Applying Liquid Manure Through Subsurface Drip Instead of Flood Irrigation Reduces N_2O Emissions in Dairy Forage Production

Martin Burger[1], Daniel Rivers[2], William Horwath[1]
[1]Dept. of Land, Air and Water Resources, University of California Davis; [2]Rivers Consulting, Stockton, CA

Introduction

- The main driver for increasing N_2O emissions in North America is management of manure and manure application to soils (IPCC 2007).
- California's dairies annually produce 30 million metric tonnes of manure.
- Liquid manure mixed with irrigation water is used, traditionally as flood irrigation, to fertilize forage crops surrounding dairies.

Objectives

- Compare the effects of subsurface drip- and flood-irrigation on yield, water and nitrogen (N) use, and nitrous oxide emissions in silage corn.
- Using liquid and solid manure as sole N sources in subsurface drip and flood irrigated systems, as well as during the winter rainy season.
- Optimize fertigation with liquid manure.

Methods

- Location: Chowchilla, California Central Valley.
- Automated adjustment of manure water flow based on electrical conductivity to keep N concentration constant.
- Sand separators and filtration of manure/fresh water blend with periodic back flushing with fresh water.
- Prototype system capable of irrigating/fertigating 16 ha corn crop divided into three blocks (max. three 8-hour sets per day).
- Nitrous oxide fluxes measured with static chamber technique
- Experimental design: 4 blocks with 2 replications each along the direction of water flow in one sector per treatment.

Table 1. Soil properties

	SDI	Flood
Sand (%)	67	60
Clay (%)	8	10
pH	7.4	7.4
Total C (mg kg^{-1})	14.2	13.6
Total N (mg kg^{-1})	1.5	1.4

- Strip tillage and surface application of solid manure in SDI treatment; incorporation of solid manure by disking in flood treatment.

Results

Table 2. Nitrous oxide emissions

	Wheat		Corn	
	kg N_2O N ha^{-1}	CO_2 eq. ha^{-1}	kg N_2O N ha^{-1}	CO_2 eq. ha^{-1}
SDI	1.8 (± 0.5)	847	0.4 (± 0.1)	180
Flood	7.5 (± 3.2)	3528	3.6 (± 0.6)	1699

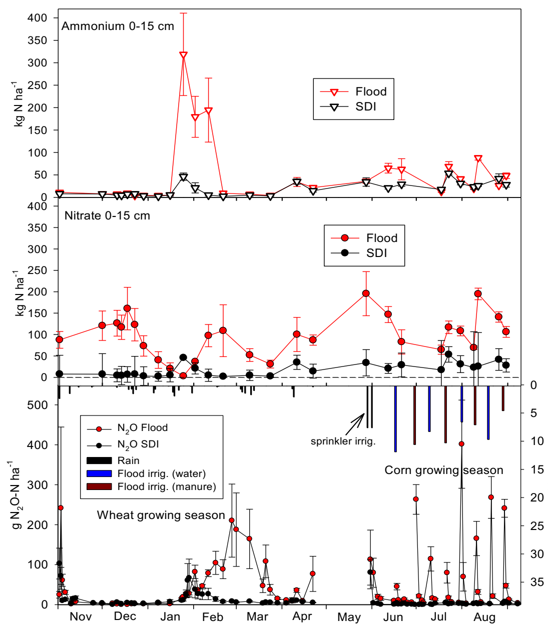

Figure 1. Ammonium and nitrate concentrations, daily N_2O emissions, and water inputs during rainfed wheat growing season and in flood- and subsurface drip-irrigated (SDI) corn growing season in 2015/16. Water inputs *via* SDI (corn season) not shown.

Table 3. Crop yields and N uptake

	Wheat		Available N applied	Corn		Available N applied
	Mg ha^{-1}	kg N ha^{-1}	kg N ha^{-1}	Mg ha^{-1}	kg N ha^{-1}	kg N ha^{-1}
SDI	57	338	35	71	206	196
Flood	52	n.a.	418	81	306	380

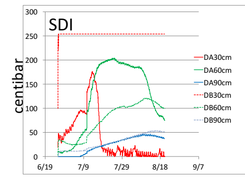

Figure 2. Soil water tension at three depths above drip tape (A) and in between drip tape locations (B).

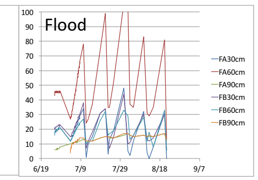

Figure 3. Soil water tension with flood irrigation at three depths near plant rows (A) and in between plant rows (B).

Table 4. Water applications and water use efficiency during corn season

	Applied Water corn	
	cm	cm Mg^{-1}
SDI	68	0.95
Flood	83	1.03

Summary & Conclusions

- Under SDI, N_2O emissions were lower than under flood irrigation by an order of magnitude (Table 2).
- High N_2O emissions in the flood treatment during the rainy season (Figure 1) were due to application of liquid manure in anticipation of a precipitation event to avoid overflowing of the manure pond (Table 3).
- The lower yields with SDI may have been due to water stress during parts of the growing season (Figure 2) and/or the difficulty to supply enough N to corn plants during the period of corn high N demand (Table 3).
- Liquid manure and water quality, in addition to soil type, are critical factors contributing to successful implementation of SDI in these systems.
- The environmental risks with liquid manure storage in California's dairy systems need to be addressed.

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