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Editorial Open Access

Biochemical and Environmental Controls of Litter Decomposition

Temel Sariyildiz*

Department of Forest Engineering, University of Kastamonu, Turkey

***Corresponding author:** *Temel Sariyildiz, Faculty of Forestry, Department of Forest Engineering, University of Kastamonu, Turkey, Tel: +90-366-280-1701; E-mail: tsariyildiz@kastamonu.edu.tr*

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Editorial

Concerns over the potential effects of increased atmospheric CO_2 have spurred research on topics as different in scale and process as plant leaf/litter quality and litter decomposition, global climatology and forest carbon storage. Atmospheric CO_2 concentration increased by about 9% between 1971 and 1990 and will probably have doubled by the end of the 21st century, mainly due to man-made emissions. This increase results in global climatic warming considered by the Rio summit in 1992 to be dangerous. The capacity of terrestrial ecosystems to act as carbon sinks could partly compensate for the increase in atmospheric CO_2 concentrations. Forest ecosystems only cover 30% of the land areas, but contain 81% of the terrestrial carbon biomass. In addition, forests accumulate 20 to 100 times as much carbon per unit area as agricultural land and are 20 times more productive than grassland. The need for an accurate inventory of carbon stocks and the capacity of forest to accumulate carbon was emphasized at the Helsinki (1993) and Kyoto (1997) conferences.

Decomposition is central to ecosystem functionality and recent studies have shown that decomposition in forest ecosystems contribute significantly to global carbon studies [1]. Plant litter decomposition has long been recognized as an essential process for nutrient cycling and organic matter turnover within ecosystems that are important determinants of plant productivity and ecosystem carbon (C) storage [2]. Decomposition rate and nutrient release patterns of plant litters are influenced by environmental conditions, the nature of the microorganisms and soil fauna active in the decomposition process, and by substrate quality or litter quality [3].

In general, it has been recognized that at broad regional scales the observed spatial patterns of mass loss appear to be dominated by climatic variables such as temperature and moisture, mainly by affecting the soil micro-organisms both their activity and the composition of the microbial community, whereas litter properties appear to be relatively insensitive indicators of regional patterns. When the analysis is confined, however, to one or a few sites with similar climates, the influence of litter quality becomes apparent [4]. On the other hand, a number of studies have shown that even at small scale topographical landforms (especially different aspects and slope positions) can create different environmental conditions which can retard or accelerate litter decomposition through negative or positive effects on the activity of organisms [5].

The main drive in these decomposition studies has been to identify general chemical predictors of litter decay rate and even more importantly, the rate of nutrient release from the chemical composition of the litter. A variety of predictive equations have been proposed, mainly using various ratios of carbon, nitrogen, lignin and polyphenols. It has been shown that nitrogen is one of the commonest factors limiting litter decomposition as it determines the growth and turnover of the microbial biomass mineralizing the organic carbon. Hence, C:N ratio remains a significantly important feature of such formulae for litters from annual crops and from woody plants containing less than 10-15% lignin because most of the C and N they contain are in compounds susceptible to microbial attack [6]. However, other studies have shown that litter with higher lignin concentration more than 20%, the amount of lignin constrains the enzymatic activity of fungi and bacteria (and the feeding activity of soil fauna) so that lignin, ligno-cellulose index or lignin:N ratio have been identified better indicator of decomposition as shown by many authors in early and recent studies e.g. [7,8].

Most of these studies in the literature investigating the effects of litter quality variables on litter decomposition have determined the influence of inter-specific differences in litter quality on rates of mass loss with the same system, or comparisons of decomposition rate of the same litter between systems. Hence, interpretations of the subtle relationships between litter quality and decomposition rates reported are often confounded not only by intra-specific differences in genotype or age of leaves but also by intra-specific variations in the environmental conditions created by the tree canopy structure such as light intensity, wind, physical stress (mainly availability of water) or soil characteristics. Although there have been evidences in the literature that plants can show considerable intra-specific variations in the litter quality in relation to differences in the tree canopy structure, variations in soil characteristics and age of leaves [7], this intra-specific variation in the litter quality and its effect on rate of mass loss has received little attention. However, intra-specific differences in litter quality can offer a means of investigating variations in the proportions and biochemical structure of different constituents without the other confounding biochemical variables.

Although the several relationships between initial litter quality and decomposition rates have been widely established, a number of authors have identified that the mechanistic basis of resource quality controls on decomposition shows important exceptions to these relationships as the decomposition proceeds with time e.g. [3]. It has been recognized that species with rapid initial mass losses have larger litter masses than species decomposing slowly at constant rates as the decomposition proceeds with time. These different patterns of decomposition were not explained by initial nitrogen, lignin or polyphenol concentrations. We still know little about why decomposition rates subsequently decrease in the leaf litters, which initially decompose at higher rates. Reasons for this phenomenon may lie in the structural configuration of lignin, hemicellulose and cellulose in the plant cell walls [5]. Therefore the mechanisms regulating processes of decomposition requires more understanding and information on the quality, quantity and spatial configuration of the ligno-cellulose complex in the plant cell wall and microbial degradation of these constituents.

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