Quantifying N_2O Emissions under Different On-farm Irrigation and Nutrient Management BMPs that Reduce Groundwater Nitrate Loading & Applied Water

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NASA ARC-CREST, UC Cooperative Extension, UC Davis, and Commercial Growers

Many Pressures on CA Farmers

- Food Safety
- Labor Shortages
- Changing Market Conditions
- National and International Supply Chains
- Managing Dozens to Hundreds of Fields

Traditionally the Above Have Been of Primary Concern to the Irrigator

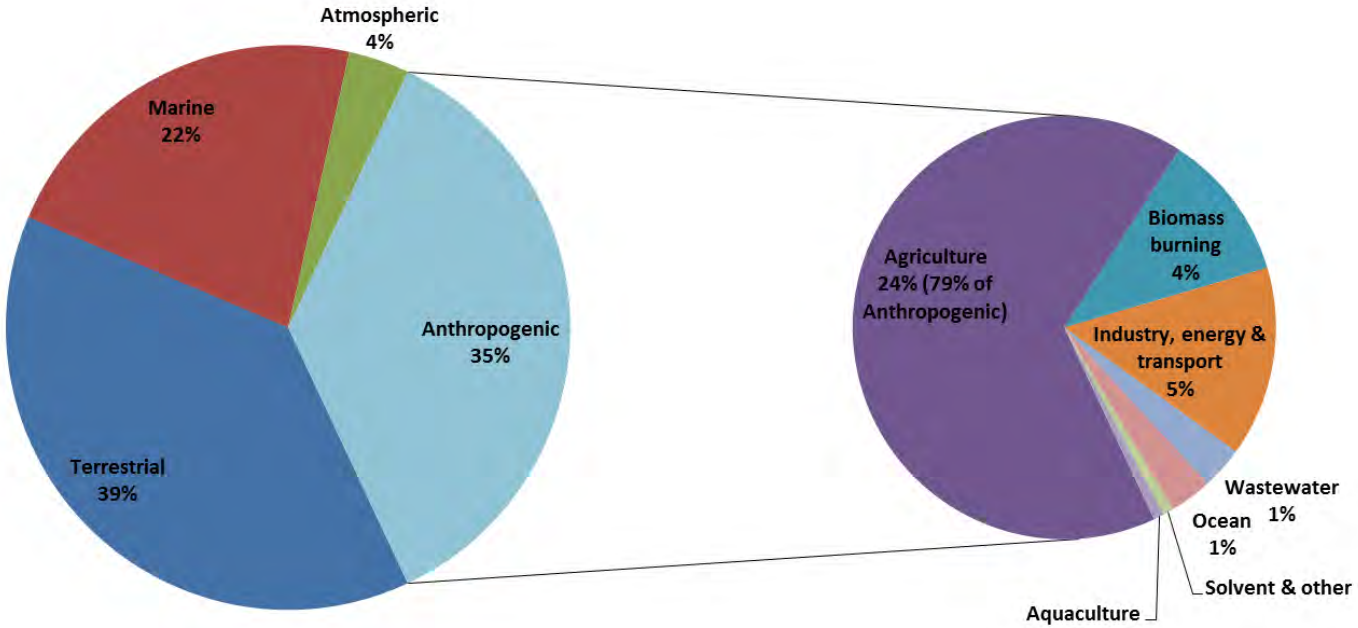
There were No Tools Available to Manage Water and Nitrogen

Regulatory Pressures on CA Farmers
-N Fertilizer Restrictions, Use of Groundwater

- Sustainable Groundwater Management Act
- 2012 Irrigated Lands Regulatory Program (ILRP)
- Growers across California are working to respond to these and potential future restrictions.
- Science is necessary to insure that policies align with best management practices.

AB 32 –C Offset Credits

- N_2O is a GHG 300x more potent than CO_2.
- Growers who optimize their Fertilizer use could be given credits for ⇩ GHG.



Global Estimates of Annual Nitrous Oxide Emissions

Davidson, E.A., and Kanter, D. Inventories and scenarios of nitrous oxide emissions. Envi Research Letters, Vol. 9, No. 10.

Research in Irrigation and Fertilizer Best Management Practices

- Commercial Crops
  - Strawberries (2015-16)
  - Broccoli (Summer 2016)
  - Romaine Lettuce (Summer 2017)
  - Broccoli (Fall 2017)
- Research Groups
  - CSUMB (Haffa, Kortman)
  - NASA ARC-CREST (Melton, Dexter)
  - UC Cooperative Extension (Cahn, Smith)
  - UC Davis (Horwath)

