California Leafy Greens Research Program
FINAL REPORT
April 1, 2022 – March 31, 2023

Continued monitoring of nitrogen management strategies for leafy greens using soil health metrics

Principal investigator:
William Horwath, Principal Investigator, University of California – Davis
3226 Plant and Environmental Sciences Building, Davis, CA 9561
Email: wrhorwath@ucdavis
Phone: 530-752-5262

Cooperating personnel:
- Cole Smith, Staff Research Associate, University of California - Davis/ANR
- Stefanie Kortman, Research Scientist, California State University - Monterey Bay
- Arlene Haffa, Associate Professor, California State University - Monterey Bay

Abstract
Production of leafy greens is intensive, requiring high chemical inputs, frequent cultivation, and heavy overhead and/or surface irrigation. These management requirements make the implementation of techniques to build soil health and sequester carbon challenging. Yet, given the abundant availability of nutrients - such as nitrogen - these systems, compared to others, may be able to rapidly build soil organic matter and store more soil carbon with minimal management changes, such as low-rate compost application. Improving soil health in lettuce production has many agronomic co-benefits including increased soil organic N, reduced need for N fertilizer and improved crop nitrogen use efficiency (NUE), and improved crop resilience to extreme weather events. While proven in many other cropping systems, there is a lack of data to validate these outcomes in lettuce. As new Central Coast Regional Water Quality Control Board regulations restricting the amount of applied fertilizer become reality, growers will need to innovate to increase NUE and optimize crop performance. Our project builds on our field trials and extension efforts focused on sustainable N management. Our primary goals include the increased adoption of tools and techniques to increase sustainability and improve soil health within lettuce production systems. To achieve these goals, we continued to collect additional crop and N loss data from our multi-year field site to monitoring and model N cycling. Overall, our project aims to increase information concerning sustainable N management and promote tools for the lettuce industry to improve soil health outcomes without impacting agronomic efficiency within these challenging systems.

Objectives

1. Evaluate the single season N impact of low-rate compost application on lettuce crop performance, soil health and greenhouse gas emissions. Completion of the objective will improve grower recommendations concerning the integration of organic matter amendments into nitrogen management plans.

2. Increase the knowledge of soil health and sustainable nutrient management practices in central coast leafy green production systems through direct outreach and education provided to growers, technical assistance providers, and government employees.

Materials and Methods

Field Trials

In partnership with D'Arrigo California, we carried out a replicated, two-level split plot field experiment that included three N application rates, grower standard (GS), Conservation Practice Standard (CPS) or No N, as the main factor and compost application at a rate of 5 d.w.t./acre as the secondary factor. The treatments were implemented over two cropping periods. Leaf (Lactuca sativa) lettuce, were grown over the 2021 season, harvested in May and September. Crop biomass and its N content in dry weight percent was determined by combustion analysis on a Costech EAS 4010 elemental analyzer. Microbial biomass was determined using chloroform fumigation. Gas measurements were made using in situ static chambers and analyzed on a gas chromatograph (Model 2014, Shimadzu Scientific Instruments). Mean cumulative area-based N_2O fluxes were calculated.

Biogeochemical Modelling

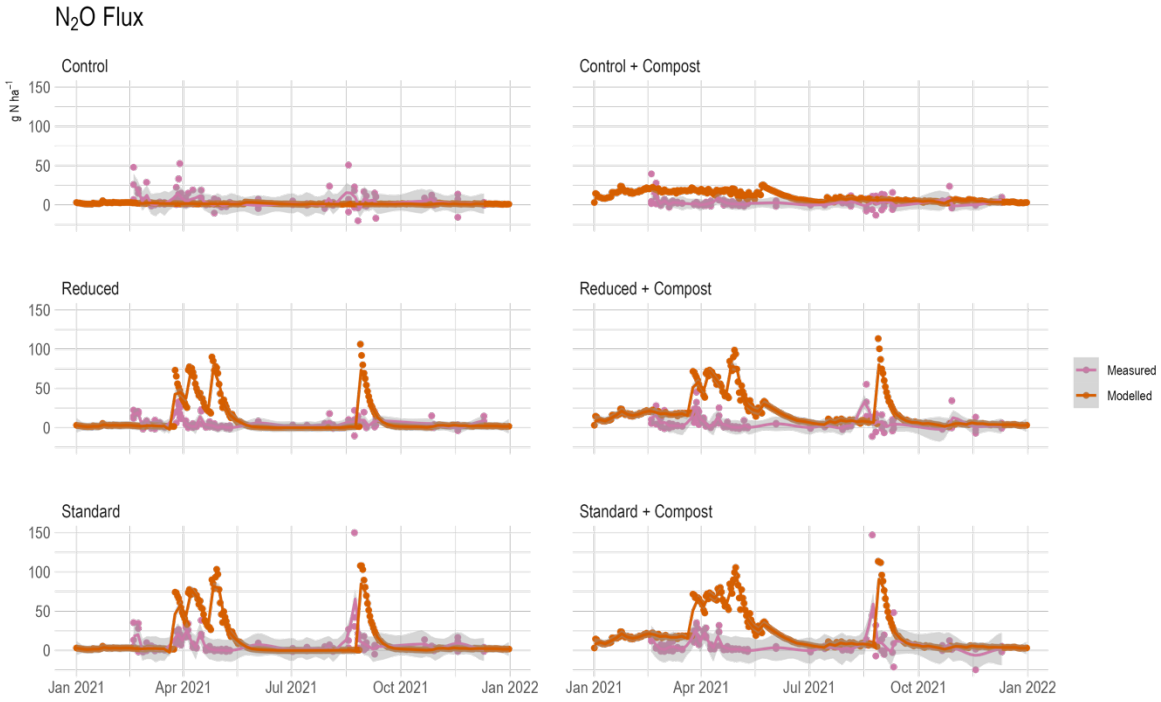
The DayCent biogeochemical model simulates C and N cycling through the soil, plant, and atmospheric systems (Del Grosso et al., 2001). Model iterations are carried out at daily time steps, providing for a high-resolution picture of nutrient pool fluxes. Using the data from our multi-year field trial, we expanded the dataset for model improvement for leafy green crops under conservation management practices. In this project, the current model was run using field data and an evaluation of model performance was quantified using various statistical measures including root mean square error (RMSE) and coefficient of determination (r^2).

