BRIDGE

Biomass Removal Impact on soil Diversity, Geochemistry and tree Ecophysiology

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Context — Biomass residues are the single renewable resources that have the potential to supply a significant portion of substitutes for fossil fuel. Nevertheless, woody residues and leaf litter represent also essential habitat resources for a wide variety of forest organisms, and consecutively nutrient resources for organisms involved in the forest ecosystem services.

Objectives — The BRIDGE project aims to provide knowledge about the consequences of logging residues / soil organic matter (SOM) removal on ecosystem services and related sensitive components, such as soil fertility, water availability, soil microbial diversity and functioning. Moreover, the originality of this project is to expand the short-term physiological responses of tree to its root associated microbiome after this anthropogenic restraint.

Approach — By the coupling of tree and microbial physiology, biogeochemistry, molecular ecology and metagenomics approaches, we propose an integrative study of the tree/root microbe nutrition and resource management by the tree in response to natural and anthropic disturbances. The study targeted functional indicators of trees (oak and beech) and forest soils. The data were obtained from tree and soil sampled within the "experimental MOS network". Two treatments were compared: conventional management of the Lorraine beech forest and massive harvesting of biomass (including litter).

Key results —

- The temporal dynamics of carbon and nitrogen reserves in the tree reveal strong variations and conversions of reserves (C) in the fine roots of beech and oak. A significant impact of the export of logging residues on the mobilization of simple sugars in fine roots has been observed also. In the short term, no significant effect of the export of slash and litter has been measured on tree growth (diameter of trunks).

- Although the soil properties were little impacted (significant decrease for Phosphorus and CEC only), microbial activities were strongly and significantly reduced in the beech plots submitted to harvesting.

- The study of microbial activities involved in the mobilization of soil elements (carbon, nitrogen and phosphorus) shows a strong correlation between the initial content of organic matter (OM) in soils and the indices of Euclidean dissimilarity of these enzymatic activities, or CLPP results (functional profiles obtained by biological approaches), in the 0-5 cm soil layer.

- In addition, only three years after the treatment, the bacterial and fungal communities differ hyghly in terms of composition between the two conditions (control versus OM removal).

- These changes in activity profiles and microbial compositions suggest a capacity for degradation of the microbial cell walls (chitin) by some groups of fungi. Theoretical data (genomics) and controlled experiments have validated these hypotheses.

- In additional studies we characterized also the succession of microbial communities involved in litter degradation, and therefore directly affected by the export of OM.

Main conclusions including key points of discussion — The export of forest biomass quickly impacts the taxonomic and functional diversity of soil fungal and bacterial communities. The amount of initial organic matter in the soil helps explain the sensitivity of microbial functioning to the removal of organic matter. Soils very poor in organic matter are the most sensitive to the export of biomass.

Future perspectives — A long-term study on these experimental sites (MOS experimental network) would help us to validate certain indicators of disturbance and to evaluate the medium-term impact of these treatments on the physiology and growth of trees.

Valorisation —

Articles

Maillard F., Leduc V., Bach C., Reichard A., Fauchery L., Saint-André Laurent., Zeller B., Buée M. (2019). Soil microbial functions are affected by organic matter removal in temperate deciduous forest. Soil Biology and Biochemistry, 133:28-36.

Maillard, F., Leduc, V., Bach, C., de Moraes Gonçalves, J. L., Androte, F. D., Saint-André, L., Laclau J-P., Buée M., Robin, A. (2018). Microbial Enzymatic Activities and Community-Level Physiological Profiles (CLPP) in Subsoil Layers Are Altered by Harvest Residue Management Practices in a Tropical Eucalyptus grandis Plantation. Microbial ecology, 1-6 (doi: 10.1007/s00248-018-1298-6).

Akroume E., Maillard F., Bach C., Hossan C., Brechet C., Angeli N., Zeller B., Saint-André L., Buée M. (2019). First evidences that the ectomycorrhizal fungus Paxillus involutus mobilizes nitrogen and carbon from saprotrophic fungus necromass. Environmental microbiology. 21: 197-208.

Maillard, F., Didion, M., Fauchery, L., Bach, C., and Buée, M. (2018). N-Acetylglucosaminidase activity, a functional trait of chitin degradation, is regulated differentially within two orders of ectomycorrhizal fungi: Boletales and Agaricales. Mycorrhiza. 28: 391-397.

Articles in process

Maillard F., Miyauchi S., Hossann C., Angeli N., Martin F., Buée M. Chitin degradation by ectomycorrhizal fungi, genomic and functional evidence. In preparation for New Phytologist.

Maillard F., Viotti C., Jerrai A., Leduc V., Truchot C., Bach C., Buée M., Gérant D. Organic matter removal impact on tree physiology revealed by year-round monitoring of non-structural carbohydrates and nitrogenous compounds in the stem sapwood and fine roots of two lowland hardwood species. In preparation for New Phytologist

Maillard F., Thebault E., Leduc V., Bach C., Reichard A., Fauchery L., Saint-André Laurent., Zeller B., Buée M. Shift in bacterial and fungal community in response to organic matter removal in temperate deciduous forests. In preparation for Environmental Microbiology

Maillard F., Ziegler-Devin I., Leduc V., Brosse N., Zeller B., Buée M. A leaf litter transplantation experiment: litter origin more than degradation site impacts the associated fungal communities. In preparation for Fungal Ecology.

Conference

Maillard F, Leduc V., Viotti C., Thebault E., Bach C., Morin E., Saint-André L., Zeller B., Gérant D., Buée M. Organic matter removal impacts forest microbial community and tree physiology. Functional Ecology Conference, Nancy Dec 10-13th 2018. Young researcher best presentation prize (communication orale).

Maillard F, Akroume E, Bach C, Didion M, Hossann C, Fauchery L, Angeli N, Zeller B, Saint-André L, Martin F and Buée M. Décomposition de la nécromasse fongique par les champignons ectomycorhiziens: rôles et fonctions potentiels dans la dépolymérisation de la chitine. Journées Francophones des Mycorhizes, June 2018, Dunkerque, France. (communication orale)

Maillard F., Viotti C., Leduc V., Truchot C., Bach C., Gérant D., Buée M. Year-round monitoring of non-structural carbohydrates in the stem sapwood and ectomycorrhized fine roots of two lowland hardwood species. 41st New Phytologist Symposium: Plant sciences for the future, April 2018, Nancy, France (poster).

Maillard F, Didion M, Bach C, Morin E, Martin F, Buée M. Exo-chitinolytic activities: phylogenetic conservatism of a functional trait in the ectomycorrhizal fungi. 9th International Conference on Mycorrhizas, August 2017, Prague, Czech Republic. Best graduate student poster prize. (poster + short talk).

Akroume E*, Maillard F*, Bach C, Hossan C, Brechet C, Angeli N, Zeller B, Saint-André L, Buée M. Fungal necromass in soil forest: are ectomycorrhizal fungi scavengers? 9th International Conference on Mycorrhizas, August 2017, Prague, Czech Republic. (poster + short talk).

Maillard F., Ziegler I., Leduc V., Brosse N., Zeller B., Buée M. A leaf litter transplantation experiment: litter origin more than degradation site impacts the associated fungal communities. Annual day of the RP2E Doctoral School, October 2016, Nancy, France. Best graduate student poster prize. (poster)