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The susceptibility of soils to priming: the impact of litter addition, nitrogen fertilisation, and heat-shock

Climate change is expected to alter soil nutrient availability and microbial community functionality. Inputs of labile carbon (C) from root exudates can stimulate the decomposition of soil organic matter (SOM) in a phenomenon known as "priming"; driven by microbial demand for limiting resources. Climate-driven changes in resource availability may therefore influence soil susceptibility to priming, with implications for long-term soil C storage.

This thesis investigated how climate change-associated shifts in resource availability – via increased litter inputs, nitrogen (N) addition, and heat-shock treatments – influenced microbial activity and subsequent SOM priming in response to glucose addition, in temperate beech forest soils. Two overarching hypotheses were tested: (H1) The climate-simulation treatments will have an effect on the functioning of the microbial community, (H2) The susceptibility of soils to priming will vary depending on the climate-simulation treatments. Soils were first subjected to the respective treatments, followed by ^{13}C-labelled glucose to simulate root exudation, to assess the effect on "priming" of SOM decomposition. Microbial respiration (glucose- and SOM-derived CO_2), growth (via isotope incorporation), and carbon use efficiency (CUE) were measured to understand the mechanisms behind the priming dynamics.

All climate-treatments altered microbial functioning and influenced soil priming susceptibility. Glucose addition consistently reduced CUE, indicating a microbial shift from growth towards respiration. Preferential substrate use was observed in control, litter, and N-amended soils after initial glucose addition, suppressing SOM mineralisation, but this reversed over time. Strong priming in the litter-amended soils was likely driven by elevated microbial nutrient demand from the high C:nutrient imbalance of the added litter and greater microbial biomass, promoting SOM via mechanisms like selective N-mining. N addition increased microbial CUE but reduced overall growth and respiration, suggesting more efficient but reduced resource use. Here, priming was also enhanced, likely via stoichiometric decomposition due to the increased N availability. Heat-shock reduced microbial biomass and bacterial growth but not fungal, shifting the community composition. Respiration increased despite the lower microbial biomass, while CUE declined, indicating a stress response. In contrast to the other treatments, heat-shock reduced the susceptibility of soils to priming.

Overall, these findings highlight how microbial responses to changing resource regimes can impact priming susceptibility and microbial C-use strategies, with implications for soil C dynamics under future climate scenarios.

Keywords: Physical Geography, Ecosystem analysis, Priming Effect, Soil Carbon Cycling, Temperate Beech Forest

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