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How to trace organic matter input by living plants into and within the soil?

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Terrestrial ecosystems are the third largest carbon storage depot. Recent research has shown that roots and root-derived compounds may play an important role in the long-term stabilization of carbon within the soil. The study of the influence of plants on soil OM stabilization processes asks for advanced methods, which can be used to differentiate various pools and fluxes without disturbing the plant-soil system. One powerful tool matching these demands is stable isotope analysis. A common method is the artificial labelling of new plant assimilates by exposing the plants in a pulse (short time period) or continuously to CO_2 strongly enriched with the heavy carbon isotope (13C). In addition the use of multiple isotopes has proven to lead to further insights in plant physiological processes and on OM cycling. In this study we tested the potential of pulse versus continuous multi-isotope labelling technique for studying OM input and stabilization within the soil.
We developed a facility (MICE - Multi Isotope labelling in a Controlled
Environment) to label plants in the lab under controlled conditions with 13C, 18O and 2H isotopes. The aboveground parts (shoot) of the plant-soil system are hermetically separated from the lower parts (roots, soil) to prevent the diffusion of the labelled gas into the soil. CO_2 enriched in 13C (99atom% and 10atom% for the pulse and continuous labelling, respectively) and depleted water vapour (δ18O = -320-370‰ and δ2H=-750-810‰ were added to the aboveground system. Each labelling experiment was conducted with 15 plants (Populus deltoides x nigra) for 8 and 14 days, respectively. At five sampling dates the leaf, stem, root and soil bulk material was analysed for δ13C and δ 18O. In addition the δ13C of the microbial biomass (chloroform fumigation extraction) and the soil respiration (Keeling plot approach) was measured.
In both experiments the plant biomass and the soil respiration has been significantly labelled with 13C (up to 1200‰ δ13C), with a steady increase in label strength in the continuous labelling and a fast decrease in the pulse labelling experiment. After 8 and 14 days the 13C label strength within the bulk soil was not detectable or very low in the pulse and continuous labeling, respectively. The 18O labelling of OM (up to 15‰ δ18O) was only successful when the label was added continuously.
The results of this study show that the continuous labelling technique is more suitable for studying OM cycling processes within the soil such as rhizodeposition and SOM stabilization since it eventually labels all carbon pools leading to stronger signal strengths in SOM, enables the multi-isotope labelling and is applicable to larger time-scales.