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.

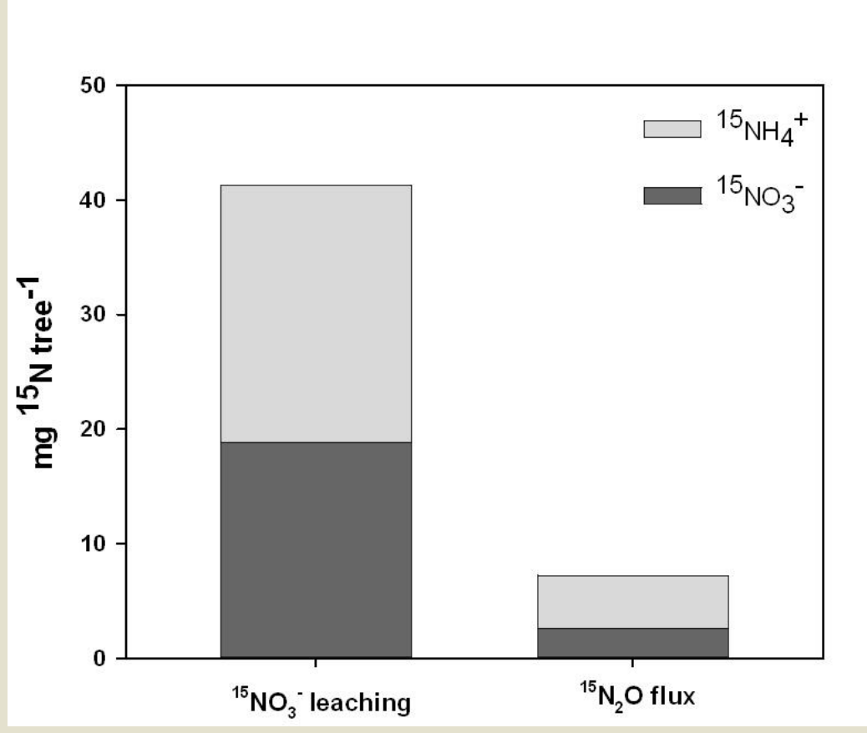
Preliminary Results

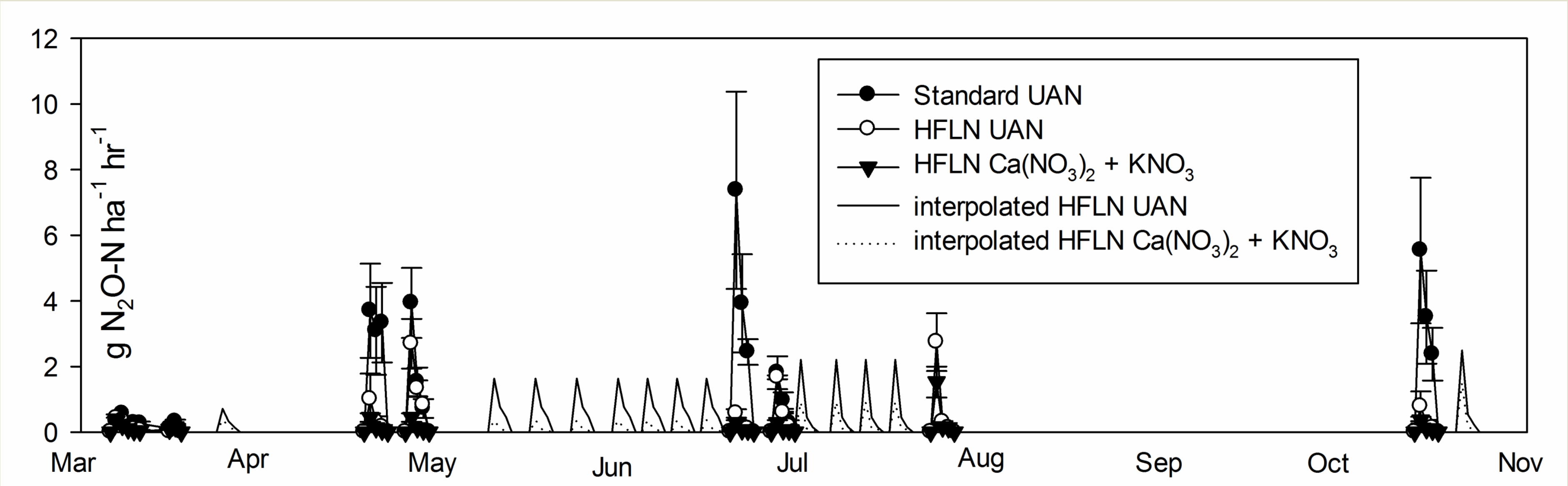
1. **NO_3^- leaching results do not appear likely to show differences**. However, the higher quantities of N_2O found at 80 cm depth under Standard fertigation suggest greater N penetration into the soil profile under Standard.
2. The first year’s data showed **slightly lower yield under HFLN**, although 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.

