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Artificial Root Exudate System (ARES): a field approach to simulate tree root exudation in soils

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The exudation of labile solutes by fine roots represents an important strategy for plants to promote soil nutrient availability in terrestrial ecosystems. Compounds exuded by roots (mainly sugars, carboxylic and amino acids) provide energy to soil microbes, thus priming the mineralization of soil organic matter (SOM) and the consequent release of inorganic nutrients into the rhizosphere. Studies in several forest ecosystems suggest that tree root exudates represent 1 to 10% of the total photoassimilated C, with exudation rates increasing markedly under elevated CO_2 scenarios. Despite their importance in ecosystem functioning, we know little about how tree root exudation affect soil carbon dynamics in situ. This is mainly because there has been no viable method to experimentally control inputs of root exudates at field scale.

Here, I present a method to apply artificial root exudates below the soil surface in small field plots. The artificial root exudate system (ARES) consists of a water container with a mixture of labile carbon solutes (mimicking tree root exudate rates and composition), which feeds a system of drip-tips covering an area of 1 m2. The tips are evenly distributed every 20 cm and inserted 4-cm into the soil with minimal disturbance. The system is regulated by a mechanical timer, such that artificial root exudate solution can be applied at frequent, regular daily intervals. We tested ARES from April to September 2015 (growing season) within a leaf-litter manipulation experiment ongoing in temperate deciduous woodland in the UK. Soil respiration was measured monthly, and soil samples were taken at the end of the growing season for PLFA, enzymatic activity and nutrient analyses. First results show a very rapid mineralization of the root exudate compounds and, interestingly, long-term increases in SOM respiration, with negligible effects on soil moisture levels. Large positive priming effects (2.5-fold increase in soil respiration during the growing season) were observed in absence of aboveground forest litter, with lower or no priming when the litter was present. Preliminary results show that soil microbial community is also significantly affected by ARES.