# Sub-surface drip irrigation reduces $N_2O$ emissions in alfalfa compared to flood irrigation

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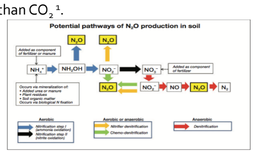
## Introduction

- Nitrous oxide ($N_2O$) is a potent greenhouse gas, approximately 300x more potent than $CO_2$ [1].
- Agriculture contributes to approximately 60% of anthropogenic $N_2O$ emissions[2].
- $N_2O$ production is a process driven by complex biochemical factors[3]:
  - Soil oxygen concentration
  - Substrate availability
  - Soil temperature
  - Soil pH




- The principal driver of $N_2O$ emissions is soil oxygen concentration[3], which in agricultural systems in California, is driven primarily by irrigation events.
- Alfalfa is grown on 79 million acres and covers more agricultural land in California than any other crop, approximately 1 million acres[4].
- Alfalfa competes with corn and soybean as the most valuable crop in the United States [4].
- Nearly 100% of California alfalfa is irrigated; requiring between 30-70 inches of water per year. Almost all alfalfa is flood irrigated and accounts for nearly 20% of California's water use [4]. Constant wetting and drying events, sometimes twice a month may trigger emissions events.
- Interest in the use of sub-surface drip (SDI) in alfalfa is growing due to the high crop value and potential for increased harvest and yields [5].
- SDI fields have shown reduce emissions due to depth of irrigation lines placement (30cm) [6].
- **We hypothesized that *in-season* $N_2O$ emissions would be lower in the SDI field but that a build up of nitrogen in th soil surface would make these savings non-sigificiant after rainfall events**

## Objectives

- To evaluate an alternative irrigation strategy, SDI, as a tool to reduce nitrous oxide emissions from alfalfa systems
- Evaluate possibility for $N_2O$ consumption in SDI alfalfa systems in California.

## Materials and Methods

**Location**

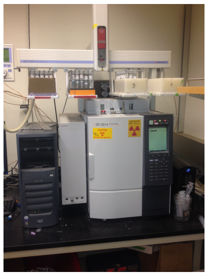
- University of California, Davis Agronomic Field Site

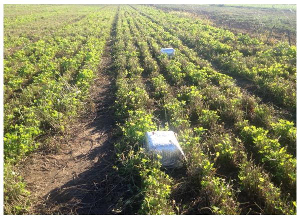
**Experimental Setup:**

- Two alfalfa fields; one conventional check flood and one SDI.
- Four replicate plots randomized within each field treatment; four in flood and four in drip.
- Two gas chamber sub-samples per plot; 8 chambers per treatment irrigation treatment.

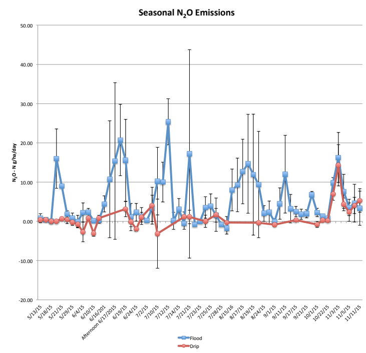
**Sampling and Processing Procedures:**

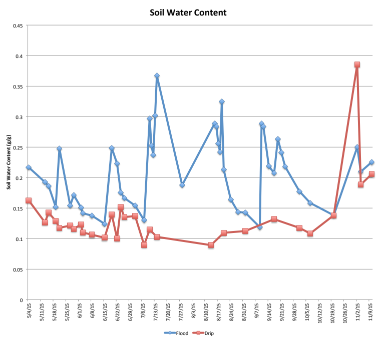
- Fields monitored for baseline emissions on a weekly to bi-monthly basis with intensive sampling following irrigation or precipitation events (3-5 days)
- Four time points used for gas sampling; T0, T1, T2, T3. Samples were drawn from chambers, transferred to pre-evacuated exitaners and processed within one week of collection.
- Soil samples collected and extracted for inorganic nitrogen ($NO_3^-$ and $NH_4^+$) and soil moisture.
- Fields were monitored on a weekly basis at baseline levels and sampled intensively following irrigation or rainfall events.

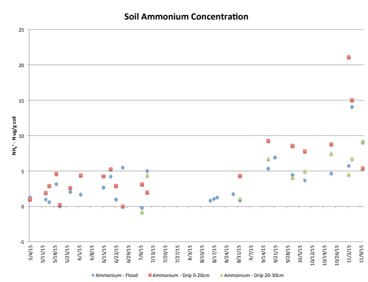


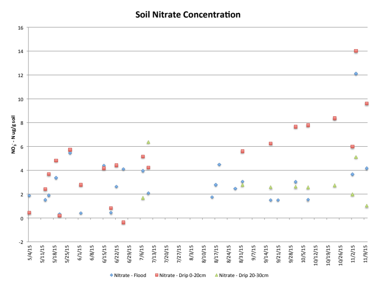


## Results




## Conclusions

- During the dry growing season emissions were lower in the SDI field.
- Emissions appear to be correlated to soil water content (soil oxygen concentration).
- SDI field exhibited $N_2O$ potential consumption at certain dates
- SDI fields may act as a sink for $N_2O$ when:
  - soil $N_2O$ concentrations are very low[7].
  - soils are dry and favor aerobic denitrification by heterotrophic nitrifiers[7].
  - however, a potential buildup of nitrogen may eliminate a net sink effect.

## Next Steps

- Continue monitoring fluxes through precipitation events to evaluate original hypothesis that emissions saved in SDI will make SDI emissions savings non-significant.
- Gross mineralization and gross nitrification rate analysis using stable isotopes to determine relative contribtions of nitrification and denitrificaiton pathways in $N_2O$ production.
- Develop field and lab methods to measure $N_2O$ consumption rates at different oxygen concentrations, lab methods will seek to mimic flood and SDI conditions, respectively.

### Acknowledgments

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### References

[1]Van Kessel, C. *et al. Global Change Biology* (2013). [2]Venterea, R. T. *et al. Frontiers in Ecology and the Environment* (2012).[3]Zhu, X. *et al. Proceedings of the National Academy of Sciences* (2013). [4]Putnam, D. H *et al.* 2007. Alfalfa Production Systems in California.5[4]Ayars, J. E. *et al. Agricultural Water Management* (1999). [6]Kennedy, T. *et al. Science of The Total Environment* (2013). [7]Wu, D. *et al. Soil Biology and Biochemistry* (2013).