Reducing Reactive-N Loss from Fertigation:

High-Frequency Application and Fertilizer Selection

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Introduction

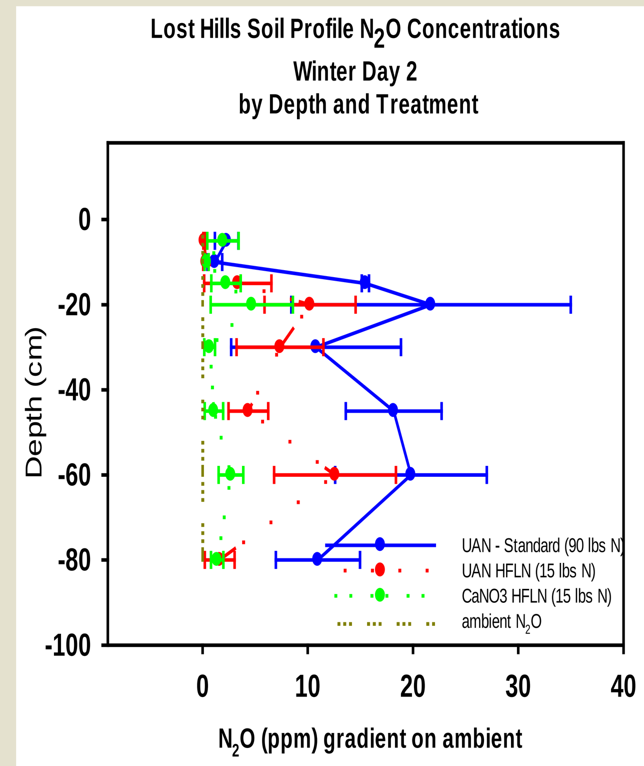
High-Frequency Low-Nitrogen fertigation (HFLN), also called "split-application," is a little-investigated and simple approach which may reduce nitrate (NO_3^-) leaching. It may also reduce emissions of the important greenhouse gas nitrous oxide (N_2O) in some systems, depending upon the N fertilizer used, and upon soil microbial community effects. Choice of N fertilizer can have important effects on the location and magnitude of N_2O production (Smith *et al.*, 1997), as well as on the microbial processes which applied N will undergo. Information on the quantity of NH_4^+, NO_3^- and N_2O at different depths in the soil profile following fertigation is essential to explaining any differences seen in NO_3^- loss or N_2O emission when comparing N-fertilizers and N-fertigation systems.

