Fall Application of High C:N Ratio Amendments to Immobilize Soil Nitrate



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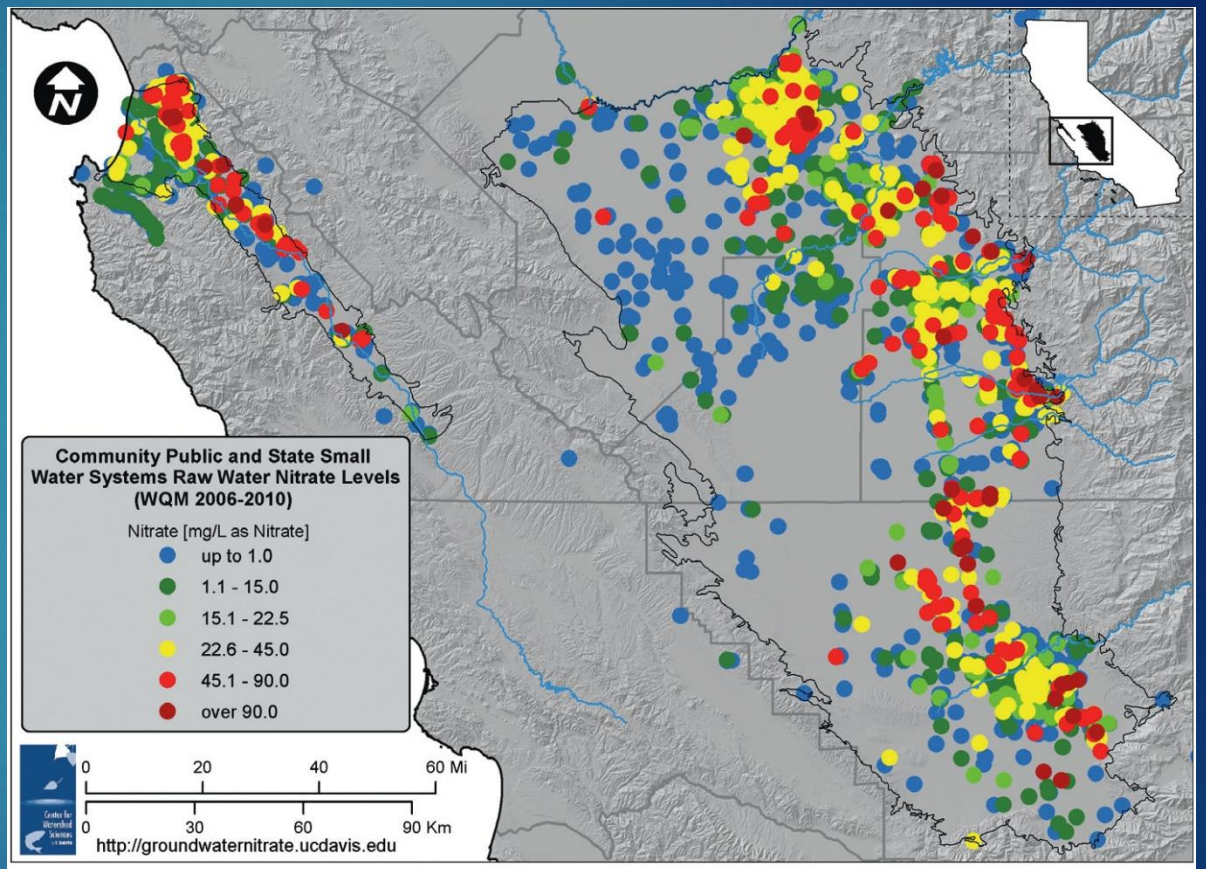
Nitrate contaminated groundwater

- ~254,000 people in Tulare Lake Basin and Salinas Valley face health risks

- Main causes:
  1. Agricultural fertilizers and animal wastes applied to croplands
  2. Fall incorporation of **N-rich crop residues**



Maximum reported raw-level nitrate concentration in community public water systems and state-documented state small water systems, 2006–2010. *Source:* CDPH PICME WQM Database.

