Geophysical Research Abstracts
Vol. 21, EGU2019-13359-1, 2019
EGU General Assembly 2019


# Temporal dynamics of soil metabolites during rhizosphere priming in the vicinity of a root exudation hotspot

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The input of labile C into soil is thought to accelerate microbial decomposition of soil organic matter in the so-called 'rhizosphere priming effect'. However, plant roots release labile organic substances into spatially and temporally constrained volumes of soil, resulting in a heterogeneous distribution of spots with dramatically increased C concentrations in the soil. Subsequent microbial and chemical dynamics, which may lead to a priming effect, are likely to take place in the immediate vicinity of these exudation spots. So far, we lack an understanding of these small-scale dynamics occurring during a priming event.

The aim of this study was to investigate the fine-scale temporal dynamics of microbial activity and soil chemistry in response to simulated root exudation at distinct spots in undisturbed soil cores. Therefore, we used microdialysis, which allows the collection or release of organic compounds via diffusion across a very fine membrane. We placed microdialysis membranes (10 mm length, 500 $\mu$m outer diameter, 20 kDa molecular weight cut-off) into undisturbed soil cores collected from a forest site and simulated a pulse of root exudation by releasing a mixture of $^{13}$C-labelled labile substrates (glucose, fructose, acetate, and succinate) for 8 hours ('reverse microdialysis'), while simultaneously collecting metabolites from the soil solution at an hour-scale time resolution. In the 12 days after the pulse, we continued collecting metabolites and measured $^{13}$C in soil respiration in regular intervals to assess substrate-induced respiration, soil organic matter (SOM) mineralization and priming effects.

The pulse of artificial root exudates reduced mineralization of native SOM in the first week of the experiment ("negative priming"). At the same time, acetate, formate, propionate, sulphate, nitrate and ammonium exhibited distinct temporal patterns, increasing significantly between 20 to 30 hours after the exudation pulse. Rising levels of acetate, formate and propionate may have originated from anaerobic metabolism, suggesting oxygen depletion at the microbial active sites. After one week, native SOM mineralization in soils that received a 'root exudate pulse' exceeded that of controls ("positive priming effect"), which persisted for the duration of the experiment. The organic acids, sulphate, nitrate and ammonium also displayed elevated concentrations at the end of the experiment.

The combination of isotopic labelling, 'reverse microdialysis' and $^{13}$C respiration measurements allowed us to observe fine-scale temporal dynamics of soil metabolites in the immediate vicinity of a simulated root exudation spot in an undisturbed soil, and to link these to the temporal dynamics of the rhizosphere priming effect. Our results provide new insights into possible mechanisms behind the priming effect.