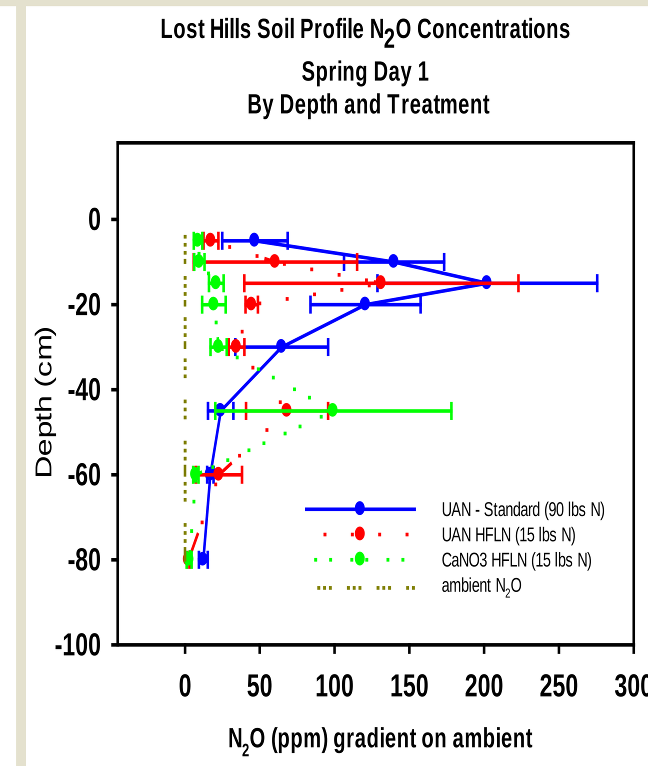
Treatments

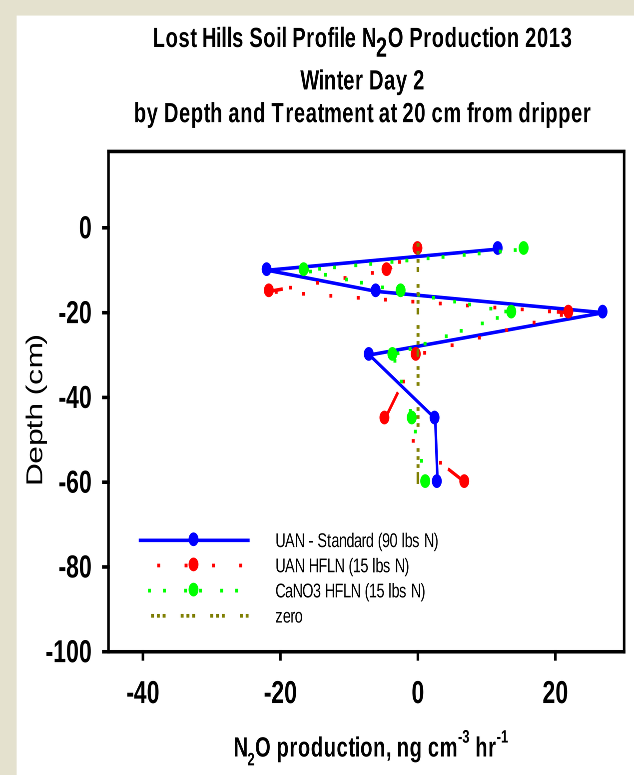
1. UAN-Standard: UAN applied over 4 fertigations, 300 lbs N/acre
2. UAN-HFLN: UAN applied over 20 fertigations, 300 lbs N/acre
3. NO_3-HFLN: $Ca(NO_3)_2$ (61%) + KNO_3 (39%) applied over 20 fertigations, 300 lbs N/acre