(Center for Watershed Science, 2012)

High-N cole crop residues

Crop	Residue biomass N lb/ac	Source	Planted acreage in CA (2013)
Broccoli	226	Smith et al, 2016	121,000
Brussels sprouts	125 - 214	Titulaer, 1993	3,200*
Cabbage	155	Smith et al, 2016	14,000
Cauliflower	218	Smith et al, 2016	31,000
Celery	22 - 53	Werhmann and Scharpf, 1989	27,000
Lettuce	66	Mitchell et al, 1999	198,500

* IPM center (1997)

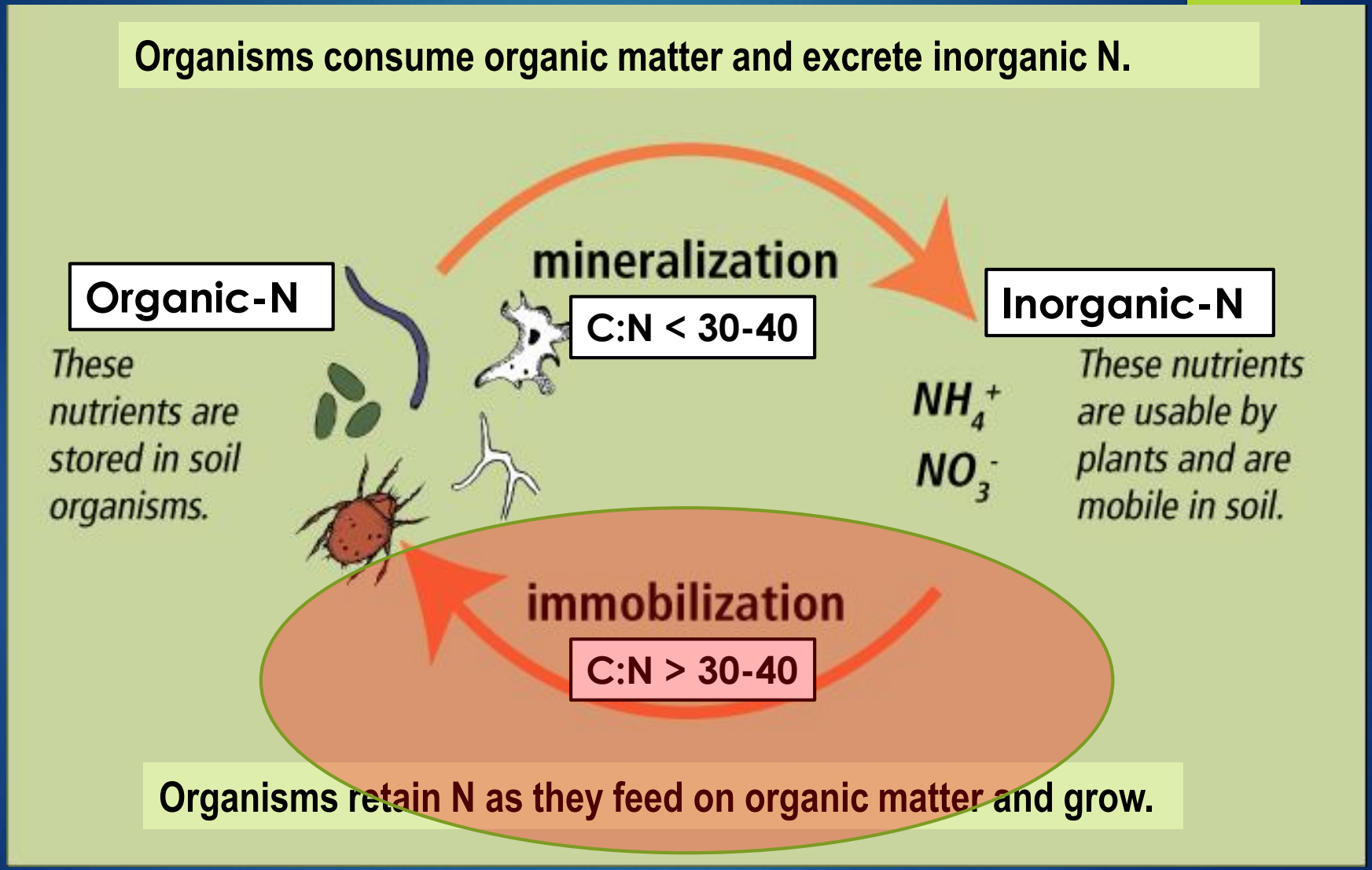
N immobilization by high C:N organic amendments (a field trial in Belgium)

