2022 USAFRI Research Project Objectives

Alfalfa-Grass Mixtures: Evaluating Trade-Offs in Forage Quality, Productivity, and Field Carbon Balance

USDA-ARS - Gamble, Duff

Project Award: $76,180

Justification:

- Alfalfa is the nation's third most valuable field crop (to corn and soybean) and the fourth most widely grown crop, covering 16+ million cropland acres in 2020 (USDA-NASS, 2021). As a perennial legume, alfalfa provides many benefits to cropping systems including increased soil nitrogen, reduced erosion, and improved soil infiltration (Campbell, 1992; Rasse et al., 2010). However, since the mid-1980's acreage has declined by 30%, while acreage of corn and soybean has increased dramatically, which may have important implications for SOC stocks. Land historically planted to perennials is now annually cropped and subject to more frequent tillage and reduced plant residue inputs. Some research has shown the potential for improved carbon (C) storage with alfalfa. For example, Syswerda and Robertson (2014) observed that alfalfa increased soil organic carbon (SOC) in the top meter of soil more than annual crops, even when annuals were managed with no-till and organic inputs. However, more recent research has shown that irrigated alfalfa is a net source of C in Minnesota (Gamble et al., 2021), despite dramatic improvement in C balance relative to silage corn. Similarly, research in Minnesota and Wisconsin has shown rainfed alfalfa to be a net sink for C in the establishment year, but a net source of C during production years when C exports in forage are high (Wiesner et al., 2022).

  However, little is known about how specific alfalfa management strategies impact carbon balance dynamics. Soil organic C stocks increase when the carbon inputs derived from photosynthesis exceed losses driven by harvest export and respiration. Perennial forages assimilate substantial amounts of carbon dioxide (CO2). Much of this C is allocated to their extensive root systems, which provide critical inputs for maintaining SOC stocks. For alfalfa, root contributions to soil can be up to 5-fold higher than for corn (Angers, 1992). Identifying management practices that promote root development earlier in the growing season, and deeper in the soil profile, is a potential strategy for further increasing SOC. Advancements in no-till and reduced tillage soil management could further improve SOC by reducing carbon losses via soil respiration and retaining more root residues relative to fields tilled for stand establishment or termination.

  There is increasing concern among forage producers about alfalfa winter kill, stand establishment, and productivity in the establishment year. Practices such as nurse cropping and planting alfalfa-grass mixtures are strategies that have been suggested for addressing these concerns, while also increasing early root development and providing more plant residue to soil for maintaining SOC. Studies comparing productivity and forage digestibility in alfalfa and alfalfa-grass mixtures have demonstrated the potential of mixtures to increase or maintain forage yield and quality (Aponte et al., 2019; McDonald et al., 2021). More research is needed evaluating nurse cropping and alfalfa-grass mixtures for dairy systems and assessing field carbon accumulation in mixtures compared to alfalfa monocultures.

Objectives:

- With the aim of reducing CO2 emissions and improving SOC balances by fostering increased adoption of alfalfa or alfalfa-grass mixtures as a perennial rotational crop, this project will evaluate and demonstrate innovative production strategies for alfalfa. Specific objectives are to: 1) Evaluate impacts of alternative alfalfa management practices on field-scale carbon dioxide (CO2) fluxes, labile soil carbon, and soil

organic carbon during the establishment period using a paired field approach. Comparisons will be made between traditionally managed alfalfa fields and alfalfa fields managed with the goal of improving soil carbon accumulation over a three-year period using one of the following practices: a. Cover or nurse crops for alfalfa establishment (e.g., oat, barley, triticale, Italian ryegrass); and b. Alfalfa-grass mixtures (e.g., meadow fescue, orchard grass, or intermediate wheatgrass); 2) Assess tradeoffs in net ecosystem carbon balance, field profitability, and forage productivity and quality over the 2-year project period; and 3) Develop outreach programming to engage agricultural producers in the research and share project results: a. Host a field day and develop fact sheets highlighting project results and the impacts of the treatments on field carbon balance, profitability, and forage productivity and quality.