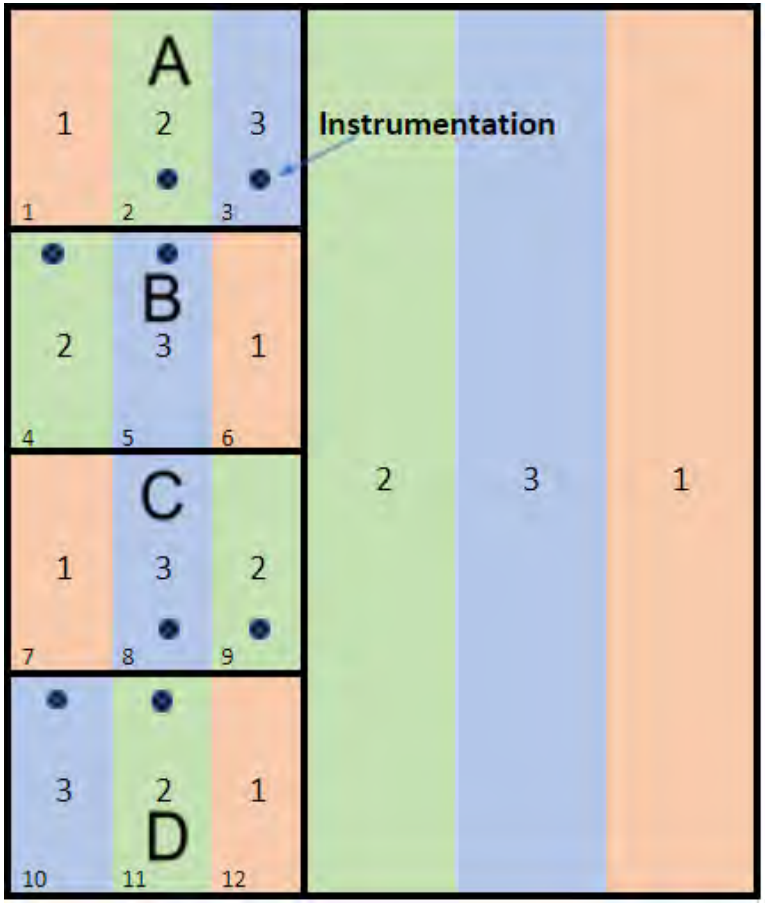
Studies Used CropManage: an ETc-Based Irrigation and Nutrient Management Tool

We used 100% ETc and 130% ETc.

These are both well below the UC ANR recommendations

The Growers we worked with used even less

Randomized Block Study Design
Romaine Lettuce 2017



Replicated Treatments:

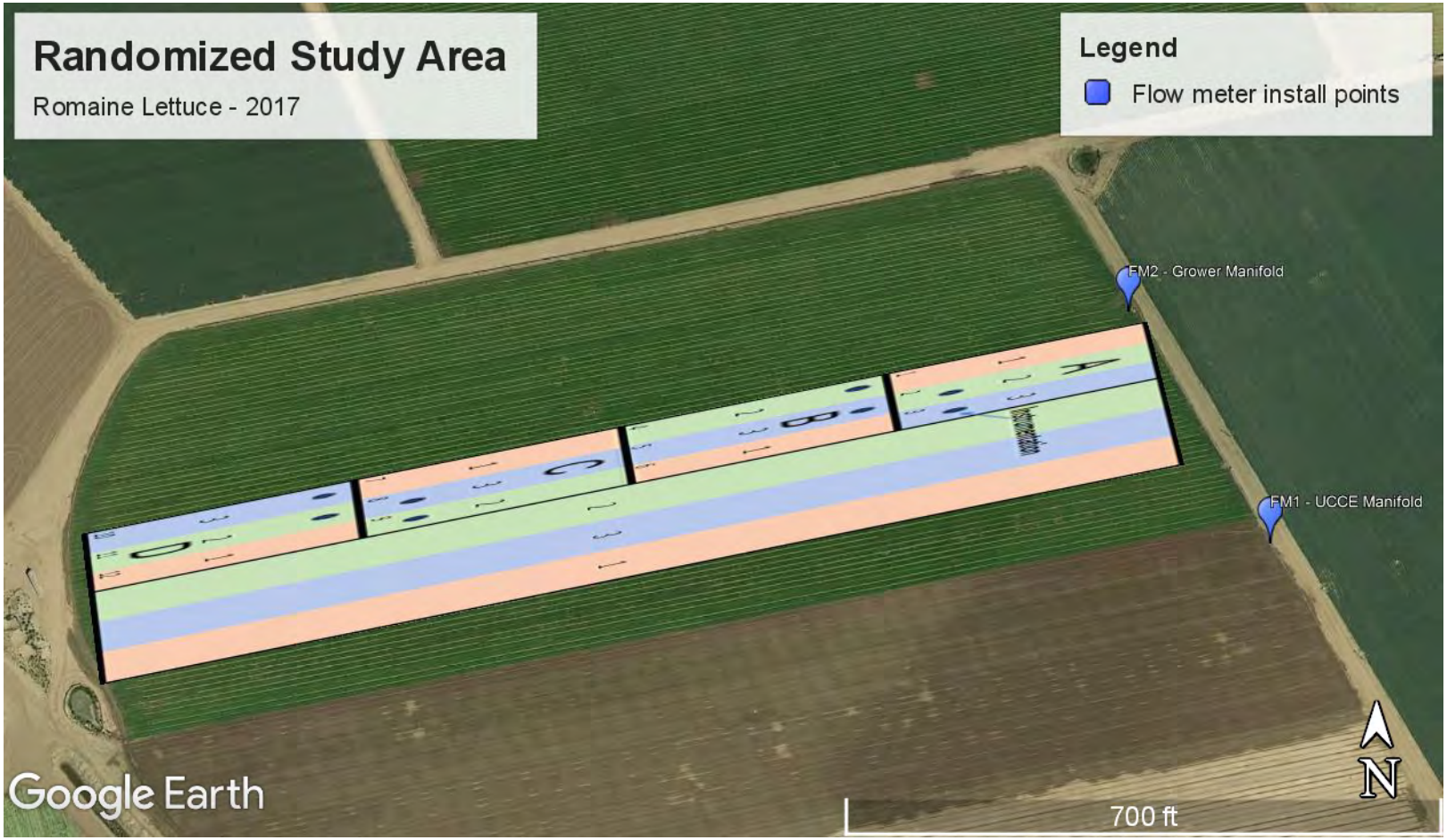
Grower Practice
100% ETc (CropManage)
130% ETc

