaf materials. Then combining our data set with others, we tried to synthesize the generic rule of N effect on decay of different quality residues and to elucidate potential mechanism about microbial mediation. Lastly, we evaluated the feasibility whether the dynamics of C or N stable isotope could capture this mechanism.

2. Materials and methods

2.1. Experimental material collection and laboratory incubation

The plant leaf and soil employed for this study were collected from "Gaofeng" forest farm in Guangxi Province, Southwest China (108°22′E, 22°58′N, 150 m above sea level). Leaf materials of two species were selected: needles of Chinese fir (*Cuninghamia lanceolata*) (*Cl*) vs. leaves of eucalyptus (*Eucalyptus urophylla*) (*Eu*). Plant residue decomposition was carried out using a modified laboratory incubation method similar to that described by Ganjegunte et al. (2005). Details of experimental procedure are provided in the Supplementary material.

2.2. Sampling and chemical analysis

Three replication samples per species of one treatment were randomly collected after 30, 60, 90, 180 and 360 days incubation. After soil particles were carefully removed, the leaf detritus was dried to a constant weight at 60 °C, and then was weighed. Each leaf sample was finely ground in a Wiley mill to pass a 60-mesh screen for later analysis. The three replications were separately analyzed and the values were averaged for each species in one treatment.

Total N and C concentrations were determined by an elemental analyzer (VariEL III, Elementar, Germany). The remaining of C or N mass was all exhibited as a percentage of initial mass. The abundance of ^{13}C and ^{15}N were analyzed using an isotopic mass spectrometer coupled with an elemental analyzer (Delta Plus, Finnigan-Matt, Germany). The analytical precision of the ^{15}N and ^{13}C measurements were 0.23‰ and 0.15‰, respectively (per mille (‰) indicated changes relative to the international standard (atmospheric N or VPDB)), when the samples were determined. In order to more clearly compare between the two residues and reveal the reasons of isotope discrimination, the ^{13}C and ^{15}N values in figures were all expressed as relative values (normalized by the corresponding initial values): relative value (%) = $(R_{sample}-R_{initial})/R_{initial} \times 100\%$, where R_{sample} and $R_{initial}$ referred to the $^{13}C/^{12}C$ or $^{15}N/^{14}N$ ratios of sample and the corresponding initial residue, respectively.

2.3. Calculation and data analysis

The double exponential model was employed to describe the C decay. The model was: $\text{percentCmassremaining} = Ae^{-k_1 t} + (1-A)e^{-k_2 t}$. Where A and $(1-A)$ are the fractions of labile and

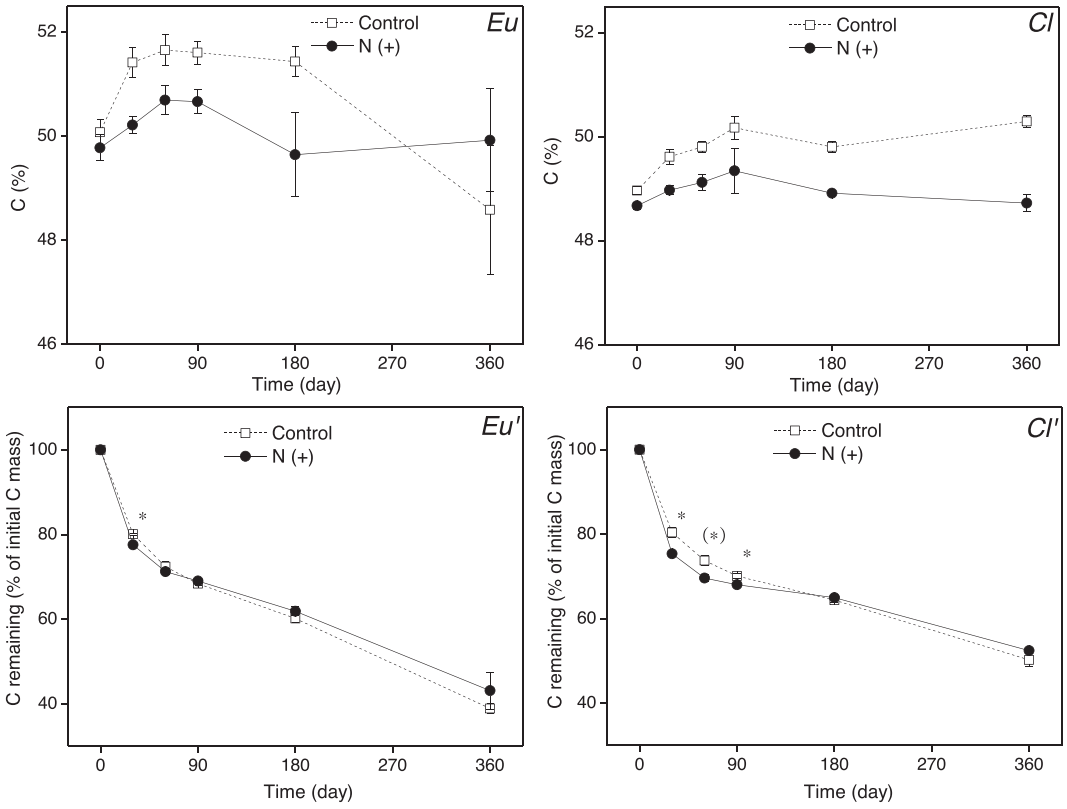

Fig. 1. C concentration (%) and percent of C remaining (% of initial C mass) during degradation of two leaf materials, *Eucalyptus urophylla* (*Eu*) and *Cuninghamia lanceolata* (*Cl*) as affected by added N. The asterisk in the figures of C remaining denoted significant difference between control and added N treatment ((*)$P < 0.10$; *$P < 0.05$). A superscript was used to distinguish the two variables. Error bars indicated 1SE ($n = 3$). The same below.