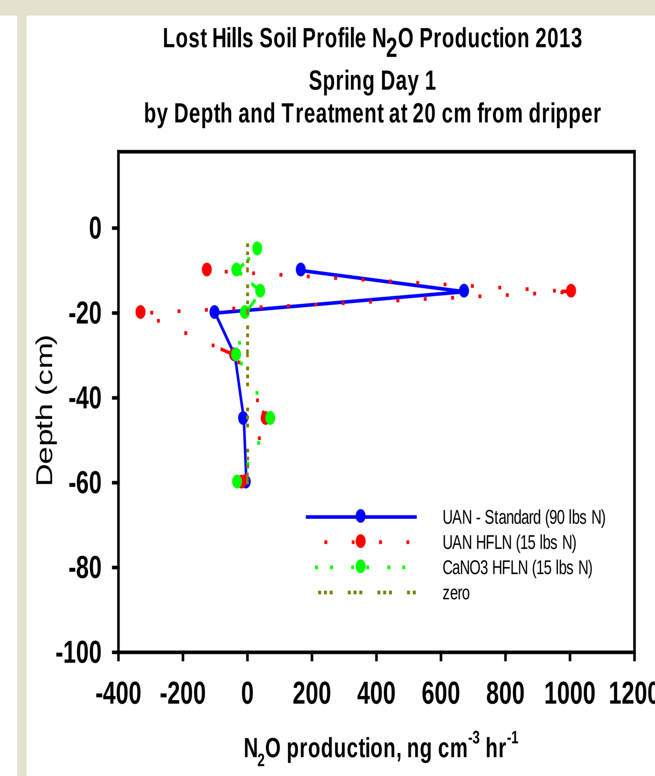
Hypotheses

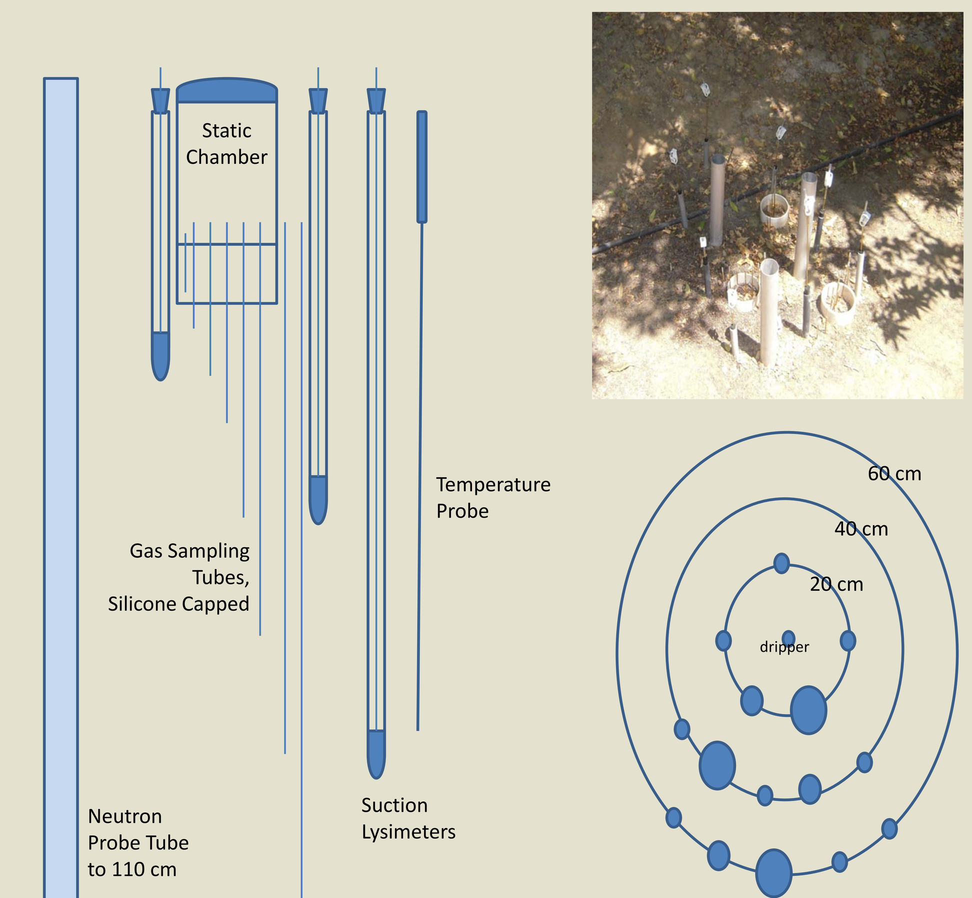
HFLN was expected to reduce NO_3^- leaching and total N_2O emissions. Within HFLN, we expected a high-NO_3^- treatment to yield lowest N_2O emissions. Determining factors were expected to include N concentration in soil solution, species of N, conditioning of soil microbial community, and location of applied N in the soil profile.











Study Array for belowground N

Preliminary Results

1. **NO_3^- leaching results do not appear likely to show differences**. However, the higher quantities of N_2O found at 80 cm depth under Standard fertigation suggest greater N penetration into the soil profile under Standard.
2. The first year's data showed **slightly lower yield under HFLN**, although differences were not significant. HFLN scheduling may require modification.
3. **HFLN with UAN has little to no effect on N_2O** emissions vs. standard fertigation strategies.
4. **HFLN with high-NO_3^- fertilizers lowers N_2O emissions significantly compared to HFLN-UAN.** HFLN may be a good option using high-NO_3^- fertilizer formulations, with lower N concentrations reducing NO_3^- leaching risks.
5. Patterns of N_2O production in the soil profile clearly show the **spatial separation of processes affecting different N fertilizer sources.** Very high amounts of N_2O are recorded in the soil profile, up to 1000x higher than ambient. Most N_2O appears to be consumed within the soil rather than emitted from the surface.

