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The effect of root exudates on soil nitrogen availability - an evaluation using microdialysis

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Plant root exudates are believed to increase root capture of nutrients (including nitrogen) by encouraging development of a rhizosphere root community, and providing them with an energy source to facilitate degradation of litter and soil organic matter. However, observing the consequences of root exudation on nutrient cycling and microbial activity is challenging with current methods, given the small scales involved. We investigated the effect of root exudation on nitrogen (N) availability by simulating root exudation with microdialysis. This novel technique enables continuous release of synthetic solutions of root exudates via diffusion in situ in soil by using a root-sized permeable membrane. Importantly, it also allows for simultaneously monitoring the effects on inorganic N fluxes. To emulate growth of a root tip through a specific soil region, sucrose was released for seven days before substituting sucrose with water for a further 7 days. We investigated boreal forest soils with and without litter amendments (ground pea shoots) to attain different C/N ratios and we used two rates of exudation by retrodialysing with either 0.5 or 5 mM sucrose solution. We observed that pea litter promoted significant N immobilisation, along with greater rates of sucrose release from microdialysis probes - peaking at 90.7 ± 8 µg sucrose m^{-2} s^{-1} using the 5 mM sucrose solution after three days. This suggests that greater root exudation may be driven by microbial demand for both C and N, with no short-term nutritional benefit for plant roots, even after exudation has ceased within a specific soil region. Glucose and fructose fluxes (breakdown products of sucrose) were also greatest in the litter treatment, indicating enzyme activity was promoted by the availability of both sucrose and litter. CO_2 respiration measurements indicated significant differences between litter and control soils, but there was no detectable effect of sucrose exudation, suggesting that the small amounts of C supplied and the limited area influenced by the diffusion of sucrose had little impact on overall microcosm respiration. We conclude that short-term C exudation presented no immediate benefit for plant nutrition in our experiment. Future studies can benefit from using microdialysis to investigate the influence of more complex root exudate solutions, as well as the mechanistic roles of transpiration-induced mass flow on plant N availability in the rhizosphere.