- 12 Blocks that were 3 beds wide
- 3 Test Strips that were 6 beds wide
- 1.86 Acres per Treatment

Point Configuration (4 points / treatment)

- G3 Passive Capillary Lysimeter
- 4 Decagon 10HS volumetric water content sensors
- Other Sensors: 5TE, flow meters, met station

Field Overview: Romaine



- Crop was directly seeded
- 7/8” drip irrigation tape, 8” emitter spacing
- Run (Length of field) ~ 1350 ’
- Soil Type: Pico Fine Sandy Loam

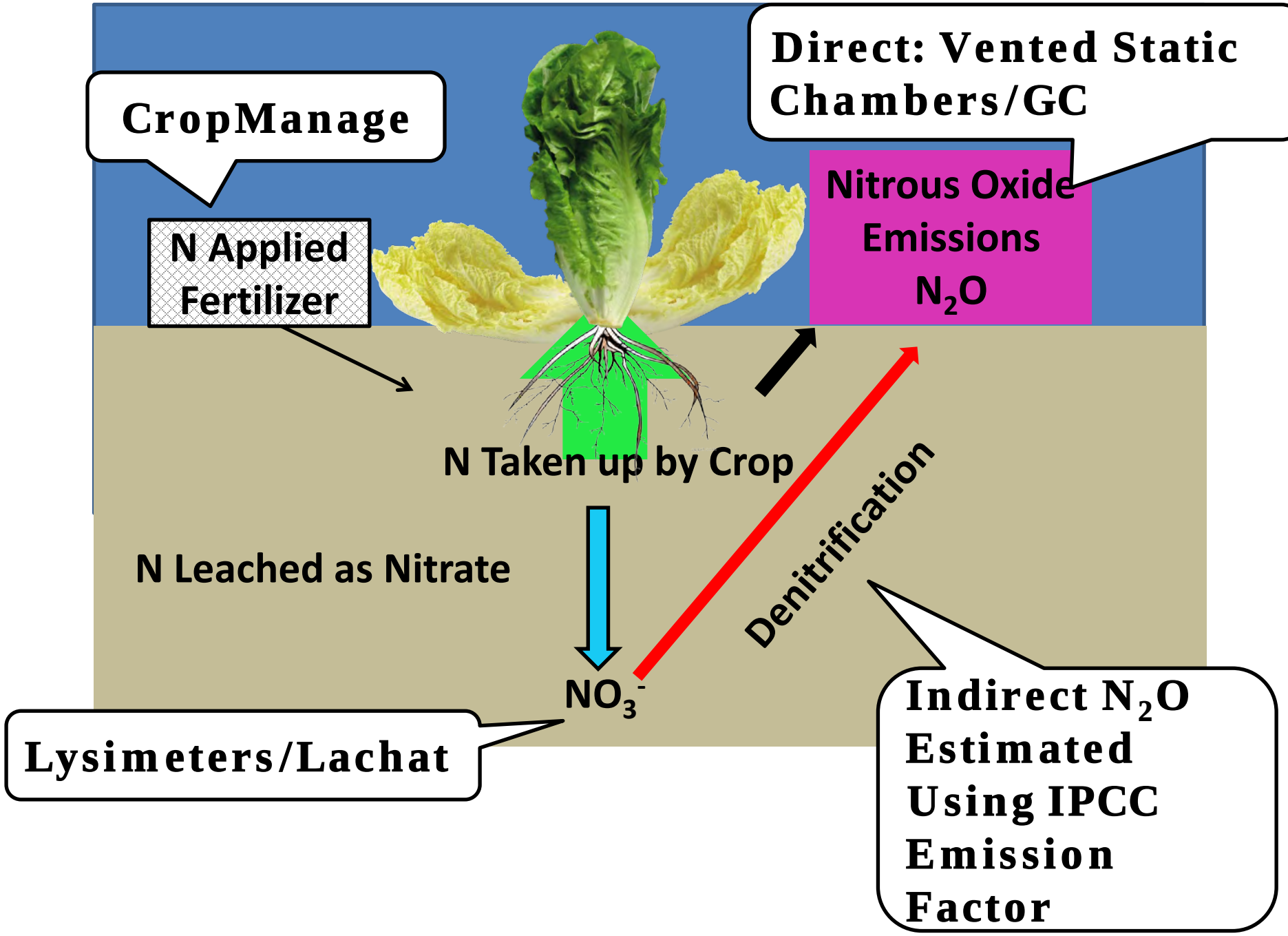
Direct Nitrous Oxide Gas Emissions

Vented Static Gas Chambers are Located Near the Other Instrumentation During Sampling

