EGU22-13569
https://doi.org/10.5194/egusphere-egu22-13569
EGU General Assembly 2022

Belowground allocation and dynamics of recently fixed plant carbon in a California annual grassland

Mary Firestone[1], Christina Fossum[1], Katerina Estera-Molina[1], Mengting Yuan[1], Don Herman[1], Ilexis Chu-Jacoby[1], Peter Nico[2], Keith Morrison[3], and Jennifer Pett-Ridge[3]

[1]Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA, USA
[2]Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA
[3]Physical and Life Sciences Directorate, Lawrence Livermore National Laboratory, Livermore, CA, USA

Plant roots and the organisms that surround them are a primary source for stabilized soil organic carbon (SOC). While grassland soils have a large capacity to store organic carbon (C), few field-based studies have quantified the amount of plant-fixed C that moves into soil and persists belowground over multiple years. Yet this characteristic of the soil C cycle is critical to C storage, soil water holding capacity and nutrient provisions, and the management of soil health. We tracked the fate of plant-fixed C following a five-day $^{13}CO_2$labeling of a Northern California annual grassland, measuring C pools starting at the end of the labeling period, at three days, four weeks, six months, one year, and two years. Soil organic carbon was fractionated using a density-based approach to separate the free-light fraction (FLF), occluded-light fraction (OLF), and heavy fraction (HF). Using isotope ratio mass spectrometry, we measured ^{13}C enrichment and total C content for plant shoots, roots, soil, soil dissolved organic carbon (DOC), and the FLF, OLF, and HF. The chemical nature of C in the HF was further analyzed by solid state ^{13}C nuclear magnetic resonance (NMR) spectroscopy.

At the end of the labeling period, a substantial portion of the ^{13}C (40%) was already found belowground in roots, soil, and soil DOC. By 4 weeks, the highest isotope enrichment and 27% of the total amount of ^{13}C remaining in the system was associated with the mineral-rich HF. At the 6-month sampling—after the dry summer period during which plants senesced and died—the amount of label in the FLF increased to an amount similar to that in the HF. The FLF ^{13}C then declined substantially by 1 year and further decreased in the 2ndyear. By the end of the 2-year experiment, 67% of remaining label was in the HF, with 19% in the FLF and 14% in the OLF.

While the ^{13}C content in the HF was stable over the final year, the chemical forms associated with the HF evolved with time. The relative proportion of aliphatic/alkyl C functional groups declined in the newly formed SOC over the 2-years in the field; simultaneously, aromatic and carbonyl/carboxylic C functional groups increased and the proportion of carbohydrate (O-alkyl C) groups remained relatively constant.

Our results indicate that plant-fixed C moved into soil within days of its fixation and was associated with the soil mineral fraction within weeks. While most of the annual plant C input in these grasslands cycles rapidly (<2-year timescale), a sizeable proportion (about 23% of the ^{13}C present at day 0) persisted in the soil for longer than 2 years. While decadal studies would allow

improved assessment of the long-term stabilization of newly fixed plant C, our 2-year field study reveals surprisingly rapid movement of plant C into the HF of soil, followed by subsequent evolution of the chemical forms of organic C in the HF.