Outreach

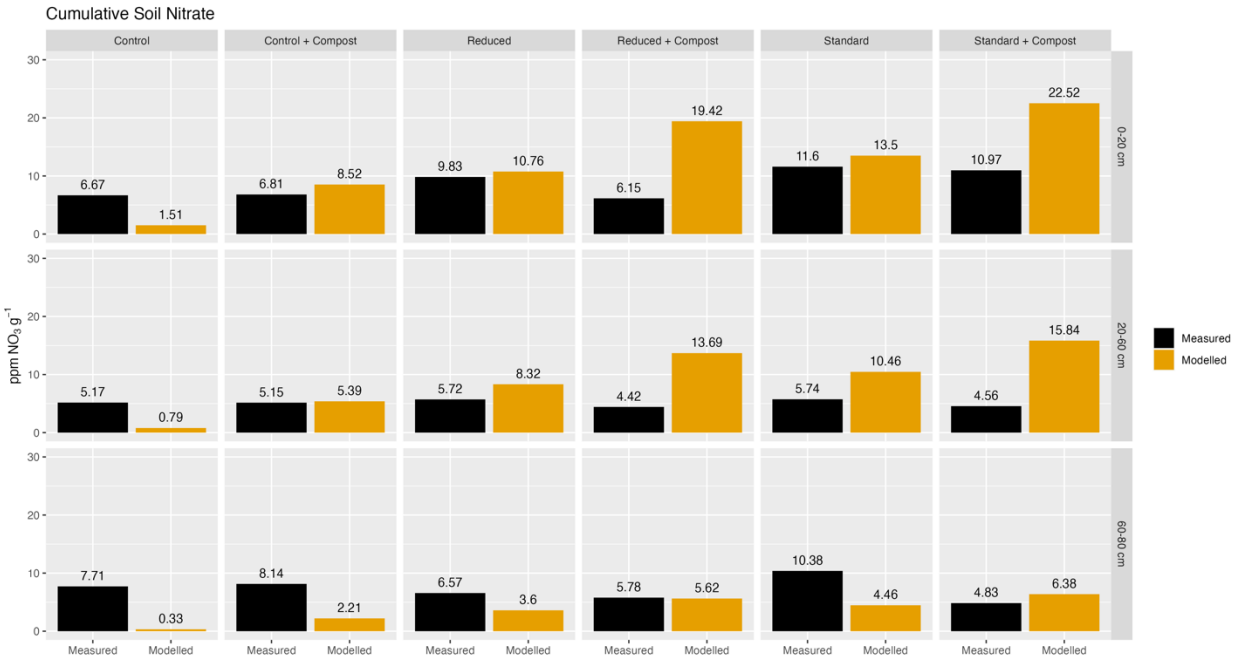
A workshop was carried out on December 9th 2022 that focused on sustainable nutrient management and soil health in Salinas, CA hosted by UC ANR and CSUMB. The morning portion of the day was held as a lecture style offering covering topics such as climate-smart agriculture, organic amendments, soil health and CCRWQCB nitrogen discharge regulations. In afternoon, attendees were invited to visit our field trial for hands on demonstration of soil health assessments and organic amendment calibration.

Results

- **Daycent Model Performance**
  Two nitrogen pools, nitrous oxide and soil nitrate N, were modelled and compared to measured data. Overall, the model tended to overestimate N loss. For N_2O, the model fit to measured data was poor (RMSE = 28.47; r^2<.01). The difference between total emissions for the treatments receiving compost were much higher than for those not receiving compost. For example, in the Grower's Standard treatment the model estimated a N loss of 20.71 g N ha^{-1}, whereas the measured value was 8.12 g N ha^{-1}.



Nitrogen loss as nitrate nitrogen was modelled and measured at three depth increments (0-20, 20-60, 60-80 cm). The modelled fit to measured data was better for nitrate (RMSE = 14.44; r^2<0.01). The model tended to overestimate soil nitrate for the treatments receiving compost, specifically in the upper layers of the soil 0-20 cm, but underestimate for the control treatments.



- **Sustainable Nutrient Management and Soil Health Field Day**
  At the field day, we had 49 total attendees from diverse backgrounds including certified crop advisors, sustainability managers and non-profit staff serving agriculture. Attendees were offered 5 continuing education credits for their attendance.

Summary

Our on-going efforts to improve sustainable nutrient management in leafy greens through research and outreach were bolstered by this project. Major take-aways from our biogeochemical modelling efforts show that if decision support tools that rely on these types of models are going to be used to assess the impacts of conservation management, more work is needed to calibrate them to specific management situations experienced under leafy green production, such as drip fertilizer application. Our direct measurements show that much less N is likely being loss from the system under conservation management than the model estimates. It is imperative that the model is improved before it is used to account for agricultural GHG emissions or nitrate loss to the environment.