2017 USAFRI Research Project Objectives

Developing a Soil Bioassay for Alfalfa Autotoxicity
Michigan State University - Cassida

Project Award: $29,738

Justification:

- We propose using checkoff funds to develop a practical, affordable soil bioassay for alfalfa autotoxicity. This goal addresses three of the USAFRI program priorities. It will provide a new technology tool (Priority #1) to inform decisions regarding soil management (Priority #3) during alfalfa establishment, and better establishment will improve alfalfa yields (Priority #2).

  Alfalfa autotoxicity is a well-known phenomenon that has never been fully explained. What we know is that alfalfa contains a water-soluble compound or compounds that are allelopathic to new alfalfa seedlings. While there are several leading candidates, the specific chemical entities have never been definitely identified, thus confounding any attempt to measure them directly. Autotoxicity causes direct failure of germination and seedling establishment in some cases, but the most damaging effect is permanent damage to root systems on seedlings that appear to have established successfully. This root damage causes reduced persistence and lifetime yield for the stand, a phenomenon called autosuppression.

  The degree and duration of autoxicity and autosuppression are influenced by a complex mix of environmental, genetic, and management factors. The problem is believed to: increase with age and density of the alfalfa stand, dissipate over time after alfalfa stand termination, dissipate faster from sandy than fine-textured soils, wash out of soil with precipitation, and be reduced by tillage after alfalfa termination (Undersander et al., 2015). Response to these factors is not always evident in field studies (Seguin et al., 2002). Genotype influences toxicity of alfalfa plant extracts in vitro (Chung and Miller, 1995), but it is not clear whether this effect is related to reduced toxin concentration, increased tolerance, or both.

  Much of our knowledge on autotoxicity is obtained from laboratory bioassays using extracts of plant material. Field studies on autotoxicity are challenging because it can take several years simply to set up field plots with a range of stand ages, and it is difficult to control for all the possible interactions of environmental and management factors. In some cases, no autotoxicity was observed (Sequin et al., 2002). Best management practices for the appropriate planting delay after termination of an existing alfalfa stand are based on relatively few field studies and range from two weeks (Tesar et al., 1993) to two years (Undersander et al., 2015). This large range of waiting period leaves growers in limbo, reluctant to risk expensive seed on trial and error, and may contribute to decline in alfalfa acreage if it seems less risky to just grow something else. Growers need an answer to the question, “is it safe to replant alfalfa, right now?” From this practical perspective, it is not necessary to quantify all the factors that contributed to autotoxicity status of particular soil, but simply to answer “yes” or “no” to alfalfa planting decisions. With this one-year funding, we propose to develop and begin validation of an affordable, rapid bioassay for field soil that can be used to evaluate the autotoxicity status of a field and assist farmers with planting decisions for alfalfa. This assay can be offered through MSU Plant Diagnostic Services to farmers across the country, or adopted by other diagnostic services.

  Michigan State University is well situated to conduct this work. In 2017, Michigan had

alfalfa hay acreage of 780 thousand acres, comprising 73% of the perennial forage acreage in the state (USDA, NASS, 2018). MSU's alfalfa variety test (Cassida et al., 2018) is currently among the largest public tests by number of entries and provides access to different soil textures with a range of alfalfa stand ages, locations, and alfalfa genetics. The PIs have well-equipped laboratory, greenhouse and growth chamber space. MSU Diagnostic Services was established in 1999, with diagnosticians specializing in plant pathology, entomology, nematology, and weed science to serve a wide variety of clients, ranging from regulatory agencies and agricultural businesses to commercial growers and homeowners. Diagnostic Services currently conducts a variety of bioassays as needed including soil bioassays to assess herbicide carryover. The addition of a bioassay testing alfalfa autotoxicity would be a natural fit within the clinic.

The potential long-term impact of this project on alfalfa acreage includes an increase in alfalfa acreage that might otherwise be switched to another forage crop. This impact can be monitored via acres of alfalfa planted and tonnage of alfalfa harvested as forage. Another longterm impact includes the ability to use bioassay results to monitor autotoxicity over a wide range of environments, alfalfa genetics, and management systems. Such a "big data" approach allows much faster progress in identifying trends than does conducting controlled field experiments for every possible combination of factors. Short-term goals include collection of preliminary data for a larger research proposal that could examine some of specific combinations of autotoxicity actors in detail with end goals of developing better predictions for autotoxicity dissipation rates and identifying specific toxins.

Objectives:

- The objective of this project is to 1) Develop a bioassay for evaluation of alfalfa autotoxicity potential in field soils.