Evaluating Nitrogen Management Strategies to Minimize Reactive Nitrogen

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Introduction

A challenge facing California almond growers is to optimize nitrogen use efficiency (NUE), here defined as N assimilated by the tree as a percent of applied N plus mobilized reactive N (N_2O and NO_3^-). Ideally, the applied N fertilizer is fully taken up from soils by the tree (NUE=100%), where it contributes to both growth and nut production. In reality, some of the N is released in various gaseous forms to the atmosphere and some as nitrate (NO_3^-) leached below the root zone. Understanding N leakage means unlocking the complexities of what happens when water, nitrogen, and soil microbes interact in the orchard under varying conditions.

The ultimate goal is to identify Best Management Practices (BMPs) with superior NUE in almond production, and maximize yield economically while minimizing offsite transport of reactive forms of N — primarily N_2O, a potent greenhouse gas (GHG), as well as NO_3^- into groundwater. Our experience with BMPs trials over two years suggests that limiting water and N to the root zone increased N residence time and minimized N losses to the atmosphere as well as the groundwater. We hypothesize that computer assisted applications that provide high frequency of low N concentrations (HFLC) will optimize and standardize a new fertigation strategy.

Objectives

- To evaluate temporal variability of GHG emissions with respect to environmental factors such as volumetric water content and seasonal temperature variation.
- To assess residence time of applied N in the root zone of an almond orchard using HFLC approach.
- To elucidate N fate in a shallow groundwater location using HFLC nutrient management practice.
- To quantify NUE during HFLC management of N additions in a California almond orchard.

Methods

- This study is conducted in an approximately 30 ha commercial almond orchard in Modesto, California, irrigated with locally pumped groundwater and fertigated with Urea Ammonium Nitrate (UAN) with one broadcast event of Calcium Ammonium Nitrate.
- Fertigation by micro sprinklers and drip emitters for 2017 season followed growers management practices, allowing baseline data collection.
- Computer assisted fertigation (HFLC) has begun post 2017 harvest and will continue through 2018 season.
- Equipment arrays were installed at 8 locations monitoring root, vadose zone and groundwater dynamics (Figure 3).
- Static gas chambers were placed at distances of 0cm, 50cm, 100cm, 150cm, and 200cm from fertigation sources in each of 4 experimental blocks (3 reps per block) (Figure1).

Figure 1: General setup of static gas chamber collars in orchard rows.

Results, Workflow and Predictions

Madera 2015-2016

- Field trials show that HFLC nutrient management significantly reduced nitrogen losses to the atmosphere (Figure 2).
- HFLC demonstrated a significant reduction in greenhouse gas emissions in regard to other treatments.
- No significant difference in yield resulted from three fertigation management practices.

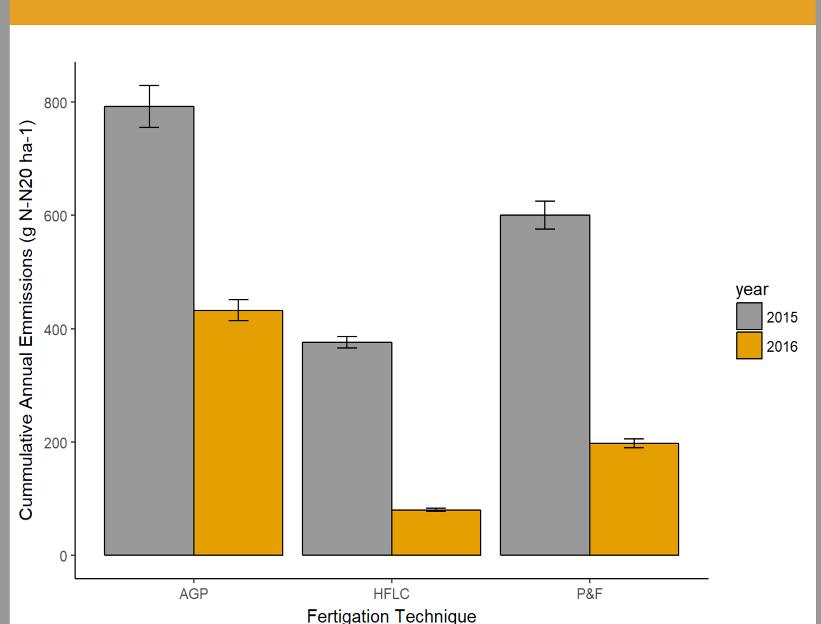

Figure 2: Total N losses to the atmosphere from each treatment for the 2015 and 2016 growing season. Treatments: Advanced Grower Practice (AGP), High Frequency Low Concentration (HFLC) and Pump and Fertigate (P&F).

Modesto Site 2017-2018

- Shallow depth to first contact with groundwater provides ability to close N cycle through direct monitoring of nitrate leaching
- Incorporate computer assisted technology to ease farmer burden for implementation of HFLC nutrient management strategy
- Provide orchard wide analysis of HFLC with more complete N cycle using two fertigation distribution heads (fan-jet micro sprinklers and drip emitters)