Organic amendment	C:N	Rate applied tons fw/ac	Caulif. N-immobilized %	N-leaching reduced* %
Cauliflower residues	14	33	-	-
Straw	46	5.3**	61	24
Green waste compost	44	9.4**	68	27
Sawdust	420	4.5**	54	18

* % of leaching reduced below 3' depth. ** 2.2 tons-C/ac

(Chaves et al., 2007)

N immobilization vs. N mineralization



(Adopted from USDA-NRCS, 2017)

Project Outline

1. Identify and select

Practical high-C:N ratio organic amendments to immobilize residual soil nitrate in California croplands

➡ Survey and incubation trials

2. Examine

Effects of selected organic amendments on N loss reduction in winter after broccoli residue incorporation, overall N dynamics and crop yields

➡ Field trials

3. Evaluate

Practice costs for different organic amendment treatments, marketable yield, price, gross and net return for strawberry and lettuce crop following organic amendment field trials

➡ Economic analysis (TBD)

Potential organic amendments for N immobilization in California (1st incubation trial)

Organic amendment	C:N	Price ($/ton)	Availability in CA (tons, annual)
Almond shell (ground)	44	30	1,000,000
Green waste mulch	48	(25)*	3,700,000**
Green waste ground cover	30	(25)*	3,700,000**
Ground redwood	126	50	>10,000
Olive pomace	44	80	50,000
Rice hull	80	25	80,000
Wood fine	100	50	>20,000

(Keith Day, Farm Fuel, and others)

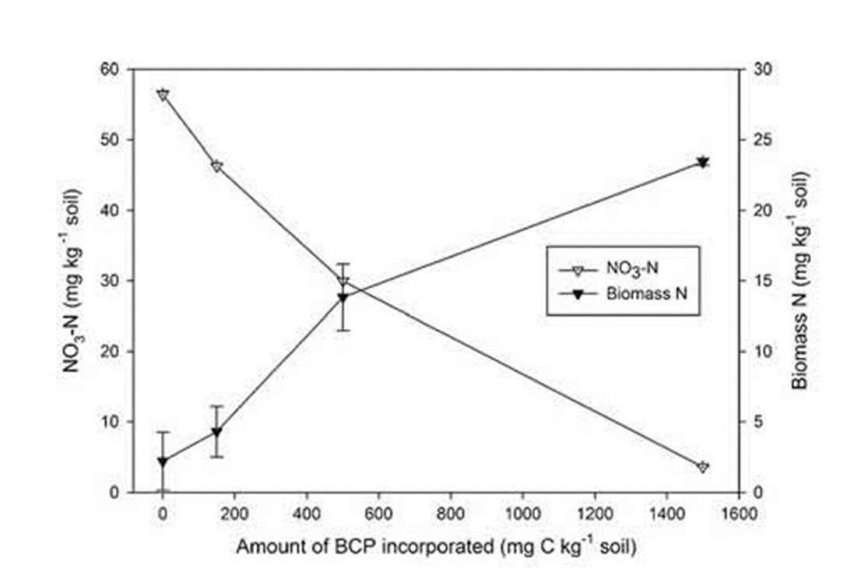
* Average price of overall green waste compost
** All types of green waste composts combined

Overall N-Immobilization
(Broccoli residues: 58 Tons f.w. /ac, Amendments: 2.2 Tons-C/ac, 68°F/59°F, 60% water filled pore space)

Potential organic amendments for N immobilization in California (2nd incubation trial)

