

Spatially Resolved Rhizosphere Function for Elucidating Key Controls on Below-ground Nutrient Interactions

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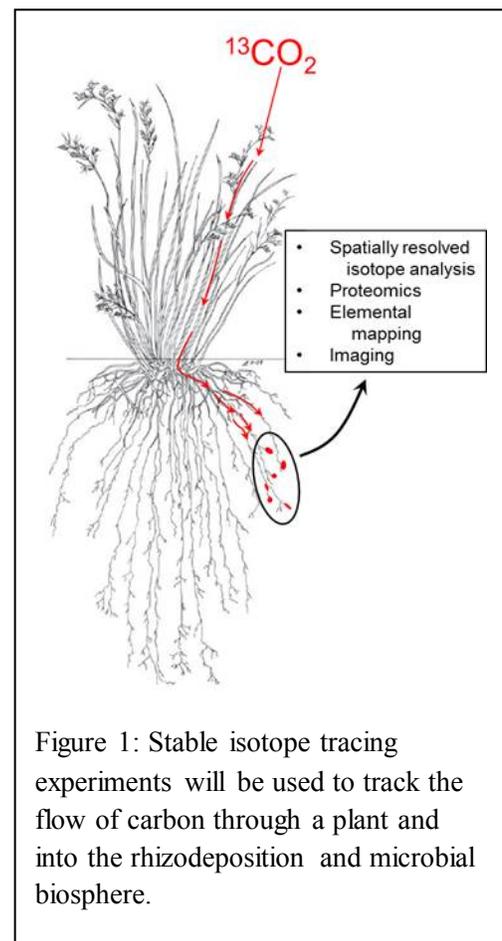
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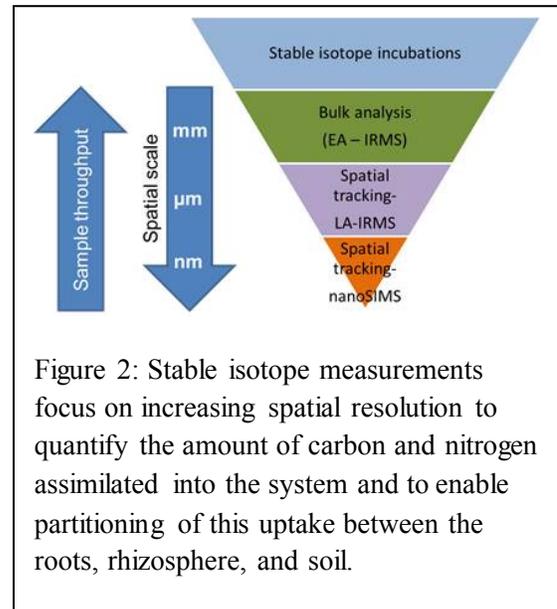
Project Goals: The main goals of this project are to elucidate key microbiological and geochemical controls on nutrient exchange through the rhizosphere and the role that spatial organization within the root-rhizosphere-soil continuum plays in nutrient transfer. Enhanced, spatially-resolved understanding of nutrient exchange within the rhizosphere can identify key variables amenable to manipulation as part of an effective rhizosphere management program targeting enhanced plant productivity. Our aims are directed towards 1) characterizing the spatial organization of nutrient exchange between soil and plant roots, 2) identifying key microbial functions within zones of high nutrient transfer, 3) evaluating whether directed geochemical and/or microbiological modifications can be used to stimulate nutrient exchange to foster improved plant biomass productivity.

The central hypothesis we are testing is that spatially focused regions belowground funnel a disproportionate amount of nutrients to a plant root. Further, we hypothesize that the location of these resulting nutrient exchange hotspots are not stochastically distributed throughout the rhizosphere but, rather, that they are controlled by microenvironmental conditions resulting from a combination of local microbiological communities in conjunction with host soil geochemistry. Initial experiments are using labeled (¹³C) carbon dioxide to track photosynthetic uptake and release of resulting rhizodeposits. A series of stable isotope analyses will be used to quantify rates of organic carbon release along transects both parallel and perpendicular to the plant root axes to assess short-term spatial heterogeneity. These measurements will be performed at increasingly resolved spatial scales (Figure 2) where each set of analyses informs the spatial zone of interest for the next, more



targeted analysis; bulk analysis (mm scale) will inform community level analyses (50 μm resolution, using laser ablation isotope ratio mass spectrometry) which will inform cellular-level analyses (10's nm, using nanoSIMS). Spatially-resolved elemental analysis (using laser induced breakdown spectroscopy) of these same regions helps reveal potential correlations between mineral or element content and localization of plant-derived organics. Proteomic analysis can provide identification of specific taxonomic groups participating in nutrient exchange (through label uptake into specific proteins trackable to the soil metagenome) and also track changes in protein synthesis associated with specific microbial functions that will accompany future elemental supplementation experiments.

Initial growth experiments are underway using controlled switchgrass mesocosms. These mesocosms are constructed with soil harvested from test fields at the Kellogg Biological Station (Hickory Corners, MI) that have been under switchgrass production for nearly a decade. In the event that we identify specific components of the system that correlate with increased rates of carbon exchange, we will perform supplementation experiments in similar mesocosms to assess whether small-scale nutrient supplementation can stimulate expansion of nutrient exchange hotspots and the extent to which this increases plant productivity. A better understanding of relevant subsurface nutrient exchange processes will enable future increases in plant production on less fertile soil and with fewer artificial nutrient additions as needed to promote energy and food security.



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