Net N_2O Production/Consumption Rate per soil layer, calculated using points of profile gas concentration

$$\alpha_i = \frac{q_i - q_{i+1}}{\frac{Z_i+Z_{i+1}}{2} - \frac{Z_i+Z_{i-1}}{2}} + \frac{dc_i}{dt} V_{Ai}$$

Cumulative Flux (g·tree^{-1})	0 - 10 cm		0 - 50 cm	
	Mean	SE	Mean	SE
Gross mineralization (m)	8.70	3.15	11.4	3.80
NH_4^+ consumption (c_{NH4})	12.3	2.38	15.1	2.93
Gross nitrification (n)	5.20	0.46	12.3	1.74
NO_3^- consumption (c_{NO3})	6.63	0.34	15.1	4.50
Gross N immobilization (i)	13.3	2.24	16.7	5.52

N_2O Production/Consumption in Soil

Combining results like those above with water-filled pore space data (WFPS) can reveal rates of net N_2O production and consumption, using the 1-dimensional model to right, above (Yoh, 1997).

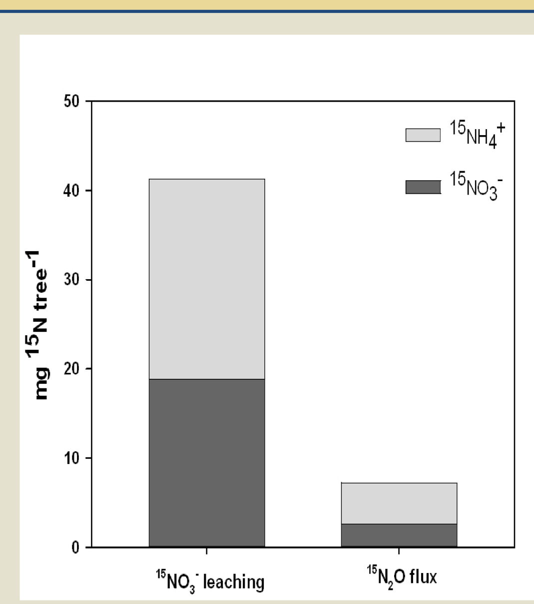
Studies of 15-N fate in this soil (right) show the effects of soil depth on the dominant processes affecting applied Nitrogen.

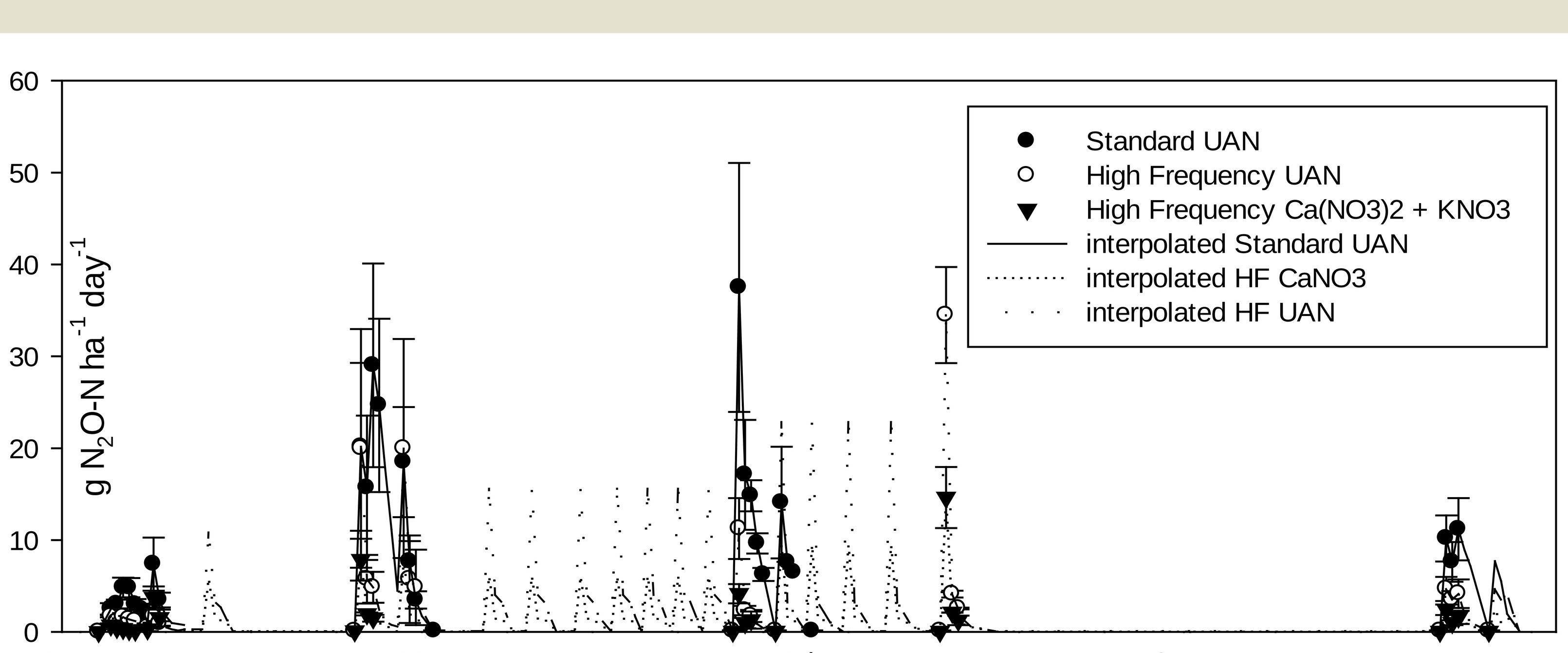
Combined with soil parameters, such data may facilitate the development of N_2O predictions using hydrological models.