Preliminary N_2O Emissions

Fertigation Strategy	Fertilizer	Emission Factor	Annual N_2O Emissions	Sig. ($p<.05$)
Standard	UAN	1.08%	3.24 kg N_2O-N ha^{-1} yr^{-1}	a
HFLN	UAN	0.90%	2.70 kg N_2O-N ha^{-1} yr^{-1}	a
HFLN	$Ca(NO_3)_2$	0.49%	1.47 kg N_2O-N ha^{-1} yr^{-1}	b

Preliminary Comparison of NO_3^- Loss and N_2O Emissions





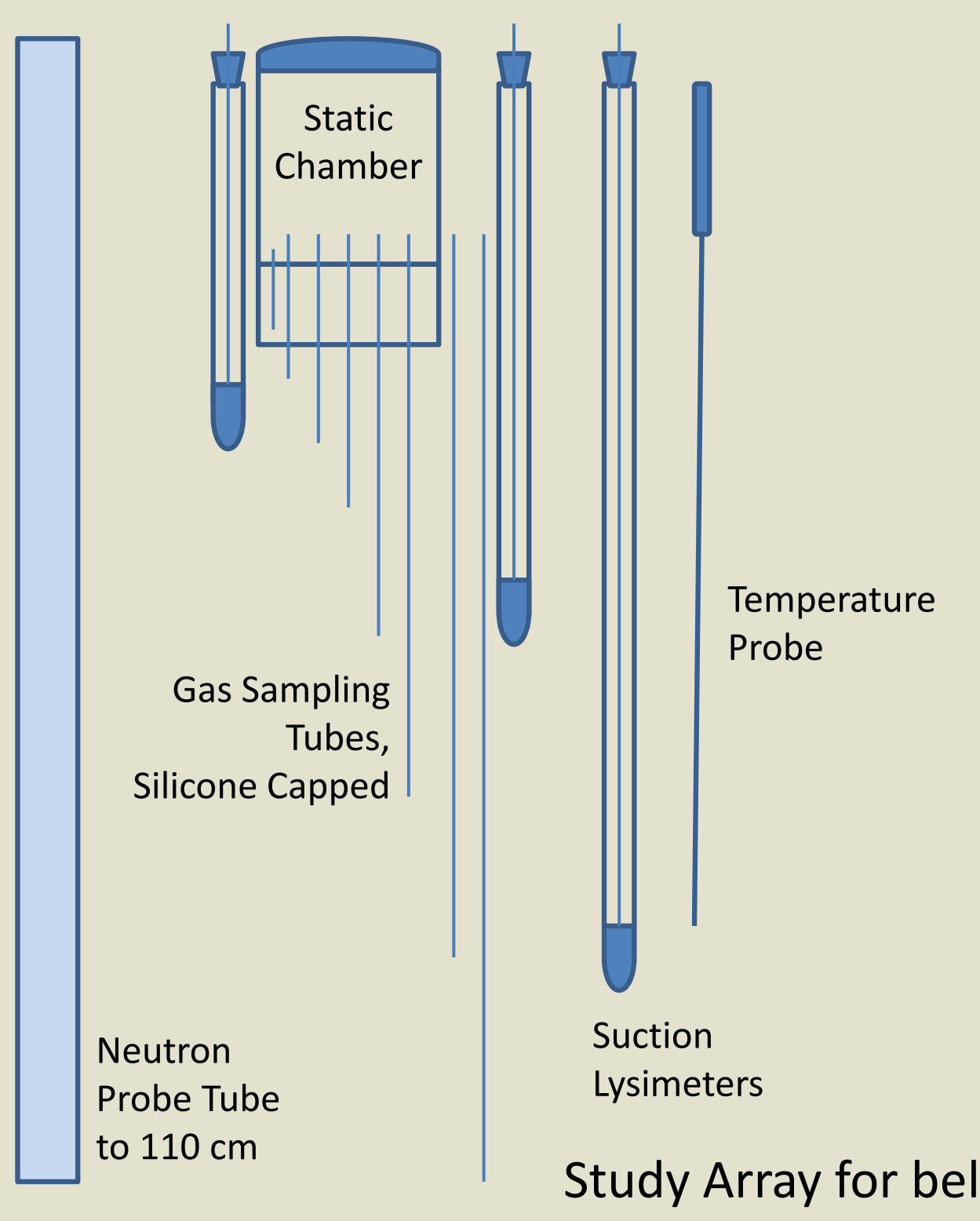
Methods

