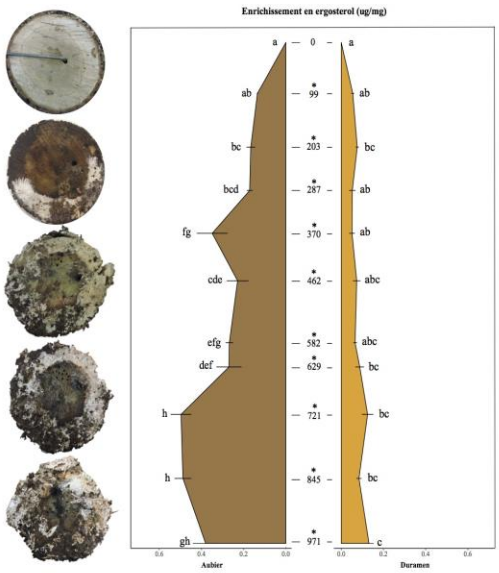
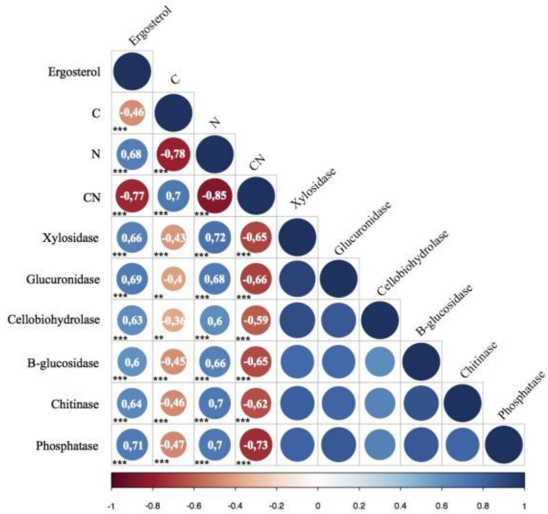
BIOPOLYMOS





Fractionation and Characterization of Fungal and Tree Biopolymers during forest MOS degradation

Principle investigator: Isabelle Ziegler-Devin

Partners: IaM (UMR INRA-UL 1136) ; BEF (UMR INRA-UL 1138)

Collaboration: Nicolas Brosse (Lermab), Marc Buée (IaM), François Maillard (PhD student, IaM), Bernd Zeller (BEF)

Context — Fungi constitute a large part of the biomass in forest soils (~ 60% of the microbial biomass of temperate forest ecosystems). With saprophytic fungi, ectomycorrhizal species contribute to the degradation of plant and fungal necromass and thus to the turnover of carbon in soil organic matter (SOM). The mechanisms of degradation of the biopolymers constituting this necromass as well as their chemical constitution during this process are little known.

Objectives — A better understanding of dynamic and interaction of both necromass and fungi could improve the prediction of long-term soil carbon storage. In order to understand how this composition could influence the rate of decomposition and/or stabilisation of SOM, a combination of physical fractionation and chemical and spectroscopic characterization will be developed to identify chemical composition of separated fractions.

Approach — Extractibles, hemicelluloses, cellulose, lignine, chitin constituting necromass and fungi were extracted by chemical methods then quantified mainly by HPLC; SEC; HPAE/PAD. In parallel, Near InfraRed (NIR) and Mid-InfraRed (MIR) spectroscopy techniques were used be to characterize organic material, as wood and leaf litter. The results of infrared spectroscopy will then be calibrated from the chromatography measurements.

Key results — Chemical and spectroscopic methods for plant and fungal (fungal biomass) biopolymers analyses.

In this study the decomposition of two leaf litters of sessile oak (Quercus petraea) has been studied for two years. One is a native litter (Champenoux-Lorraine), the other is an imported litter (Breuil-Bourgogne), and both of them decomposed on the same soil (Champenoux-Lorraine). The study has shown that the two litters present a different initial and final chemical composition. Extractives content is increasing but not regularly throughout the two years, whereas lignin content is always increasing, consolidating this polymer as highly recalcitrant. Finally, kinetic rate of degradation for cellulose and hemicelluloses are close, whereas hemicelluloses are known to be easier to decay. This observation can be input to the presence of fungi able to decay cellulose in the litter.

In addition, the quantification of fungal organic matter was estimated with two approaches targeting fungal lipids (ergosterols) and cell-walls (chitin polymers) from different samples: pure fungal culture (*Postia placenta*), leaf litter and decayed wood. The extraction and quantification of ergosterols from natural matrices remain the most easily achievable steps in comparison with extractions and quantification of N-acetyl-glucosamine from chitin. However, the latter approach remains relevant for quantitative analysis couplings (HPLC) of fungal organic matter (necromass) and microbial decomposition activities of this substrate (N-acetylglucosaminidase).

- Relationships between biopolymer fractions and microbial activities: ecological applications:
  From environmental samples (litter, decayed wood, soils), we were able to positively correlate the expression of different microbial functions (e.g. fungal functions), with the degradation of plant biopolymers or the accumulation of mycelial biomass. In particular, the increase of exo-chitinase activities is positively correlated with the accumulation of fungal biomass measured though ergosterol assays. Moreover, the ratios “cellulose (and hemicellulose) / lignin” in leaf litter decrease with the increase of certain microbial functional indicators, such as xylosidases.

Main conclusions including key points of discussion — Efficient protocols for extracting indicators of microbial (fungal) organic matter have been applied for the quantification of fungal biomass in complex environmental matrices (deadwood and litter). Two fungal biopolymer (chitin) assay methods have been validated also on fungal material from pure cultures, but their implementations on a large number of environmental samples seems to be not feasible, given the complexity of the matrices studied.

Nevertheless, cellulose, hemicellulose and lignin analyses are easily applicable to the study of the degradation of plant organic matter and our study has allowed to highlight a strong effect of the chemical quality of leaf litter in the processes of degradation of these polymers by microorganisms.

Future perspectives — The BioPolyMOS project has allowed new interactions between the LERMAB and IAM units. Based on this local collaboration, a larger network has been created to propose a new project targeting on the role of microbes in carbon stock in forest soils, both as a constituent of this carbon stock (microbial necromass potentially recalcitrant), but also as actors in the decomposition and respiration (CO_2 production) of organic matter (pre-proposal to AAP-2019 ANR).

Valorisation —

François Maillard, Isabelle Ziegler-Devin, Emmanuelle Morin, Valentin Leduc, Nicolas Brosse, Bernhard Zeller, Marc Buée. Transplantation de litières foliaires de chêne : réponses taxonomique et fonctionnelle des communautés fongiques associées à la décomposition. Séminaire de l’Ecole Doctorale RP2E, 2017.

Maillard F, Ziegler-Devin I, Morin E, Leduc V, Brosse N, Zeller B, Buée M. Influence of oak litter chemistry on fungal functions and community structure during decomposition processes (in preparation).