N_2O Data was Collected Following Field Events

- Irrigation
- Fertigation
- Rain

Samples of gas are collected from a septum in the chamber using a needle and syringe and brought to the lab for analysis on the Gas Chromatograph

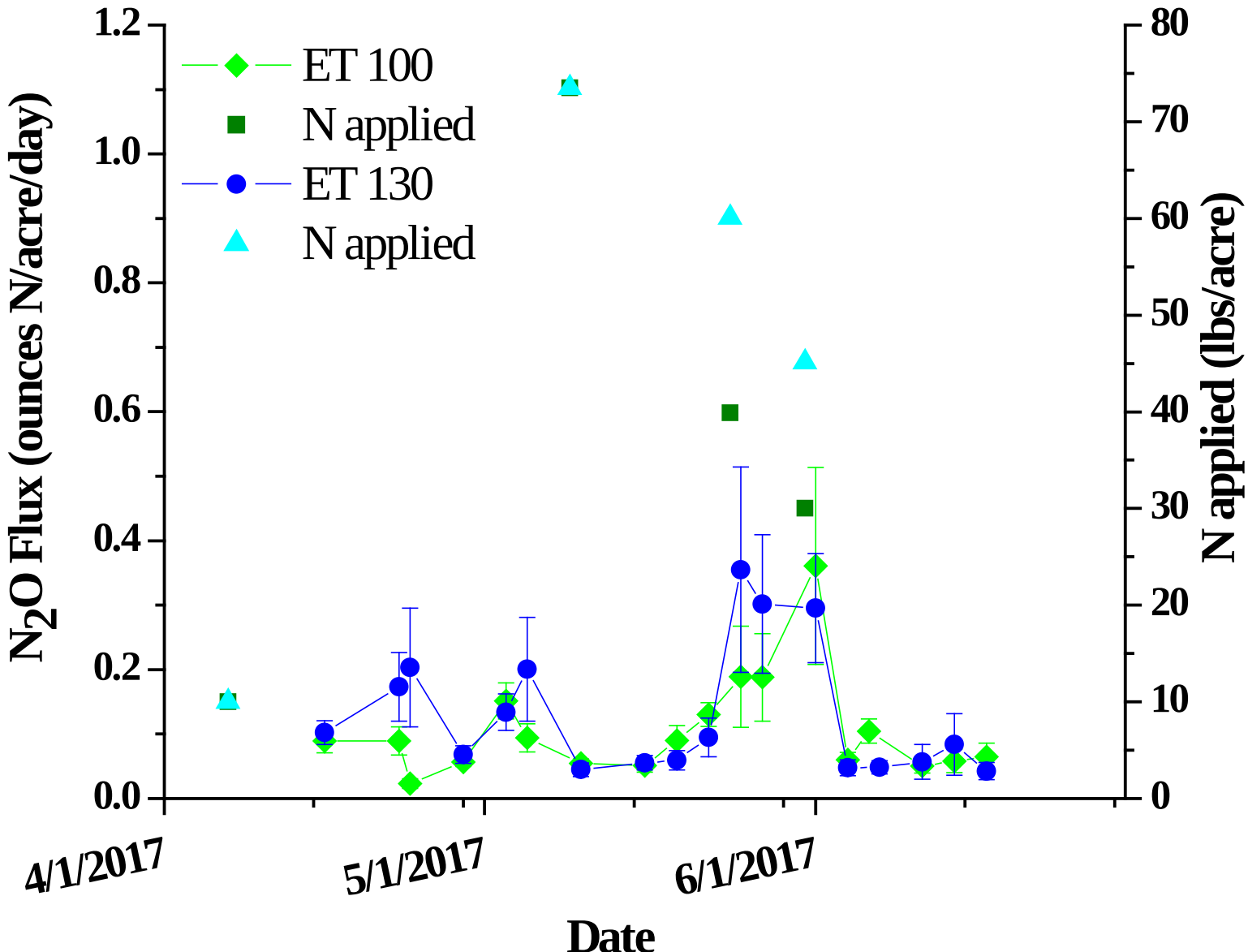

CropManage
Direct: Vented Static Chambers/GC
N Applied Fertilizer
Nitrous Oxide Emissions N_2O
N Taken up by Crop
N Leached as Nitrate
Denitrification
NO_3^-
Lysimeters/Lachat
Indirect N_2O Estimated Using IPCC Emission Factor

Yield and Other Biomass Estimates in Collaboration with the Commercial Partners Using Standard Industry Practices