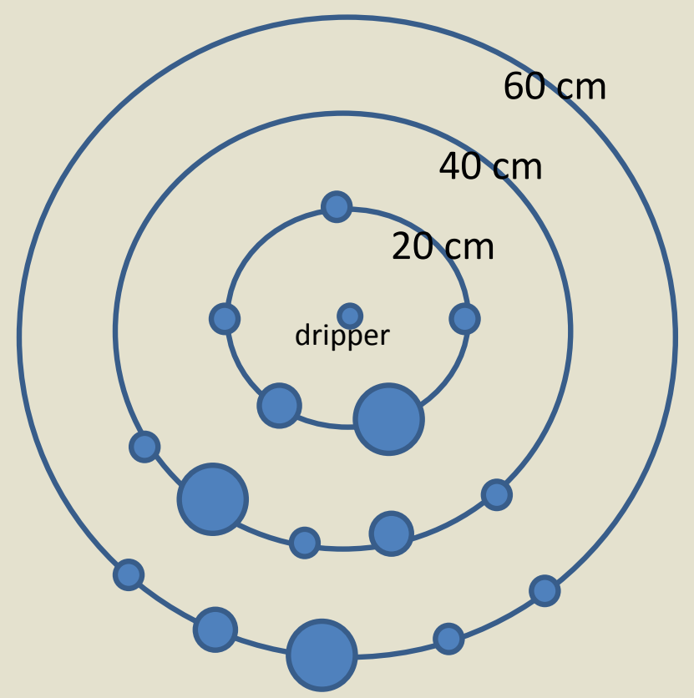
N_2O emissions and NO_3^- losses are being assessed in a San Joaquin Valley almond orchard (*Prunus dulcis)* in Belridge, California under drip fertigation laid out in an RCB design with 5 blocks. Yield is being evaluated over 5 years. The soil is a calcareous sandy loam (pH 8.3) with two clay layers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

