Is there a direct link between free-living nitrogen fixation rates and nitrogen mineralization rates?

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Project Goals: The primary goals of this project are to increase our understanding of how rhizosphere microbiomes in perennial biofuel cropping systems (PBCS) use C resources, especially root exudates, to fuel N-transformations. We are particularly interested in trade-offs between free-living N-fixation and N-mineralization and how root exudates support both processes.

Representing the main pathways to plant accessible nitrogen (N), the relationship between free-living N fixation (N-fix) and N mineralization (N-min) is relatively unexplored. In particular, free-living N-fix, thought to be supported mainly by plant root exudates, has often been overlooked. Currently, there is no information on the link between N-fix and N-min rates available in the literature. In order to address this knowledge gap, we are using a three-pronged approach, including a meta-analysis, a greenhouse study and field experiments.

Following an extensive literature search, we found 12 papers that simultaneously reported N-fix and N-min rates. Surprisingly, these data indicated a positive relationship between N-fix and N-min rates; however, the scarcity of data limits our ability to draw any strong conclusions. We have explored the relationship between N-fix and N-min in a controlled greenhouse experiment using switchgrass (Panicum virgatum) because recent evidence suggests switchgrass may support free-living N-fix when N limited. Indeed, in our study switchgrass and soils exposed to N limiting conditions experienced no adverse effects, namely no differences in plant growth or tissue chemistry (C:N) or soil enzyme activities compared to non-N limiting conditions. Soils used in this study are from marginal lands, low in soil organic matter and N, so it is likely N deficits are compensated for via N-fix. Analysis of 15N2 –Fix and gross N-min rates, determined via 15N pool dilution, will elucidate this source of N. Finally, our field experiment encompasses six marginal land sites across MI and WI, part of the Great Lakes Bioenergy Research Center. In 2016, we measured N-fix and N-min rates in switchgrass monoculture plots at all six sites once, at the peak of growing season, and bi-weekly, from April to September, at two MI field sites. Data collected to date from two MI sites show no difference in N-min rates in N fertilized versus unfertilized switchgrass plots. We anticipate greater N-fix at these sites in the unfertilized relative to the N fertilized plots. Overall, evidence suggests free-living N-fix is an important source of N, which is often overlooked despite its potentially large impacts on plant productivity and soil microbial activities such as enzyme production and N-min.

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