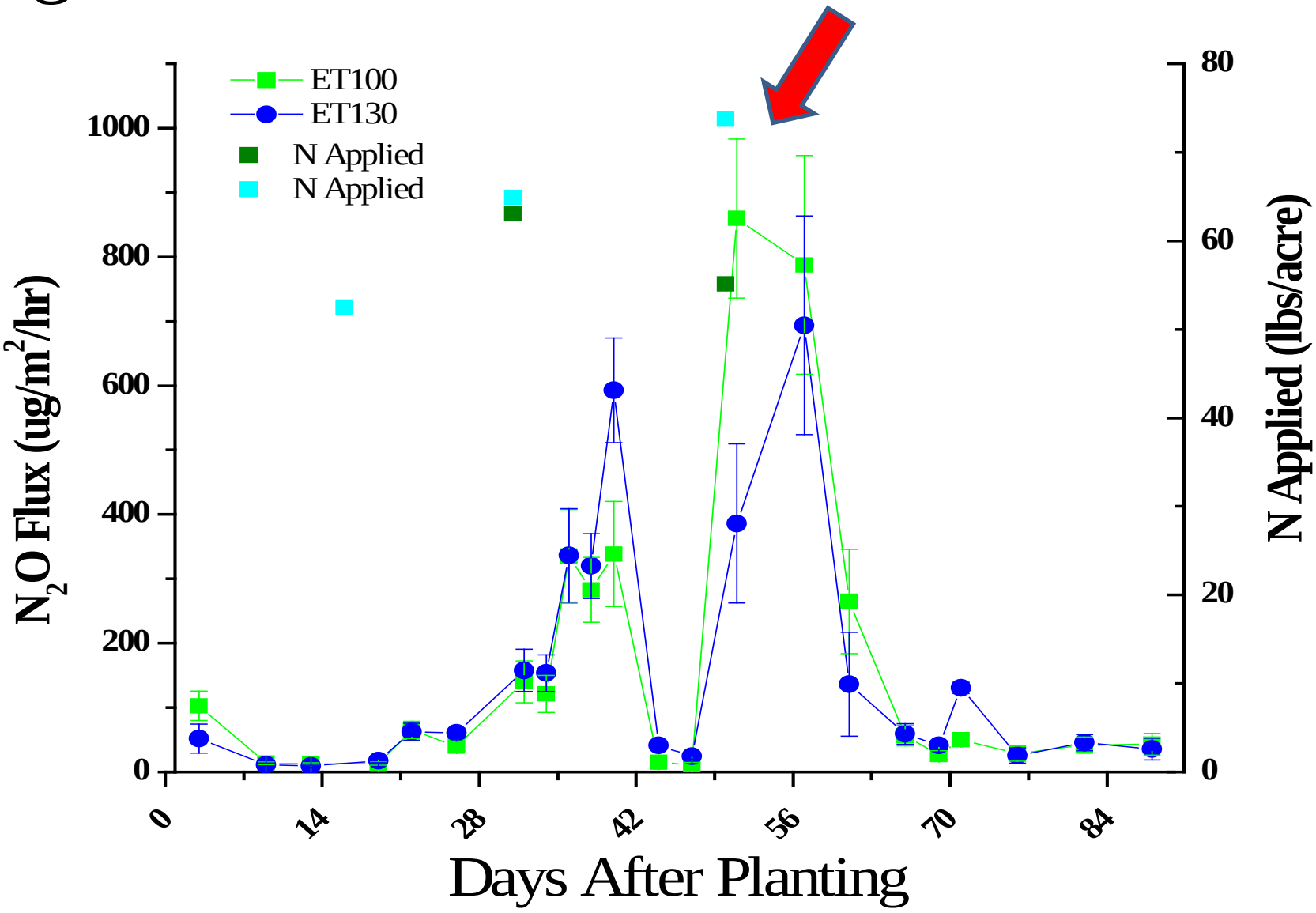
Yield:

Treatment and Crop Type	Yield Mg ha^{-1}
ET 100 Strawberries	94
ET 130 Strawberries	93
ET 100 Broccoli (2016)	13
GP Broccoli (2016)	15
ET 100 Romaine Lettuce	**75**
ET 130 Romaine Lettuce	**75**
ET 100 Broccoli (2017)	18
ET 130 Broccoli (2017)	18