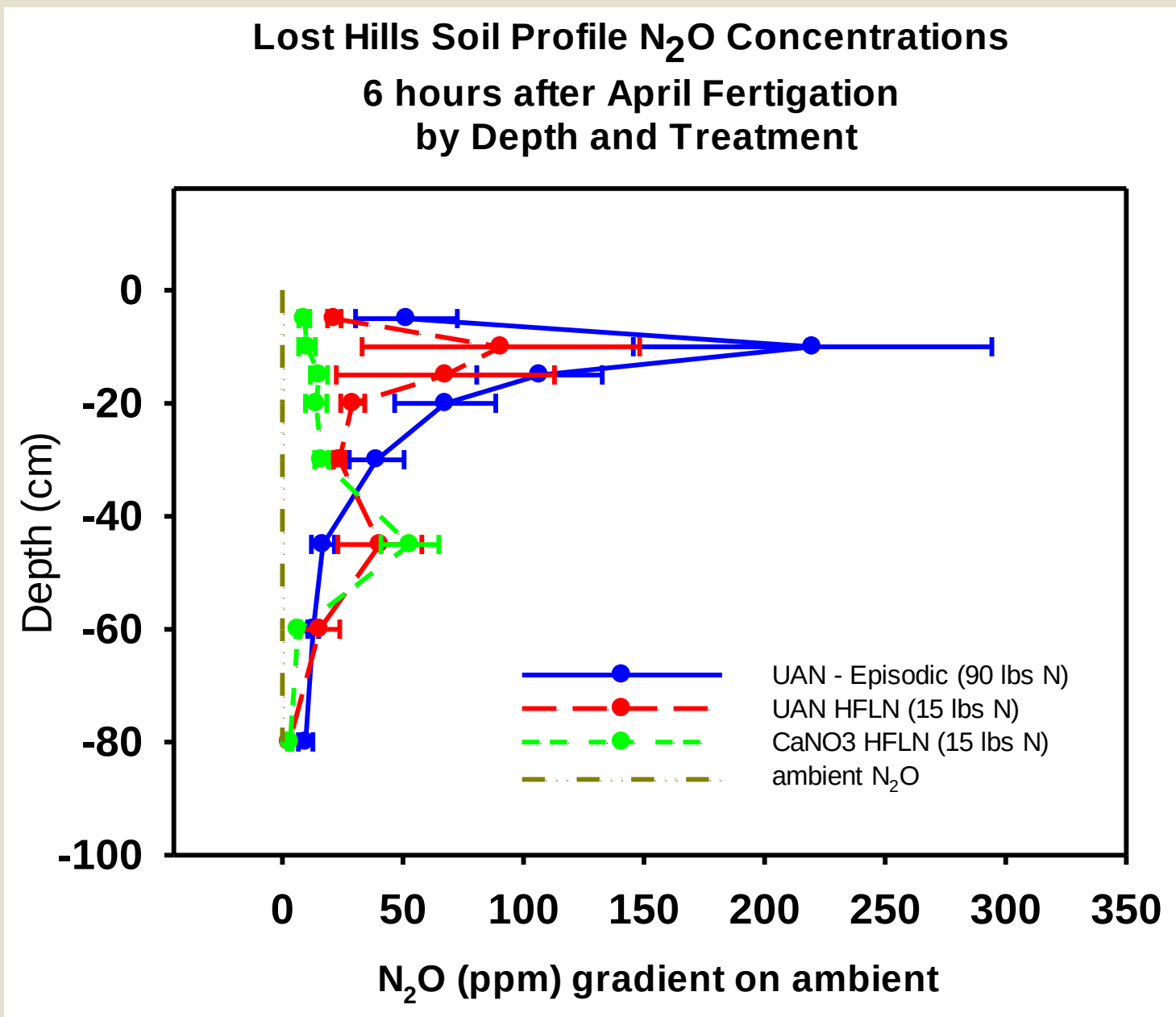
At 20 cm from the dripper, the location of highest N2O efflux, 1/8” brass tubes sample soil gas at 5,10,15,20,30,45,60 and 80 cm deep. Suction lysimeters sample soil solution for NH_4^+ and NO_3^- at 15, 30 and 60 cm. A Campbell Hydroprobe is used to evaluate water-filled pore-space at intervals from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

