Forest Ecology and Management 429 (2018) 77–83

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Effects of litter manipulation on soil respiration under short-term nitrogen addition in a subtropical evergreen forest

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ARTICLE INFO

Keywords:
Nitrogen deposition
Litter alteration
Subtropical forest
Carbon sequestration

ABSTRACT

Nitrogen (N) availability is rapidly increasing in subtropical ecosystems, where litterfall is also accelerating and may substantially affect belowground carbon (C) storage and soil respiration (R_s). This study aims to detect how litter inputs affect R_s under N addition in a subtropical forest. We conducted a two-factor experiment (N addition and litter manipulation) in a subtropical *Schima superba* evergreen broad-leaved forest in eastern China. Three levels of N addition included low-N (50 kg N ha^{-1} yr^{-1}), high-N (100 kg N ha^{-1} yr^{-1}) and ambient N (0 kg N ha^{-1} yr^{-1}), and three levels of litter manipulation consisting of litter removal (NL), litter addition (DL) and Control litter input were conducted. Our results showed NL decreased R_s by 41% and 38% under low- and high-N additions, respectively, compared to Control litter input. DL decreased R_s by 24% compared to Control litter input under high-N addition. Furthermore, low- and high-N additions decreased the effect size of NL on R_s, whereas high-N addition decreased the effect size of DL on R_s in the study period, in both rainy and dry seasons. The effect of litter input alteration on R_s under N addition decreased, compared to R_s in Control litter input under N addition. Thus, the increase in R_s under N addition was alleviated, suggesting that soil organic C sequestration may benefit from increasing N deposition in the future. Further study is needed to clarify the effects of litter input alteration on R_s and soil C cycling under long-term N addition in subtropical forests.

1. Introduction

Globally, soil is currently the largest carbon (C) pool in terrestrial ecosystems, and stores more organic C than plants and the atmosphere (IPCC, 2007). Soil respiration (R_s), as the second largest carbon dioxide (CO_2) efflux from terrestrial ecosystems to the atmosphere (Luo and Zhou, 2006; Wang and Yang, 2007), is the primary pathway for soil CO_2 emission from terrestrial ecosystems to the atmosphere (Bond-Lamberty and Thomson, 2010a). Meanwhile, R_s plays an important role in regulating C sequestration in soils and C cycling in terrestrial ecosystems (Lal, 2004), and even a subtle change in R_s altered by global change could significantly affect the global C cycle and the consequent feedbacks to global changes (Davidson and Janssens, 2006). Therefore, understanding the responses of R_s to global changes is urgently needed for accurately evaluating the C balance and climate-C feedbacks.

Human activity (e.g., fossil fuel burning, deforestation, and fertilizer consumption) has doubled reactive nitrogen (N) deposition since the industrial and agricultural revolution (Galloway et al., 2008; Gruber and Galloway, 2008). And, the widespread N deposition is continuing to alter global and regional environments and has affected R_s in forest ecosystems (Aerts and Chapin, 1999; Tian et al., 2017). However, the response of R_s to N addition is inconsistent (Tian et al., 2017), with increases (Craine et al., 2001; Hasselquist et al., 2012), decreases (Phillips and Fahey, 2007; Janssens et al., 2010), and no change (Lee and Jose, 2003; Samuelson et al., 2009) being reported previously. Although there is an emerging consensus that N addition reduces R_s in temperate forests (Janssens et al., 2010), the responses of R_s to N addition in subtropical forests are still not fully understood (Bond-Lamberty and Thomson, 2010b; Fan et al., 2014; Yan et al., 2017). There were conflicting results of N addition on R_s in subtropical forests. For instance, previous studies have reported negative response of R_s to N fertilization in N saturated subtropical forests (Mo et al., 2008; Yan et al., 2017), whereas positive response (Tu et al., 2013) and no response (Koehler et al., 2009) also have been found in subtropical

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https://doi.org/10.1016/j.foreco.2018.06.037
Received 6 June 2018; Received in revised form 24 June 2018; Accepted 26 June 2018
0378-1127/

