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Nitrogen addition enhances home-field advantage during litter decomposition in subtropical forest plantations

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Nitrogen (N) exerts strong effects on litter decomposition through altering microbial abundance and community composition. However, the effect of N addition on plant–soil interactions such as home-field advantage (HFA: enhanced decomposition at a home environment compared to a guest environment) in relation to litter decomposition remains unclear. To fill this knowledge gap, we conducted a reciprocal litter transplant plus N addition experiment in *Mytilaria laosensis* and *Cunninghamia lanceolata* plantations for two years in subtropical China where anthropogenic N input is amongst the highest in the world. We found positive HFA effects (in which the calculation incorporates litter of both species) with litter mass loss 11.2% faster at home than in the guest environment in the N addition (50 kg N ha^{-1} yr^{-1}) treatment, but no significant HFA effects were found in the control treatment. The magnitude of the HFA effect on carbon (C) release increased with N addition, while that on N release decreased. The HFA effects on phosphorus, potassium, calcium, sodium, and magnesium release were positive overall, but varied through time and the magnitude of the effects were different among elements. The greater HFA effects in the N addition treatment were associated with greater differences in microbial biomass and community composition between home and guest environments than in the control treatment. Our results indicate that anthropogenic N enrichment could lead to enhanced HFA effects, through modification of microbial communities, and thereby affect C sequestration and N cycling in subtropical forests.

1. Introduction

The return of carbon (C) and nutrients to the soil through litter decomposition is a fundamental ecological process closely linked to C sequestration through its effects on soil organic matter formation and turnover (Kramer et al., 2003; Hobara et al., 2013). Litter decomposition is largely affected by environmental conditions (e.g., temperature and precipitation) on a global scale, by litter quality on a local scale (Melillo et al., 1982; Coûteaux et al., 1995; Zhang et al., 2008), and is mediated by soil organisms, nutrient availability and their interactions (Berg and Matzner, 1997; González and Seastedt, 2011; Rinkes et al., 2013). Several recent studies have illustrated that interactions between soil biota and litter quality may have additive effects on litter decomposition (Ayres et al., 2009a). It has also been suggested that litter decomposition responds positively to increased soil nitrogen (N) availability (Norris et al., 2013).

Home-field advantage (HFA) (i.e., litter decomposes faster when placed in its habitat of origin than when placed out of its habitat of origin) has been a salient topic in studies of litter decomposition in recent years (Ayres et al., 2009a; Perez et al., 2013; Chomel et al., 2015; Veen et al., 2015a). Some researchers have proposed that HFA is a previously unrecognized factor in explaining variability in litter decomposition at the global scale (Wang et al., 2012; Veen et al., 2015a). The HFA hypothesis is based on the assumption that decomposer communities are functionally equivalent rather than dissimilar, but specialize in decomposing the plant species above them (Ayres et al., 2009a, 2009b; Keiser et al., 2014). However, although a number of studies have reported positive HFA effects (Kagata and Ohgushi, 2012; Wang et al., 2012; Wallenstein et al., 2013; Austin et al., 2014), studies that have found no or

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negative effects are common. For example, St. John et al. (2011) found no HFA effects in a grassland-forest reciprocal litter transplant study. Perez et al. (2013) found little support for HFA effects in a plant successional gradient from open grasslands to forests. Freschet et al. (2012) reported a continuum from positive to negative interactions between specific litters and decomposer communities, as specific litter and the ecosystem litter layer become increasingly dissimilar in quality. The lack of universal positive HFA effects suggest that the occurrence and magnitude of HFA effects likely vary among ecosystem types, succession stages, plant species and climate zones (Gießelmann et al., 2011; Milcu and Manning, 2011; Makkonen et al., 2012; Austin et al., 2014).

At a given site, HFA effects may also vary at different stages of decomposition (Ayres et al., 2009a), but the mechanisms remain poorly understood as most studies are based on single point in time sampling (Veen et al., 2015a). Moreover, the magnitude or even the occurrence of HFA may be different if different aspects of litter decomposition, such as biomass and nutrient release, are considered because different elements may be immobilized or released at different rates and the rates may change through time (Ayres et al., 2009a; Fujii and Takeda, 2010; Aponte et al., 2012; Wang et al., 2012; Liu et al., 2015). For example, N and phosphorus (P) are often immobilized in early stages and released in later stages, while C is decomposed more rapidly in early stages (Wang et al., 2012). The differences in HFA effects among different elements and decomposition stages have rarely been examined. Thus, although the role of HFA on litter decomposition is widely recognized and supported by many studies, the conditions of its occurrence, its magnitude and interactions with other factors are not well understood (Gießelmann et al., 2011; St. John et al., 2011; Veen et al., 2015a, 2015b).