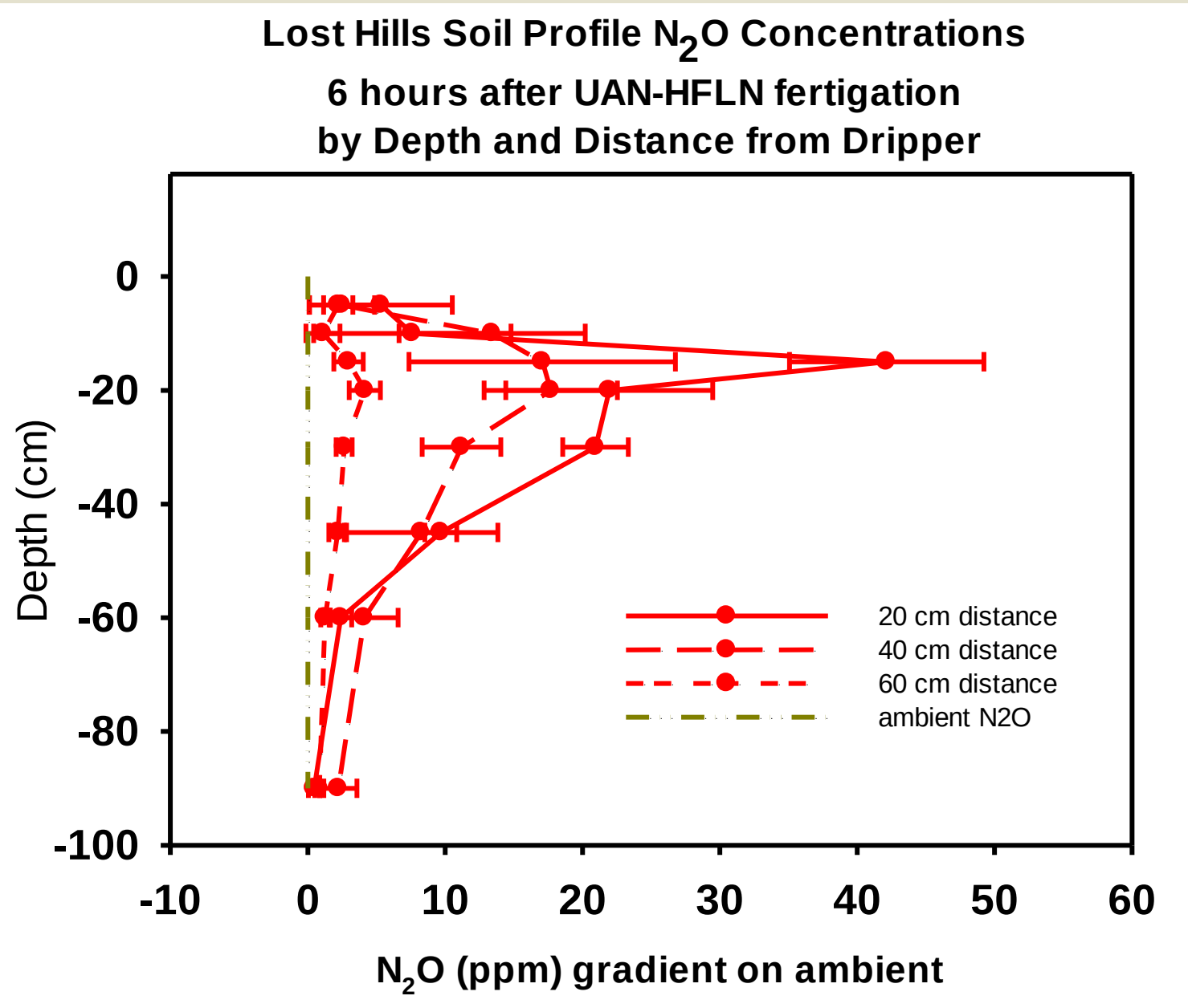
NO_3^- losses are estimated using suction lysimeters at 250 cm compared to results from tensiometers at 220 cm and 280 cm to estimate infiltration rates.





