Regulation of litter decomposition in bamboo stands

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（竹林におけるリター分解の制御機構）

Category：Kou

Thesis Summary

Litter decomposition is an essential process that regulates the fate of carbon and nutrients in soils through the progressive breakdown of organic matter, and thus is crucial for the functioning of terrestrial ecosystems. In East Asia, bamboo invasion is a serious concern due to its ecological and socio-economic implications, and thus evaluating litter decomposition dynamics in bamboo stands is essential to better assess their impacts in forest ecosystems.

The aim of this thesis is to further our understanding of litter decomposition and nutrient dynamics in bamboo stands and explore the controlling factors regulating litter decomposition processes. The first part of the thesis explored the influence of macroenvironmental, soil and stand structure factors on early-stage litter decomposition and stabilization in bamboo stands at a regional scale. The results showed that climatic factors are the main drivers of decomposition processes in Moso bamboo stands. Long-term climate influences litter stabilization, while the interaction between precipitation and temperature affects litter decomposition rates at early stages. Stand structure and soil properties have limited direct effects, but indirect effects from stand density impact litter stabilization through organic matter input and soil bulk density. These results further suggest that future environmental changes resulting from global climate change would greatly affect decomposition and soil carbon storage in this region.

The second part of the thesis evaluated the interactive effects litter traits and soil fauna on litter decomposition processes of above- and below-ground organs. After two years of litter decomposition, the mass loss followed the order of leaf > fine root > rhizome = branch > culm litter. The results showed that chemical and structural litter traits were predictors of mass and carbon loss but not nitrogen loss. The presence of soil fauna did not change the relationship between litter traits and decomposability, indicating that soil fauna effects were not dependent on litter quality. Soil fauna decreased litter mass and carbon loss of leaf and branch litter, but had limited effects on fine root, rhizome and culm litter decomposition. The large disparities in the contribution of soil fauna to litter decomposition and nutrient release suggest that considering the effects of soil fauna in whole-plant litter decomposition is essential for understanding the role of soil decomposers in bamboo forest carbon cycling.

The third part of the thesis investigated the chemical and morphological controls on below-ground litter decomposition following a root functional order classification. The results highlight the morphological and chemical heterogeneity of fine roots in Hachiku, Madake and Moso bamboo. The analysis of root litter using ^{13}C-NMR spectroscopy revealed differences in the biochemical composition within the branching root system. Notably, slower decomposition rates were observed in lower order roots compared to higher order

roots. The results also revealed the limited predictability of litter C/N and lignin/N ratios on fine root litter decomposition. Furthermore, the recalcitrance of lower order roots was associated with the presence of aromatic compounds, while the rapid decomposition of higher order roots was linked with the presence of labile cellulosic compounds. Given that lower order roots are typically short-lived and represent a significant proportion of the total fine root biomass in bamboo stands, their slower decomposition may have significant effects in soil carbon cycling through the formation of stable soil organic matter.

The fourth part of the thesis explored the influence of fallen bamboos on the forest floor and soil fauna on litter decomposition dynamics and discussed whether the removal of these structural components as part of management practices could potentially affect litter decomposition and nutrient cycling. The results showed that dead culms in Moso bamboo stands play a crucial role in modifying the soil microenvironment, enhancing litter biotic activity and accelerating the loss of litter mass, carbon and nitrogen. The dead culms have a significant impact on mesofauna abundance, diversity and fauna assemblage during litter decomposition. However, the presence of dead culms does not alter the direct effect of soil fauna on litter decomposition, suggesting that their influence is mainly through changes in the soil environment and litter microbial activity. Dead bamboo culms are important structural components that affect decomposer organisms and the litter nutrient dynamics in bamboo stands. These results further show that the removal of dead culms from the forest floor could have substantial effects on soil biota and ecosystem processes in managed stands.

In conclusion, this thesis contributes to the understanding of the interplay among various factors that regulate litter decomposition, and illustrates how climate, litter quality and soil fauna impact decomposition processes in bamboo stands. Moreover, the findings on the indirect impacts of dead culms on nutrient cycling hold practical implications for the management of bamboo stands.