Exploring a new microbial pathway for nitrate control using cover crops and bioreactors at the Southeast Research Station

PI: Shin-Yi Marzano, South Dakota State University; **Co-PI:** Michael Lehman, USDA-ARS

Purpose: High N fertilizer application to support corn production can result in nitrate leaching into waters which causes eutrophication. Some commercial corn/soybean producers use cover crops to increase nutrient retention, although there is some concern that nutrient leaching, especially phosphorus, may occur during cover crop decomposition. Managing agricultural soils to optimize cover crop benefit and the N-cycling process that competes with nitrification are promising approaches for the control of nutrient leaching. By retaining soil N, available nitrogen to crops will be increased while mitigating the environmental impacts from leached N. We hypothesize that microbes capable of biological nitrification inhibition (BNI) are enriched in corn rhizospheric soil. Soil samples after rye cover crops were characterized for the abundance for N cycling genes. Two objectives were investigated: Objective 1. Determine the BNI effect of rye on soil health. Objective 2. Determine the BNI effect of rye on N-cycling genes.

Methods: The field plots have been in a corn and soybean rotation with or without rye cover crops since Fall 2017. Soil and plant samples were collected for analysis before and after decomposition of rye in the field, and by varying the timing of suppression in the greenhouse. Soil health indicators including soil protein, permanganate oxidizable carbon, enzyme activities, and carbon mineralization activity were measured. N cycling genes were measured by a NiCE qPCR chip method after the DNA is extracted from soil. Statistics analyses were performed using paired t-test in Rstudio.

Results: In the two years since the rye cover crop treatments were applied, soil health measures have progressively improved in response to cover crop treatments. Cover crop rye treated plots showed a significant reduction in nitrification corresponding to a decrease in overall archaea population, archaeal ammonia monooxygenase, and *Nitrospira* population responsible for nitrite oxidation in the second step of nitrification. In 2018, there were increases in rye-treated plots for the levels of soil protein, soil oxidizable carbon, and mineralizable carbon compared to the control without the cover crop treatment, albeit not significant statistically ($P>0.10$). However, in 2019, the levels of bioavailable N, general microbial activity, and mineralizable carbon reached a significant increase compared to the control plots without rye cover crop treatment ($P<0.05$).

Impacts of the research: The impact of the project is to improve understanding about the importance of cover crop treatment and microbial processes in nutrient leaching and retention in SD agricultural soil. In two years, we demonstrate that rye cover crop plays a role of biological nitrification inhibition in the Beresford, SD experimental site. Therefore, including cover crop such as rye with BNI effects will help shift the existing production system towards a low-nitrifying production system to reduce unintended and unknown consequences on the environment of massive injections of N-fertilizer into agricultural systems.