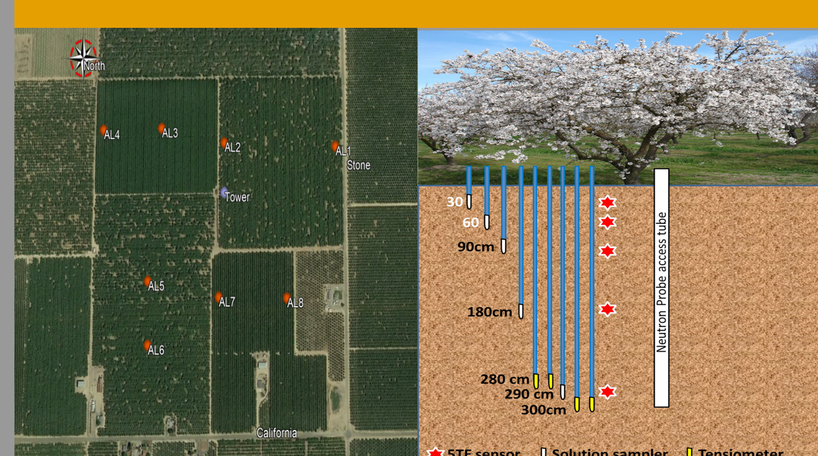

Figure 3: Left: Arial photograph of the new research site showing sampling arrays AL1-AL8 and Eddy Covariance tower. Right: Each array consists of a neutron probe tubes, five solution samplers at various depths, four tensiometers at two depths, and a flow meter (not shown).

Modesto Site 2017

- Develop field site and study blocks.
- Design and install computer assisted irrigation technology. (pH Technologies)
- Design and install monitoring equipment.
- Begin baseline greenhouse gas sampling with standard grower fertigation management.

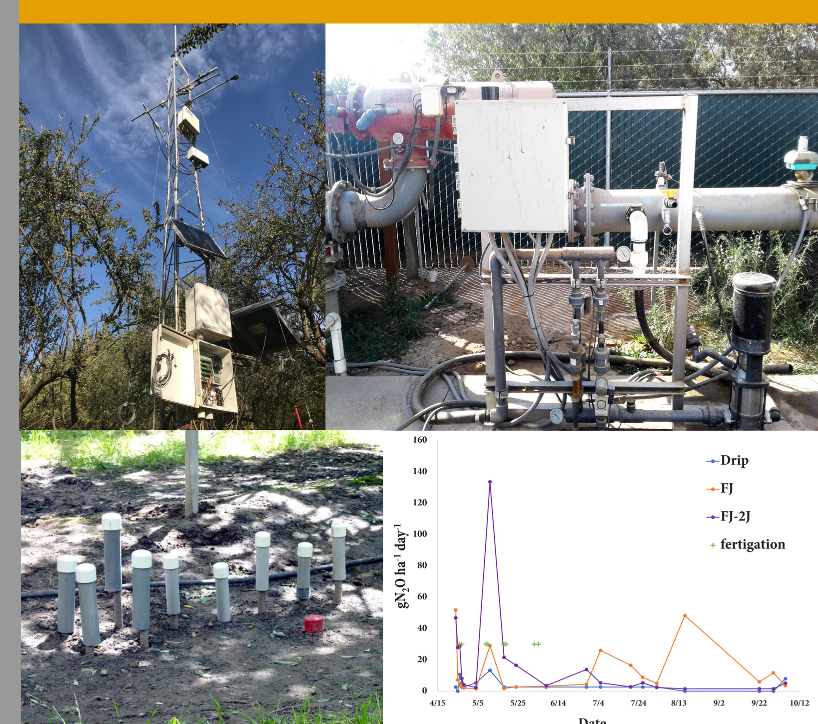

Figure 4: Top left: Eddy Covariance/Flux tower. Top right: pH Technologies computer controlled fertigation injector. Bottom left: Arrays of soil solution instrumentation. Bottom right: Baseline N2O flux data for 2017 for each emitter treatment (fan-jet micro sprinklers (FJ) and drip emitters (Drip).

Modesto Site 2018

- Monitor complete N cycle through out growing season.
- Determine effective NUE using computer assisted HFLC (identify and quantify losses).
- Elucidate vadose zone N dynamics under HFLC management.
- Validate a Yield-Scaled Global Warming Potential for HFLC orchard.

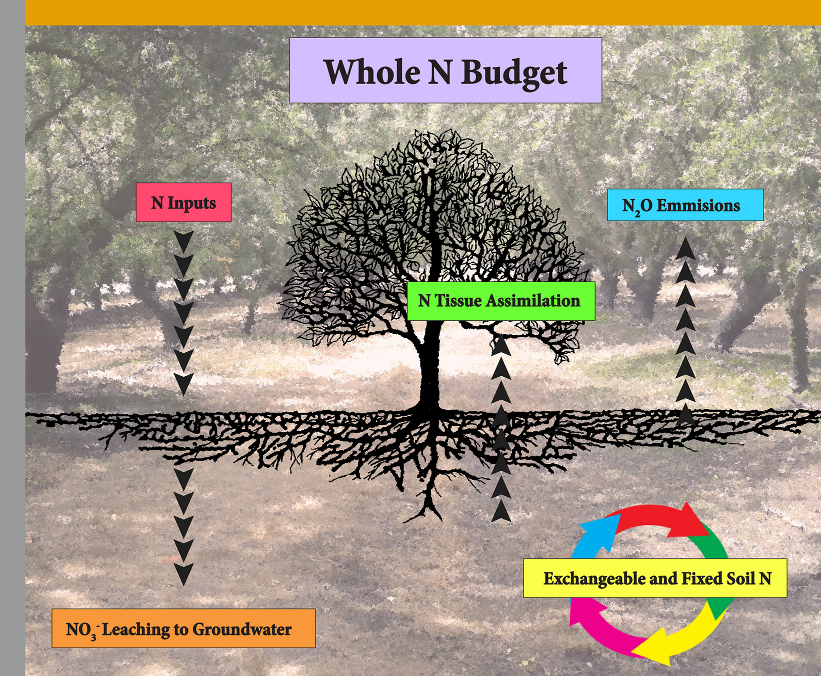

Figure 5: Orchard nitrogen budget approach, attempting to close the cycle through monitoring of N flows.

Acknowledgments

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