N_2O Emissions

Fertigation Strategy	Fertilizer	Emission Factor (%)	Annual N_2O Emissions (g N_2O-N ha^{-1} yr^{-1})	Sig. (p<.05)
Standard	UAN	0.23	780.56	ab
HFLN	UAN	0.31	1036.13	a
HFLN	$Ca(NO_3)_2$	0.15	511.17	b

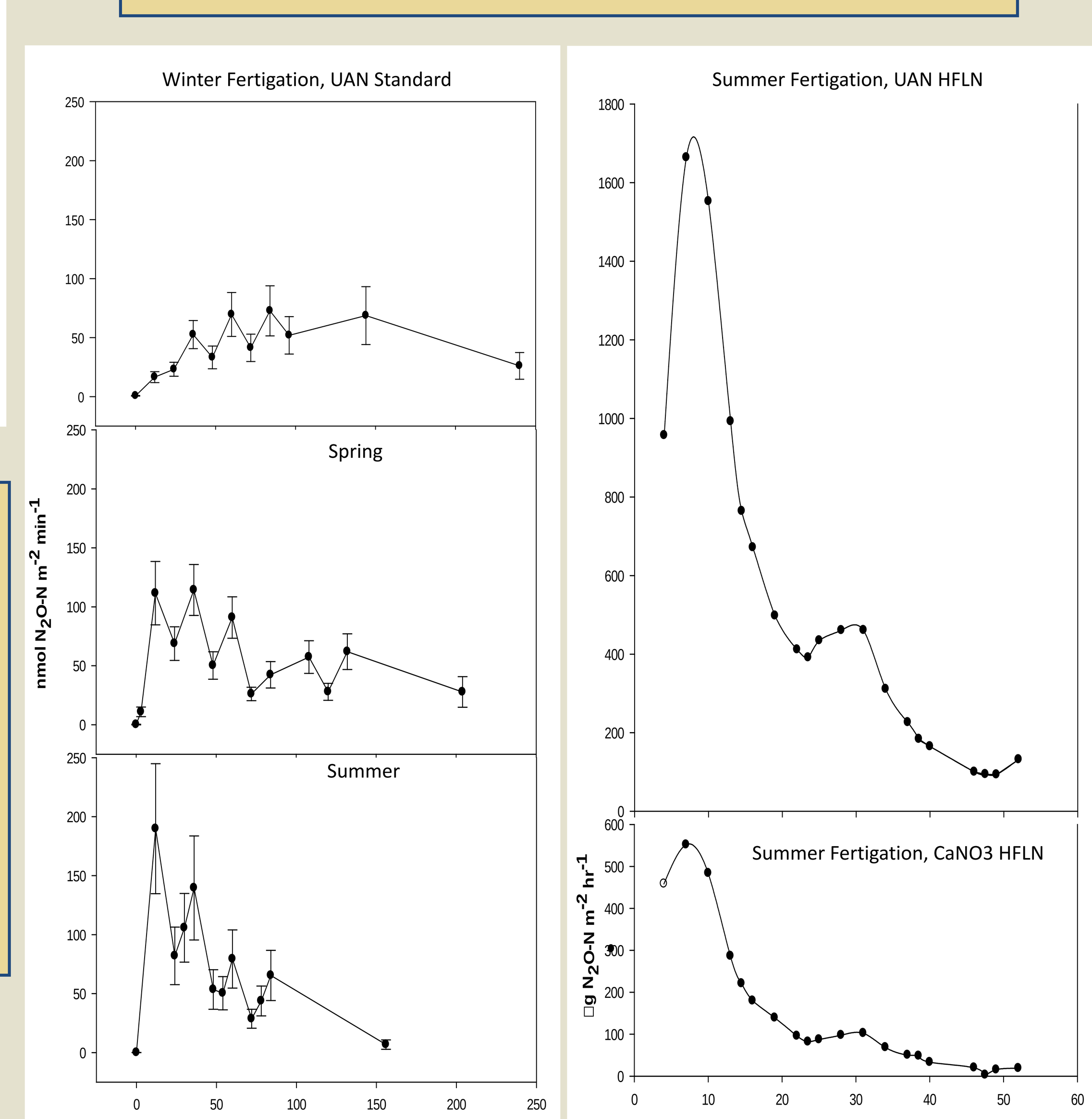
Comparison of NO_3^- Loss and N_2O Emissions