Gas Sampling and Fertigation Events: Romaine



Gas Data: Broccoli→ Late Fertigation Higher Emissions



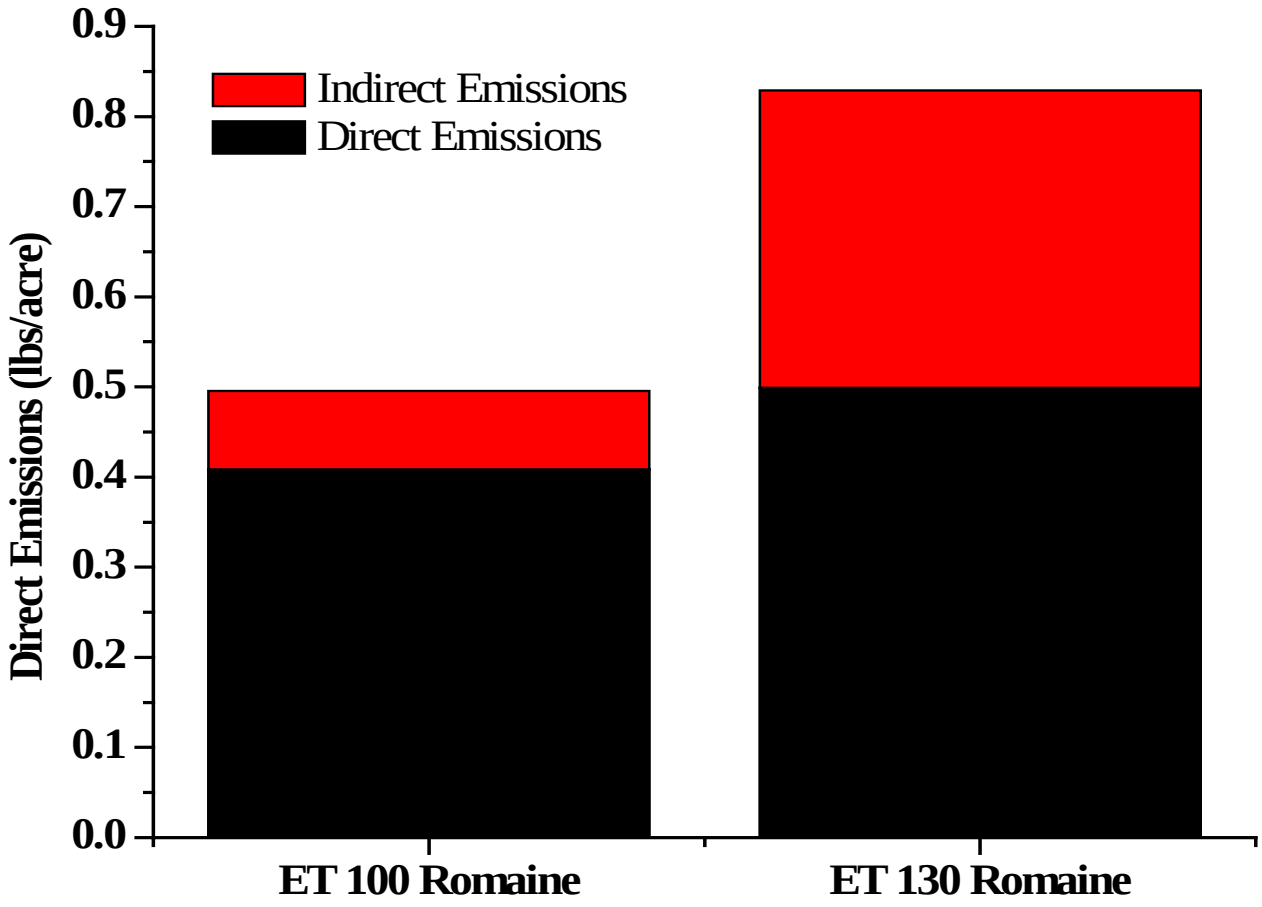
Direct Nitrous Oxide Emission Data

Treatment and Crop Type	Cumulative direct N_2O emissions kg N ha^{-1}	Yield-scaled N_2O emissions g N Mg-1 yield
ET 100 Strawberries	2.2	17
ET 130 Strawberries	2.1	17
ET 100 Broccoli (2016)	3.4	291
GP Broccoli (2016)	4.7	374
ET 100 Romaine Lettuce	**0.46**	**9**
ET 130 Romaine Lettuce	**0.56**	**11**
ET 100 Broccoli (2017)	3.5	186
ET 130 Broccoli (2017)	3.0	153

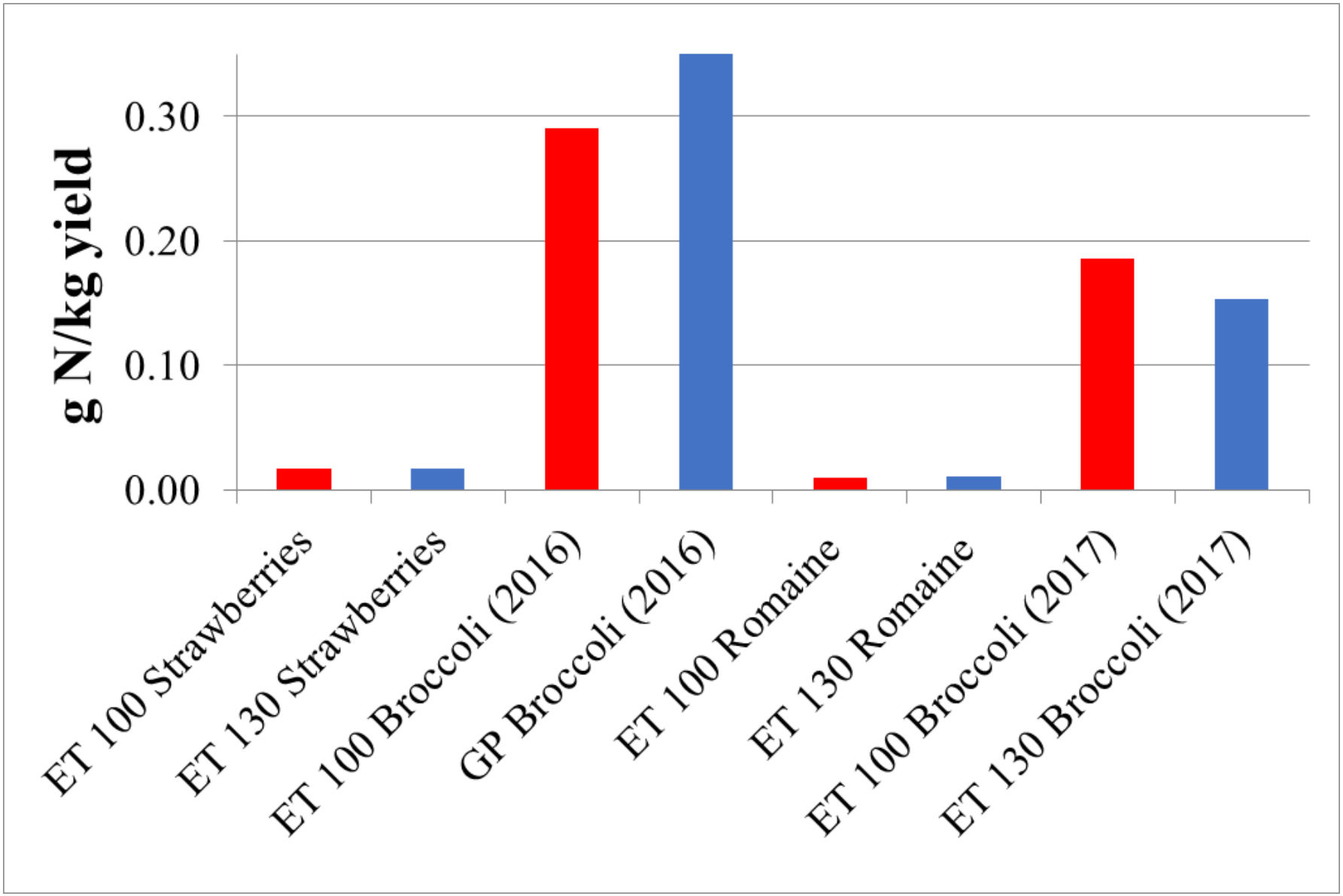
Indirect Nitrous Oxide Emission Data (kg N ha-1)