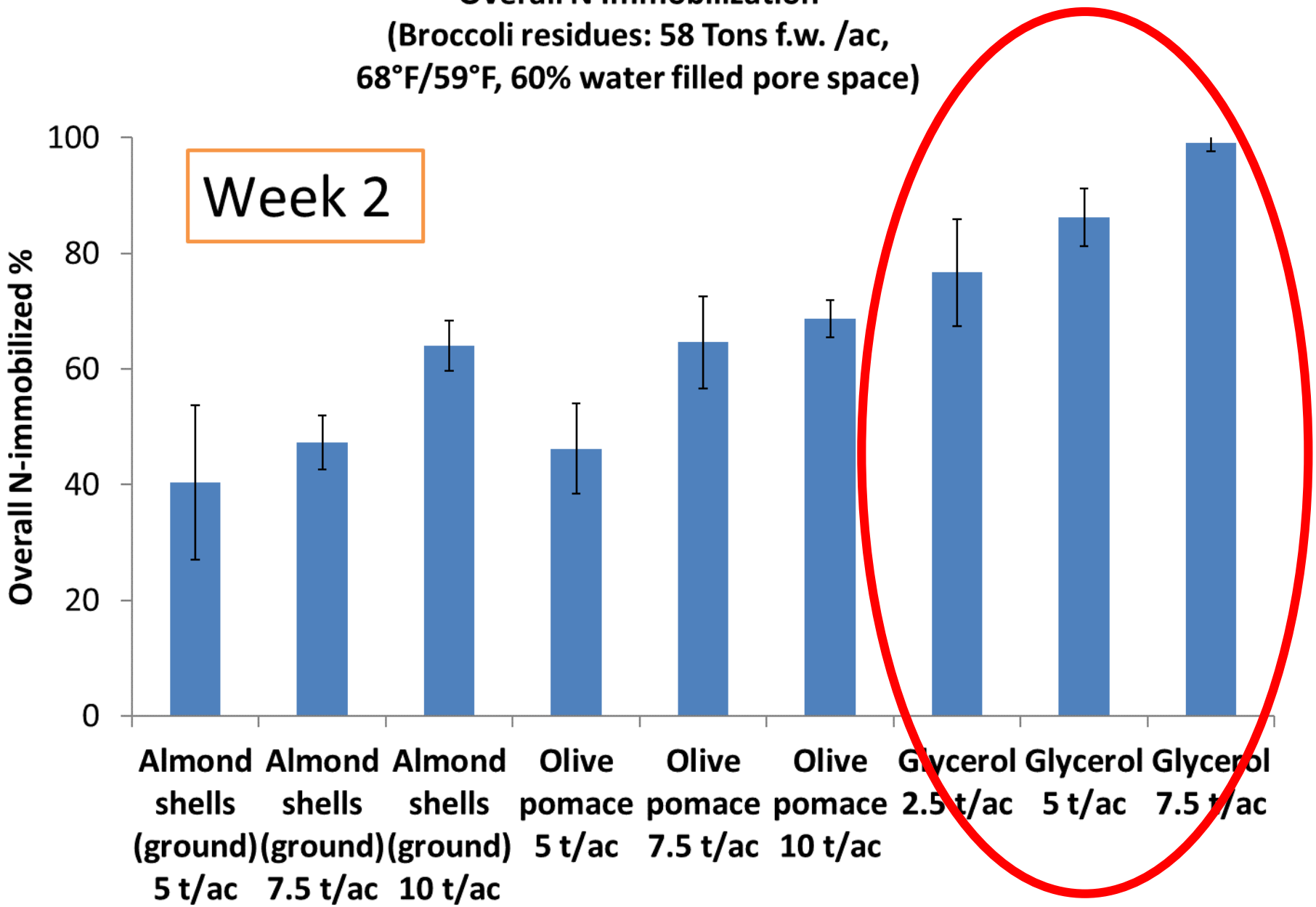
Organic amendment	C:N	Price ($/ton)	Availability in CA (tons, annual)
Almond shell (ground)	75	30	1,000,000
Olive pomace	44	80	50,000
Glycerol (liquid)	>1555	116	500,000