Nitrogen enrichment from both atmospheric deposition and fertilization is becoming a major environmental issue in regions undergoing rapid industrialization such as China (Liu et al., 2013). Anthropogenic N input could either accelerate or inhibit decomposition through modification of decomposer communities in different decay stages (Berg and Matzner, 1997; Carreiro et al., 2000; Hobbie, 2008; Hobbie et al., 2012). Liu et al. (2015) found that N addition significantly enhanced nutrient release through increased soil microbial biomass and enhanced leaf litter quality. Knorr et al. (2005) reported that the responses to N addition depend on levels of N deposition, fertilization and litter quality. Studies have examined the effects of N additions and HFA on decomposition separately, but the effects of N addition on litter decomposition through its influence on HFA have only been examined in a few studies (Vivanco and Austin, 2011; Allison et al., 2013). In addition, although HFA effects have been examined in a variety of ecosystems, studies from the tropical and subtropical regions are rare (Veen et al., 2015a). More studies on how N affects the occurrence, direction and magnitude of HFA from ecosystems in diverse regions are needed for a thorough understanding of the effects of anthropogenic N enrichment on C and nutrient cycling.

Forest plantations in subtropical China have been recognized as an important C pool at the global scale (Xu, 2011; Huang et al., 2013a). Plantations of *Cunninghamia lanceolata* in subtropical China alone (9.11 million ha) account for approximately 18% and 5% of all forest plantations in China and the world, respectively (Huang et al., 2013b). Because timber production of *C. lanceolata* decreases significantly in consecutive rotations (Wei et al., 2012), plantations of native broadleaved tree species alone or in mixtures with coniferous species are encouraged in China (Xu, 2011). Several studies have compared litter decomposition between different forest types using reciprocal transplant experiments (Yang et al., 2004; Liu et al., 2005; Wang et al., 2008), and some have examined litter decomposition in response to N addition in subtropical China (Mo et al., 2006). One study examined HFA effects in two types of natural forests in central China (Wang et al., 2015) but to our knowledge, no studies have examined HFA effects in forest plantations of China.

We conducted a litter decomposition experiment with reciprocal litter transplant plus N addition treatments in *C. lanceolata* and broadleaved *Mytilaria laosensis* plantations in subtropical China where the atmospheric N deposition rate reaches 30–50 kg N ha^{-1} yr^{-1}. The objectives of this study were to 1) explore the effects of litter quality, habitat (home vs. guest environments) and microbial community composition on decomposition rate and 2) evaluate the effects of N addition on microbial community composition and litter–soil interactions during litter decomposition. Specifically we tested the following hypotheses. First, because the two forests had very different soil properties and litter quality (Huang et al., 2013b) we expected that HFA effects would occur in both *C. lanceolata* and *M. laosensis* forest plantations. Second, because numerous studies have found that low quality recalcitrant litter (Ayres et al., 2009a; Milcu and Manning, 2011; Keiser et al., 2014) is likely to have greater HFA effects than high quality litter, we hypothesized that N addition would improve litter quality (Allison et al., 2013; Liu et al., 2015), and thus decrease HFA effects. Third, because different nutrients/elements are released or immobilized at different rates and the rates vary with time, we hypothesized that HFA effects would differ among elements and change through time.

2. Materials and methods

2.1. Site description

The experiment was conducted at Xiayang, northwestern Fujian Province of southeastern China (26°48′N, 117°58′E) between July 2012 and June 2014. The experimental site is located on a deep red soil classified as a sandy clay loam Ferric Acrisol according to the FAO/UNESCO classification (Huang et al., 2013b). The site is characterized by a humid subtropical climate with short and mild winters (with occasional frost) in January and February, and long, hot and humid summers between June and October. Spring and autumn are warm transitional periods. During the two-year study period, mean annual precipitation was 1747 mm and mean annual temperature was 20 °C. In October 1996, seedlings of *C. lanceolata* and *M. laosensis* were planted on a site where *C. lanceolata* had previously been grown and harvested in April 1995. The 5-ha area was divided equally for the planting of monocultures of the two species. The seedlings were planted at 2 m × 2 m intervals giving a seedling density of 2500 individuals ha^{-1}.

2.2. Experimental design, litterbag preparation and sampling

In June 2012, before N addition, top soil samples (10 cm) were collected from three soil cores in each plot for analyses of the initial soil pH and concentrations of total C, total N, mineral N (NH_4^+–N, NO_3^-–N) and dissolved organic C and N. Soil samples were transported to the laboratory and stored at 4 °C for less than 2 days prior to processing. The moist soils were sieved through 2 mm mesh to remove large pieces of organic debris prior to analysis.

Six 2 m × 2 m plots were established in each of the *M. laosensis* and *C. lanceolata* plantations (Fig. S1). Three of the six plots of each species were randomly assigned as N addition plots which received 50 g N m^{-2} yr^{-1} in the form of granular NH_4NO_3 from the beginning of the study while no N addition was applied to the other three plots. The inorganic N addition was divided into six applications and applied evenly every two months. Each of the six plots was split into two equal parts. In July 2012, fifteen *C. lanceolata* litterbags