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Impact of plant-specific priming on greenhouse gas emissions in thawing permafrost stages

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Thawing permafrost soils are of concern for climate change projections as vast amounts of organic carbon become accessible for microorganisms and subsequently convertible to greenhouse gases (GHGs). In Northern permafrost, thawing often results in waterlogged soils with opposing geochemistry and different vegetation composition compared to intact permafrost soils. In a process called rhizosphere priming effect, labile, low-molecular-weight organic compounds are exuded by plant roots, whose degradation stimulates the turnover of native organic carbon, in turn resulting in increased GHG production, but priming in northern permafrost soils remains poorly understood. Previous lab experiments using simple carbon sources as amendment suggest that rhizosphere priming increases soil respiration in permafrost soils. However, root exudation patterns are plant (species-) specific and may differ among thaw stages. Thus, amendment studies with artificial, simplified root exudates may not suffice for assessing the true and heterogeneous priming effect of different plants in permafrost soils and across thaw stages.

To investigate plant-specific exudate priming in different thaw stages, field-sampled root exudates from two plant species that are widespread for the intact (*Andromeda polifolia*) and thawed soil (*Eriophorum vaginatum*) were sampled in Abisko, Sweden. By adding the sampled root exudates to both soils, we explored priming of CO_2 and CH_4 production under oxic/anoxic conditions, while monitoring soil chemistry, enzymatic activities and microbial abundances as well as CH_4-cycling functional genes and their transcripts. Root exudates contained more short chain fatty and amino acids, simple sugars and were overall less aromatic than organic carbon extracted from bulk soil. In the thawed soil, we observed priming effects in response to root exudate addition, with 30 and 70% increase in CO_2 and CH_4 emissions after five days compared to soils amended with bulk soil extracts. This was accompanied by increasing aromaticity over time in the root exudation treatments indicating enhanced decomposition of amended carbon substrates.

Our findings suggest that plant species-specific root exudates intersect differently with the elemental cycles of each thaw stage, leading to increased primed greenhouse gas emissions. Considering that waterlogged permafrost areas with enhanced plant productivity will increase in the upcoming years, climate feedback may be more pronounced than anticipated.