Study Array for belowground N





N_2O Production/Consumption in Soil

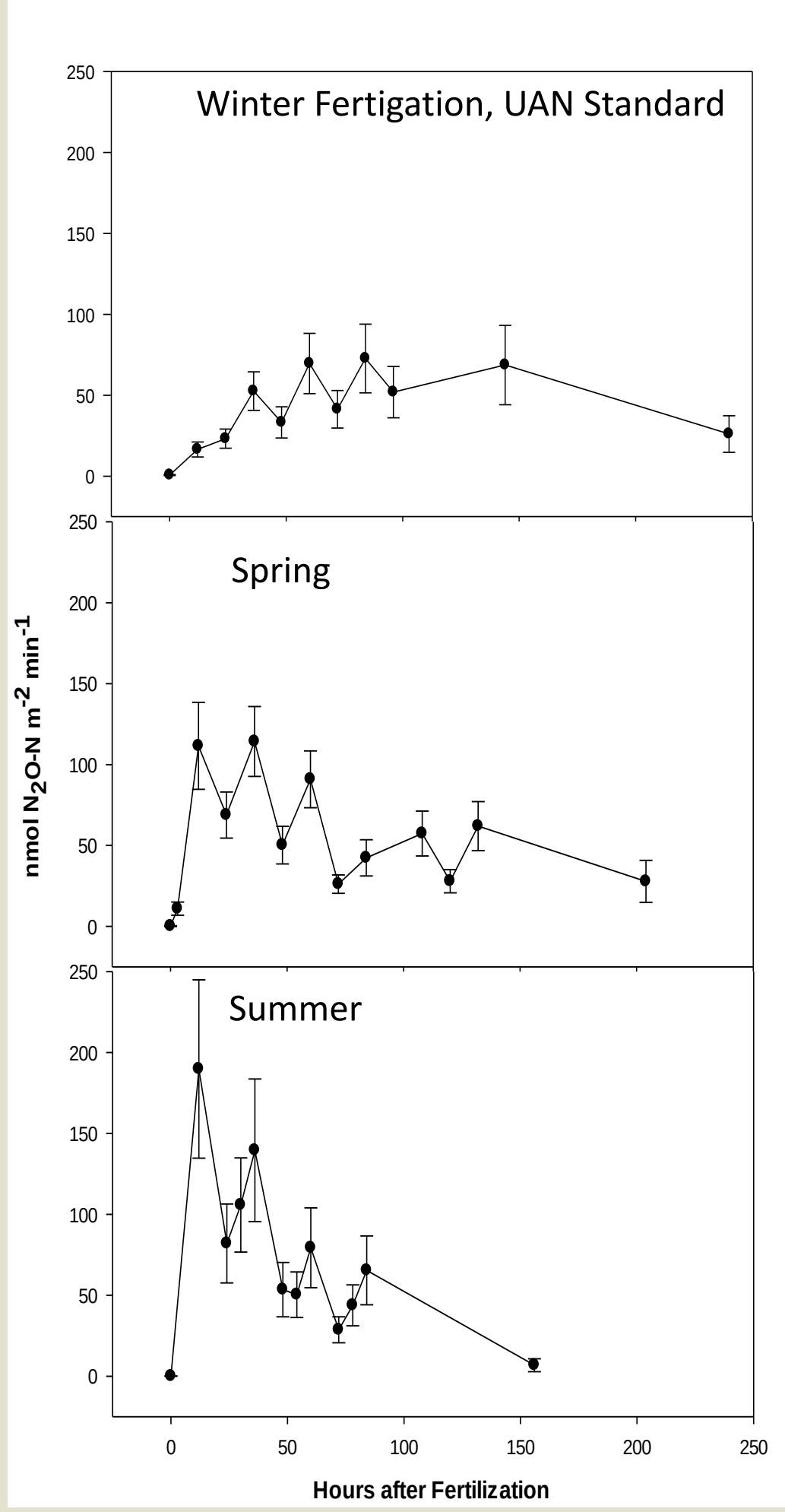
Combining results like those above with water-filled pore space data (WFPS) can reveal rates of net N_2O production and consumption, using the 1-dimensional model to right, above (Yoh, 1997).

