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Native soil organic matter composition affects the magnitude of the rhizosphere priming effect in permafrost soils

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The Arctic is warming at a rate of almost twice the global average, promoting both soil organic matter (SOM) mineralization and plant photosynthesis. Plants release labile organic compounds into the soil that may stimulate SOM decomposition. This so-called 'rhizosphere priming effect' has the potential to accelerate SOM losses from permafrost soils under warming, but the controls on its magnitude are unclear. For instance, the magnitude of the priming effect may depend on the chemical composition of native SOM, with some compounds being more prone to priming than others and other compounds inhibiting priming.

In this study, we investigated the relationship between rhizosphere priming and SOM composition in permafrost soils. We made use of a previous laboratory incubation study in which soil samples from active layer and shallow permafrost of four Siberian sites were amended with 13C-labelled cellulose or protein (Wild et al., 2016). This study showed a significant increase in the mineralization of native SOM by cellulose and protein addition compared to control soils, but also large variability between and within soil horizons and sites. Here, we hypothesized that such variability was driven by differences in the chemical composition of native SOM, and tested this hypothesis by analysing initial soil samples from the same study with pyrolysis gas chromatography mass spectrometry (Pyr-GC/MS).

Our results revealed that the magnitude of the priming effect by protein addition was significantly affected by SOM composition. Soils that contained a higher proportion of carbohydrates and lignin exhibited a lower priming response compared to soils with a higher proportion of aromatic and phenolic compounds. However, no relationship was found between SOM composition and the priming effect by cellulose addition.

Our results demonstrate, for the first time, that the magnitude of the rhizosphere priming effect may be determined by the interplay between the microbial community (its physiological state and activity) and the chemical composition of native soil organic matter and the composition of labile organic carbon input.