Diurnal N_2O Emissions after Fertigation

Careful diurnal monitoring is necessary to quantify N_2O emissions following applications of fertilizer N. Temperature differences cause varying patterns by season, left and below.



Questions for Improved N Fertigation:

- *What difference does applied N concentration make to N_2O production?*
- *Does frequency of N-fertigation affect soil microbial N-processing rates?*
- *What is the contribution of nitrifiers to N_2O production at shallow depth?*
- *When choosing an N-fertilizer, should fertigation strategies consider the moisture levels the fertigation will produce, at various depths?*
- *How will choice of applicator (surface drip, subsurface drip, fanjet, etc.) affect mobile N loss?*
- *Can hydrological models be equipped to predict N_2O emissions, as they already predict NO_3^- loss, under various fertigation strategies?*

Methods

N_2O emissions and NO_3^- losses are being assessed in a San Joaquin Valley almond orchard (*Prunus dulcis)* in Belridge, California under drip fertigation laid out in an RCB design with 5 blocks. Yield is being evaluated over 5 years. The soil is a calcareous sandy loam (pH 8.3) with two clay layers (50-80 cm, approx. 30% clay; 180-250 cm approx. 45% clay).

N_2O emissions are evaluated using static chambers with 2, 10-minute fluxes. Evaluations take place at each Standard fertigation, 4x/year (February, April, June, September). They include emissions from the first 3-5 days following fertigation, as well as the 3 days following the next irrigation. Chambers are placed at 4 distances from the dripper (0, 20, 50, 90 cm), which are used for emissions estimates assuming radial symmetry. Treatments are compared as N_2O emitted/N applied.

At 20 cm from the dripper, the location of highest N2O efflux, 1/8" brass tubes sample soil gas at 5,10,15,20,30,45,60 and 80 cm deep. Suction lysimeters sample soil solution for NH_4^+ and NO_3^- at 15, 30 and 60 cm. A Campbell Hydroprobe is used to evaluate water-filled pore-space at intervals from 15 to 90 cm. A Decagon ECH_2O probe is used to estimate surface WFPS.

NO_3^- losses are estimated using suction lysimeters at 250 cm compared to results from tensiometers at 220 cm and 280 cm to estimate infiltration rates.

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