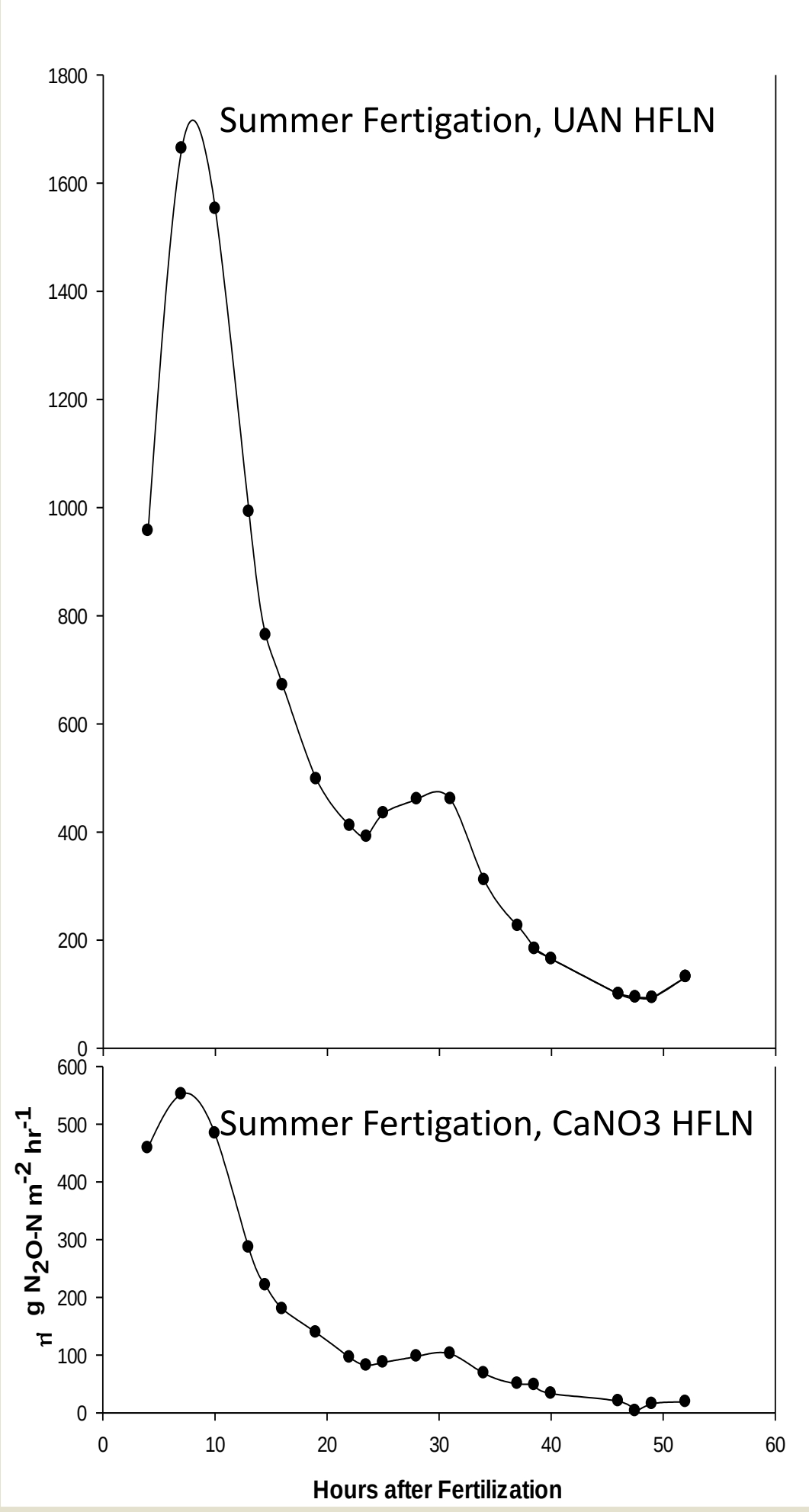
Studies of 15-N fate in this soil (right) show the effects of soil depth on the dominant processes affecting applied Nitrogen.