Treatment and Crop Type	NO_3 leaching	Indirect N_2O		
		EF 0.05	EF 0.75	EF 2.5
ET 100 Strawberries	65	0.03	0.4	1.3
ET 130 Strawberries	123	0.05	0.7	2.5
ET 100 Broccoli (2016)	31	0.02	0.29	0.98
GP Broccoli (2016)	32	0.02	0.30	0.99
ET 100 Romaine	**10**	**0.01**	**0.10**	**0.33**
ET 130 Romaine	**39**	**0.02**	**0.37**	**1.23**
ET 100 Broccoli (2017)	62	0.02	0.37	1.24
ET 130 Broccoli (2017)	76	0.03	0.45	1.51

Nitrous Oxide Gas Emissions: Romaine

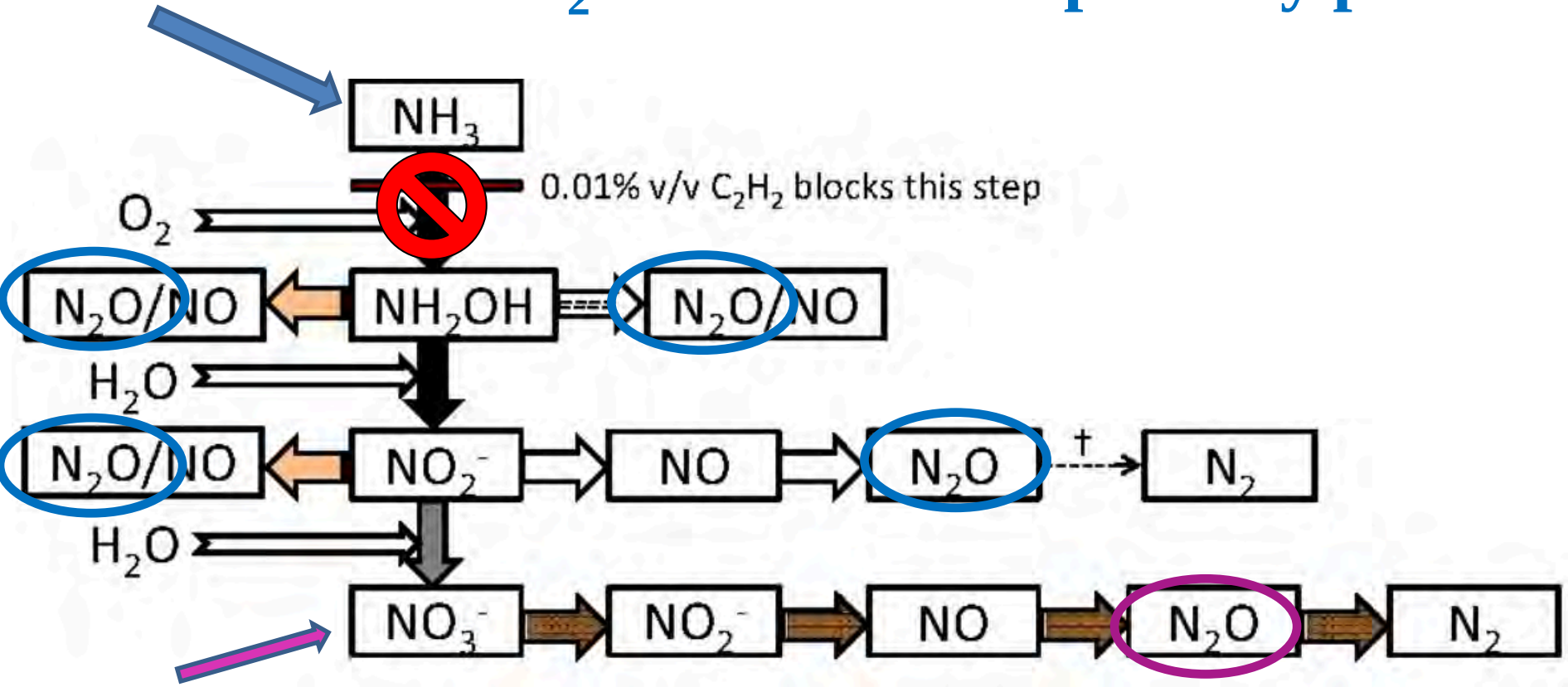


Yield-scaled Direct Nitrous Oxide Emissions



