2018 USAFRI Research Project Objectives

Regional Characterization of Alfalfa and Manure Legacy Impacts on Soil Quality in Crop Rotations
USDA-ARS - Gamble

Project Award: $32,621

Justification:

- Managing agricultural soils for improved soil quality has the potential to enhance resilience and yield, reduce environmental impacts, and increase economic profitability in agricultural production systems. Soils provide fundamental functions in agricultural systems related to nutrient availability and cycling, water availability and infiltration, and the control of pests and diseases. A healthy soil is one that has a high capacity to provide these desired functions (Karlen et al., 1997), many of which are mediated by soil microbial communities. Agronomic practices such as fertilization, organic matter additions, and crop rotation alter soil physical and chemical properties with significant implications for soil microbial communities (Fernandez et al., 2016). Understanding the long-term effects of agronomic practices on soil properties and biota is essential for improving management to optimize these microbial communities for agricultural sustainability.

  Alfalfa, a perennial forage legume, is the fourth most widely grown crop in the US, covering over 17 million cropland acres in 2017 (USDA NASS, 2018). Alfalfa provides many benefits to cropping systems, including the "rotation effect" in which subsequent crops experience increased yield potential compared with following other crops. Some of this benefit is attributable to reduced weed, insect, and disease pressure, as well as the substantial amount of symbiotically fixed inorganic nitrogen available in the soil as alfalfa residues decompose (UMN Extension, 2018). Alfalfa also improves soil quality by increasing soil organic matter (SOM) and nitrogen, reducing erosion, and improving soil infiltration, and has been shown to increase soil microbial biomass relative to grass forages (Campbell, 1992; Min et al., 2003). However, little research has been conducted to assess the broader impacts of alfalfa on soil microbial community composition and function. Understanding how alfalfa affects soil microbial populations and function will shed light on the mechanisms contributing to the "rotation affect" and will have far-reaching implications for US forage production systems.

  Manure application can also greatly improve soil health. However, to date, most research has been devoted to understanding the impacts of manure applications on crop yield and soil physical and chemical properties. However, there is growing recognition that the benefits of manure application extend beyond simple additions of N and P (Robbins et al., 1997; Tarkalson et al., 2018). For example, manure applications can have long-lasting impacts on soil organic carbon (Grandy et al., 2002) and there is evidence to suggest that manure applications have beneficial impacts on soil microbial communities. A meta-analysis of 64 studies showed that when applied at high rates, cattle manure can increase soil microbial biomass by 60% over and above inorganic fertilizer additions (Kallenbach and Grandy, 2011). Further, the impacts of manure on microbial communities can confer soil health benefits for years after application. For example, Zhang et al., (2018) demonstrated that manure still had a legacy effect on soil microbial community composition for up to 13 years after suspending manure application. They noted increased populations of soil N-fixing and ammonia oxidizing bacteria compared to soils that never received manure, which improved soil N-cycling and crop N utilization in the previously manured soils. However, despite the broad recognition of the potential benefits of dairy manure for increasing soil health and forage crop yields, the specific long-term impacts on soil microbiome community composition and function are relatively unknown.

  Here, we propose to investigate the impacts of one-time dairy manure applications on soil chemical properties, soil microbial communities, and alfalfa forage and corn grain and biomass yields and to explore relationships between microbial community structure, nutrient-cycling functions, and soil characteristics. Over time, we also hope to better understand how alfalfa affects soil microbial populations and whether they contribute to the rotation effect". This project will be conducted in coordination with other USDA-ARS locations as part of the ARS Dairy Agroecosystem Working (DAWG) group common experiment. The objective of the DAWG experiment is to determine the long-term effects (economic, environmental, and soil chemical, biological and physical) of a one-time or short-term manure application. The study idea originated at the USDA-ARS Northwest Irrigation and Soils Lab in Kimberly, Idaho where researchers observed improved crop yields from plots that had received manure nearly a decade ago, but now received only mineral fertilizer, compared to plots that have only ever received mineral fertilizer. Their findings suggest that even short-term or single manure applications can influence soil properties, and likely soil microbes, to the benefit of crops for years following application. However, the mechanisms responsible for this benefit are unknown. Quantifying the true benefits of manure to long-term soil health and crop production could enhance its value and improve the economic feasibility of longer distance manure hauling. This will expand the acreage available for land-application, reduce the likelihood of overloading soils near livestock operations, and therefore reduce the risk of N and P losses. The study has been initiated at Kimberly, ID and University Park, PA and plans are in place to begin in Bushland, TX; Fort Collins, CO; Madison, WI; and St. Paul, MN. This project aligns with the USAFRI Research Priority: Fertility, Soil Management, Soil Health, Macro/Micro Nutrients.

Objectives:

- The objectives of this research are to 1) Determine the impacts of dairy manure applications on soil microbial community structure and yield in forage cropping systems; and 2) Determine the relationships between soil microbial community structure, nutrient-cycling functions, and soil edaphic characteristics in the context of forage-cropped agricultural soils.

  With the goal of increasing forage production system resilience through measures that improve the functionality and the quality of soils, we designed a full factorial dairy manure addition experiment. In order to capture the generality of plant and microbial responses to manure applications, this work will use a long-term agricultural research platform including three different agricultural sites varying in climate, soil properties, and historical agronomic practices. Importantly, sites are known to harbor distinct bacterial and fungal communities (Castle et al.,2018; Castle et al. (In Review).