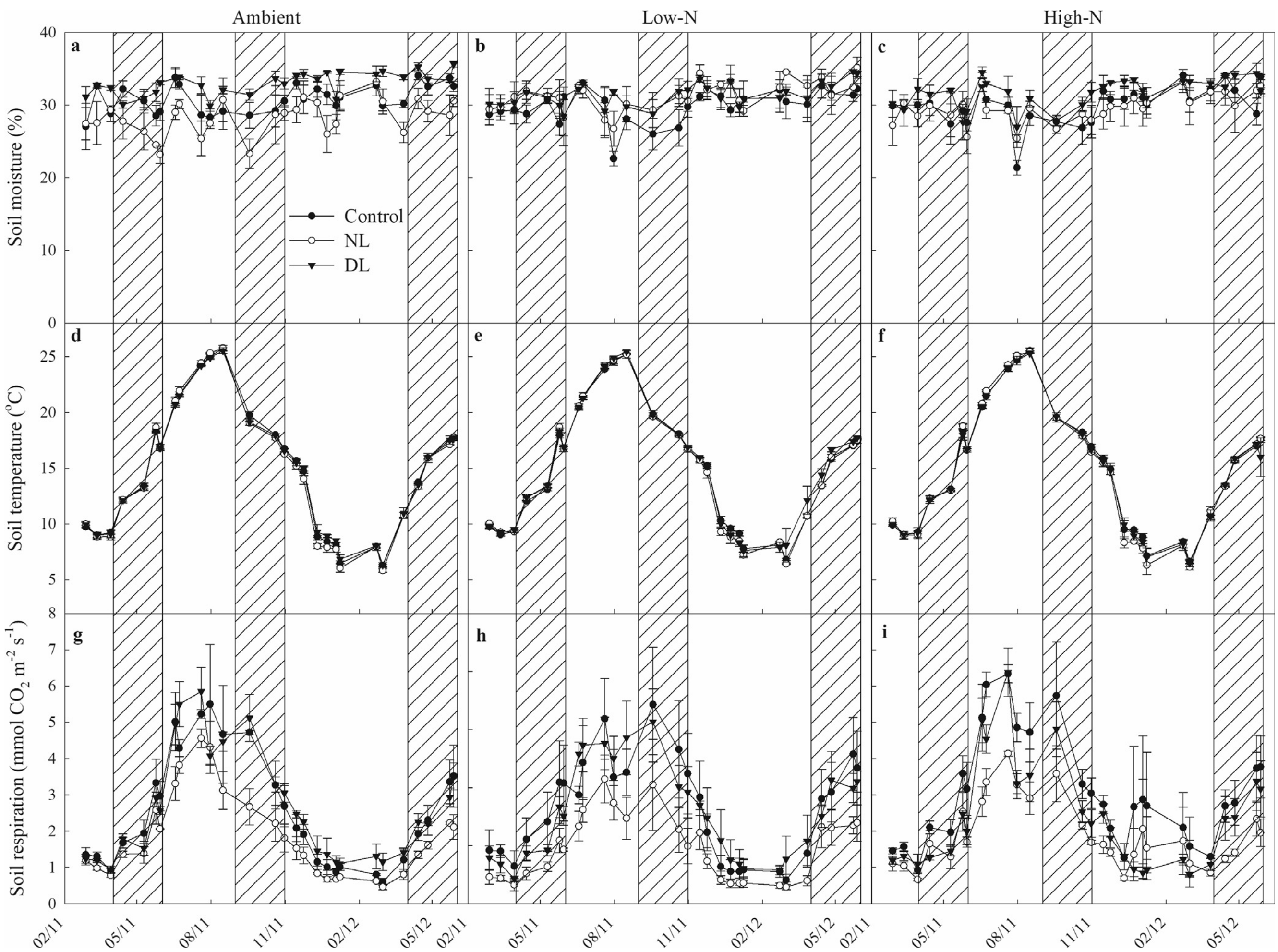

Fig. 1. Seasonal dynamics of average soil temperature (a, b, c), soil moisture (d, e, f) and R_s (g, h, i) under different N additions and litter manipulation in a subtropical *Schima superba* forest in eastern China. N additions included ambient N addition of 0 kg N ha^{-1} yr^{-1}, low-N addition of 50 kg N ha^{-1} yr^{-1}, and high-N addition of 100 kg N ha^{-1} yr^{-1}. Litter manipulation included Control litter input, NL (no-litter) and DL (double litter) in each N addition plot. Hatched areas correspond to the rainy season (April-June and September – November). Data point represents the mean ± SE (N = 3).

Table 1
Statistical results of three-way ANOVA followed by *post hoc* tests of N addition, litter manipulation and season on soil temperature, soil moisture and R_s in a subtropical *Schima superba* forest in eastern China. Bold indicates that $P < 0.05$.

	R_s (μmol m^{-2} s^{-1})		Soil moisture (%)		Soil temperature (°C)	
	F	*P*	*F*	*P*	*F*	*P*
N addition (N)	2.252	0.107	0.857	0.426	0.035	0.966
Season (S)	35.734	**< 0.001**	3.727	0.055	42.713	**< 0.001**
Litter (L)	13.703	**< 0.001**	26.262	**< 0.001**	0.023	0.977
N × S	1.769	0.173	1.318	0.270	0.016	0.984
N × L	1.142	0.337	9.630	**< 0.001**	0.007	1.000
S × L	1.314	0.271	0.565	0.569	0.010	0.990
N × S × L	0.165	0.956	0.453	0.770	0.003	1.000

forests.

Meanwhile, the increase in N availability, combining with increasing atmospheric CO_2, usually stimulate forest aboveground net primary production (NPP) and change litter inputs to soils (LeBauer and Treseder, 2008; Xia and Wan, 2008), therefore potentially impacting R_s through directly altering litter quality and quantity (Liu et al., 2005), changing physiochemical and biological properties of litter layer (Xu et al., 2013), and indirectly affecting both root activity and microbial communities (Ryan and Law, 2005; Sayer, 2006). Although litter manipulation experiments have been widely conducted (Xu et al., 2013; Chen and Chen, 2018) to examine the potential effects of changes in plant-derived C inputs on belowground C cycling (e.g., Lajtha et al., 2005; Vincent et al., 2010; Feng et al., 2011; Leff et al., 2012), there still remains a knowledge gap on the magnitude and direction of R_s to litter input alteration among different forest ecosystems (Xu et al., 2013; Chen and Chen, 2018). Especially, the effects in subtropical forests could be quite different from those in temperate forests (Sayer et al., 2007; Leff et al., 2012; Fang et al., 2015; Han et al., 2015). Numerous studies suggest that litter input alteration generally exerts nonlinear effects on R_s (Sayer et al., 2011; van Groenigen et al., 2014), with disproportionate enhances in R_s under litter addition due to the priming effects (Nottingham et al., 2009; Kuzyakov, 2010) and decreases in R_s