Soil Microbial Data: Lettuce → Broccoli Nitrous Oxide Emissions Circled

N as Ammonia: N_2O blocked thus primary process



N as Nitrate: No change

Fig from: Xia Zhu et al. PNAS 2013;110:16:6328-6333

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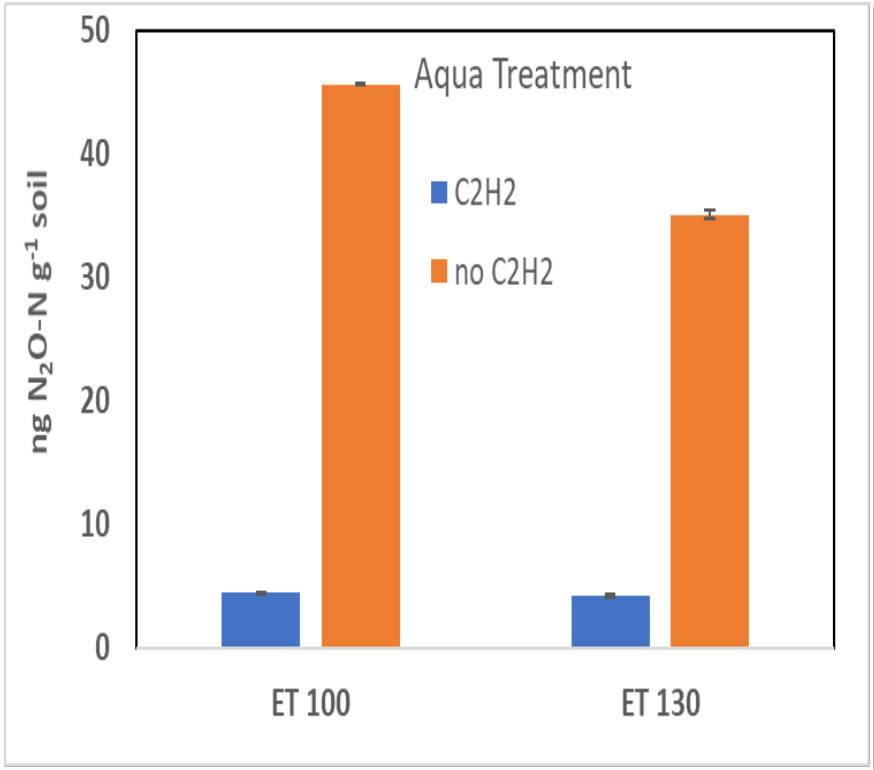

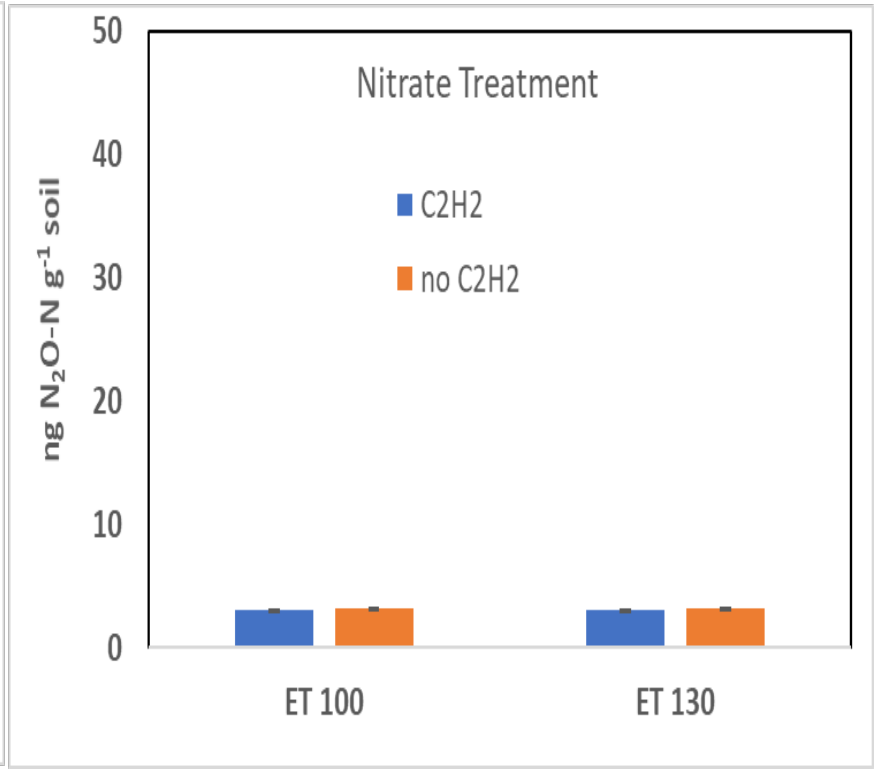

100% ETc treatment reduced N_2O emissions and N leaching without compromising crop quality or yield, and saved the grower on fertilizer and water costs.

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