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Decomposition of European beech and Black pine foliar litter along an Alpine elevation gradient: Mass loss and molecular characteristics

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ABSTRACT

Litter decomposition is an important process in global carbon (C) and nutrient cycles. The objective of this study was to evaluate the role of climate on litter decomposition along an altitudinal gradient in a temperate Alpine region, and to characterize the decompositional stages of the litter material with Fourier-transform mid-infrared spectroscopy (FT-MIR). Foliar litter of European beech (*Fagus sylvatica*) and Black pine (*Pinus nigra*) was incubated in litterbags during two years in the Hochschwab massif of the Northern Limestone Alps of Austria. Six incubation sites were selected following an altitudinal/climatic transect from 1900 to 900 meters above sea level (m asl), with soil properties (carbon:nitrogen—C:N ratios and pH) being strongly influenced by vegetation. The results indicated that the climatic gradient played only a secondary role for decomposition rates. First year mass loss of both litter types was positively related to soil C:N ratio, which was the major explanatory variable in multiple regression analysis. For second year mass loss, soil pH appeared to be a determinant factor, while altitude was the least related parameter. The FT-MIR spectra of the remaining litter did not follow typical patterns of decomposing organic matter (OM) in forest litter horizons. A strong increase of most band areas—particularly those at 1515, 1420, 1270, and 1230 cm^{-1}—suggested the accumulation of lignin in the remaining litter. We conclude that the effect of climate on litter mass loss can be offset by differences in soil parameters, possibly through related soil microbial populations.

1. Introduction

Mountain regions cover about one fifth of the earth's continental area but their ecological and economical importance, e.g. regarding water cycle regulation, reaches far beyond their boundaries (Beniston et al., 1997), and their soil organic carbon (SOC) stocks are among the highest in terrestrial biomes (Djukic et al., 2010a). It is predicted that under climate change, mountain areas will experience stronger temperature fluctuations and stronger warming than the global climate (Beniston et al., 1997).

Litter decomposition is a key process in carbon and nutrient cycles which involves (1) humification and mineralization of organic compounds present in the litter and (2) leaching of soluble compounds (Berg and McClaugherty, 2008). The main components of plant fiber structures are lignin (15–40%), which is a complex aromatic polymer, cellulose (10–50%) and hemicelluloses which are polymer carbohydrates, cutin and suberin, tannins, etc. (Berg and McClaugherty, 2008). Litter decomposition is mainly controlled by three factors: (1) physical environment, (2) substrate quality and (3) nature and abundance of decomposer organisms (Coûteaux et al., 1995; Gavazov, 2010). Although the relative importance of these different factors is still a matter of debate and is particularly dependent on the constraining factors in the studied environments (Prescott, 2010), recent research agrees that climate change is not a mere rise in temperatures (Davidson and Janssens, 2006; Gavazov, 2010). Direct and indirect influences of climate change on ecosystem variables such as (1) soil water regimes, i.e. waterlogging or surface drying (Davidson and Janssens, 2006; Gavazov, 2010; Sjögersten and Wookey, 2004), (2) soil insulation through snow cover (Hobbie et al., 2000; Williams et al., 1998), (3) climate driven shifts in species composition and associated litter quality (Cornelissen et al., 2007; Cornwell et al., 2008; Theurillat and Guisan, 2001) have to be accounted for. It is the combination of all these factors that will govern litter decomposition—and as a consequence SOC storage and nutrient dynamics—under future climatic conditions.

Additional to mass loss, several analytical methods are available to characterize chemical changes during the decay of organic matter (OM). Among those methods, Fourier-transformed infrared spectroscopy, which is based on the vibrations of different functional groups at specific wavenumbers is a comparatively fast, inexpensive and

Abbreviations: FT-MIR, Fourier-transform mid-infrared spectroscopy; MAT, mean annual temperature; ML, mass loss (%); ML_1 and ML_2, mass loss during first and second year of decomposition, respectively; OL, original litter (i.e. before incubation); OM, organic matter; SOC, soil organic carbon; SOM, soil organic matter; t_1 and t_2, end of the first and of the second year of decomposition, respectively.

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