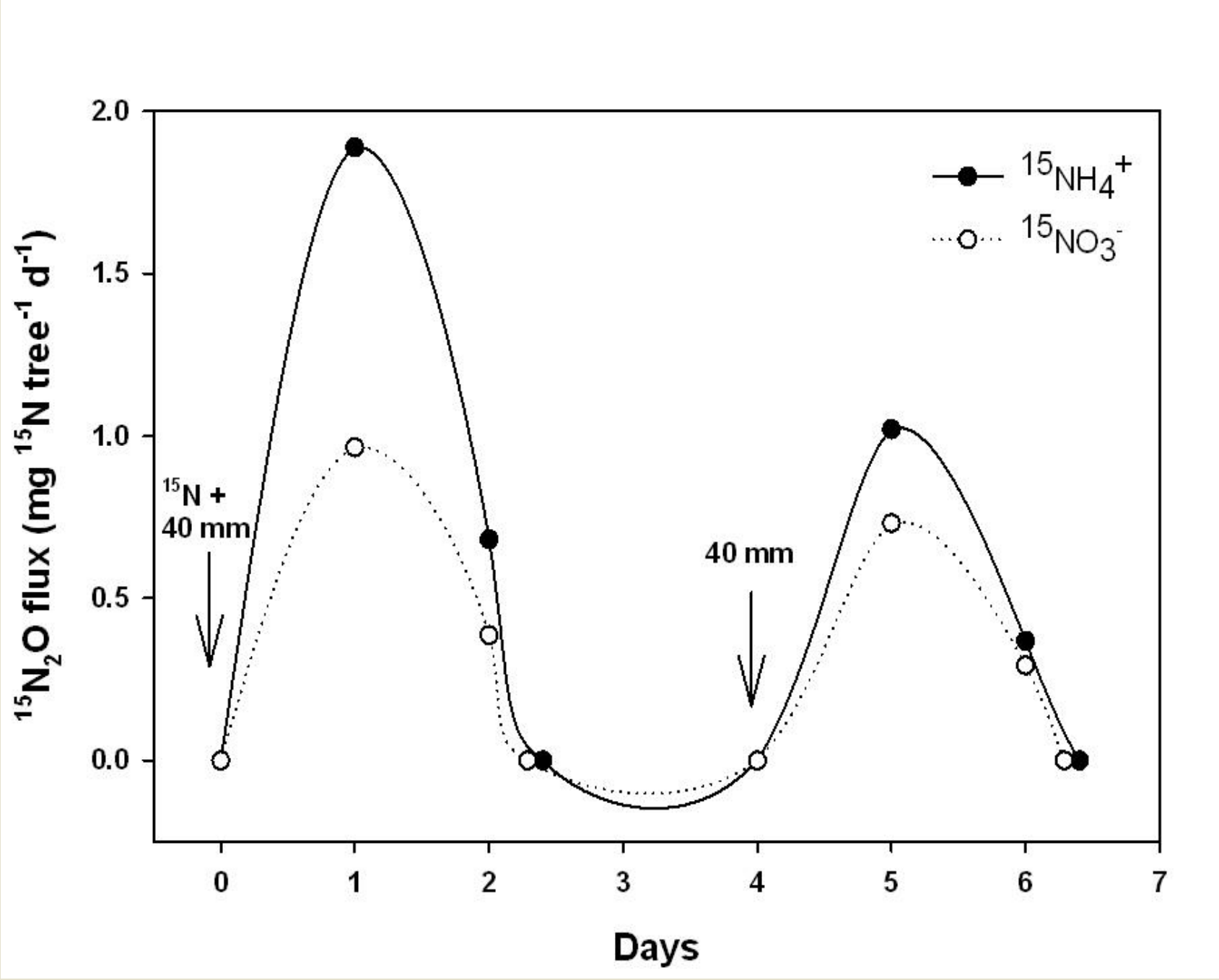
Combined with soil parameters, such data may facilitate the development of N_2O predictions using hydrological models.

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.







Origin of N_2O from UAN application

Comparing emissions results from the above field 15-N tracer study with soil gas data on the left, it is suggested that nitrification of ammonium applied as UAN in upper levels of the soil contributes to the higher emissions seen from UAN than from $Ca(NO_3)_2$. Further research remains to be done on this question.

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

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?*

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