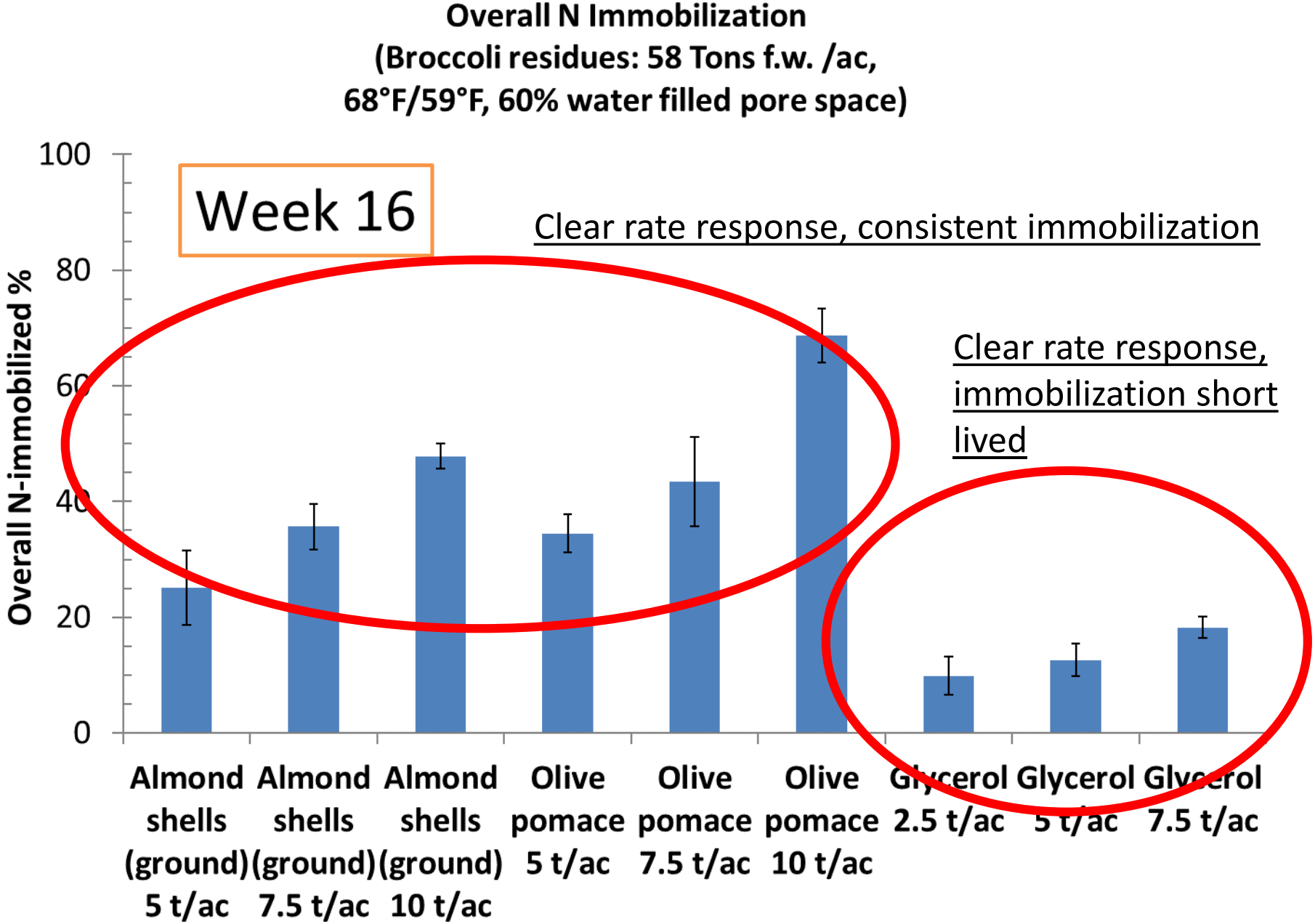
(Keith Day, Farm Fuel, and REG)



Crude Glycerol ($C_3H_8O_3$) 70%

(Redmile-Gordon et al., 2014)

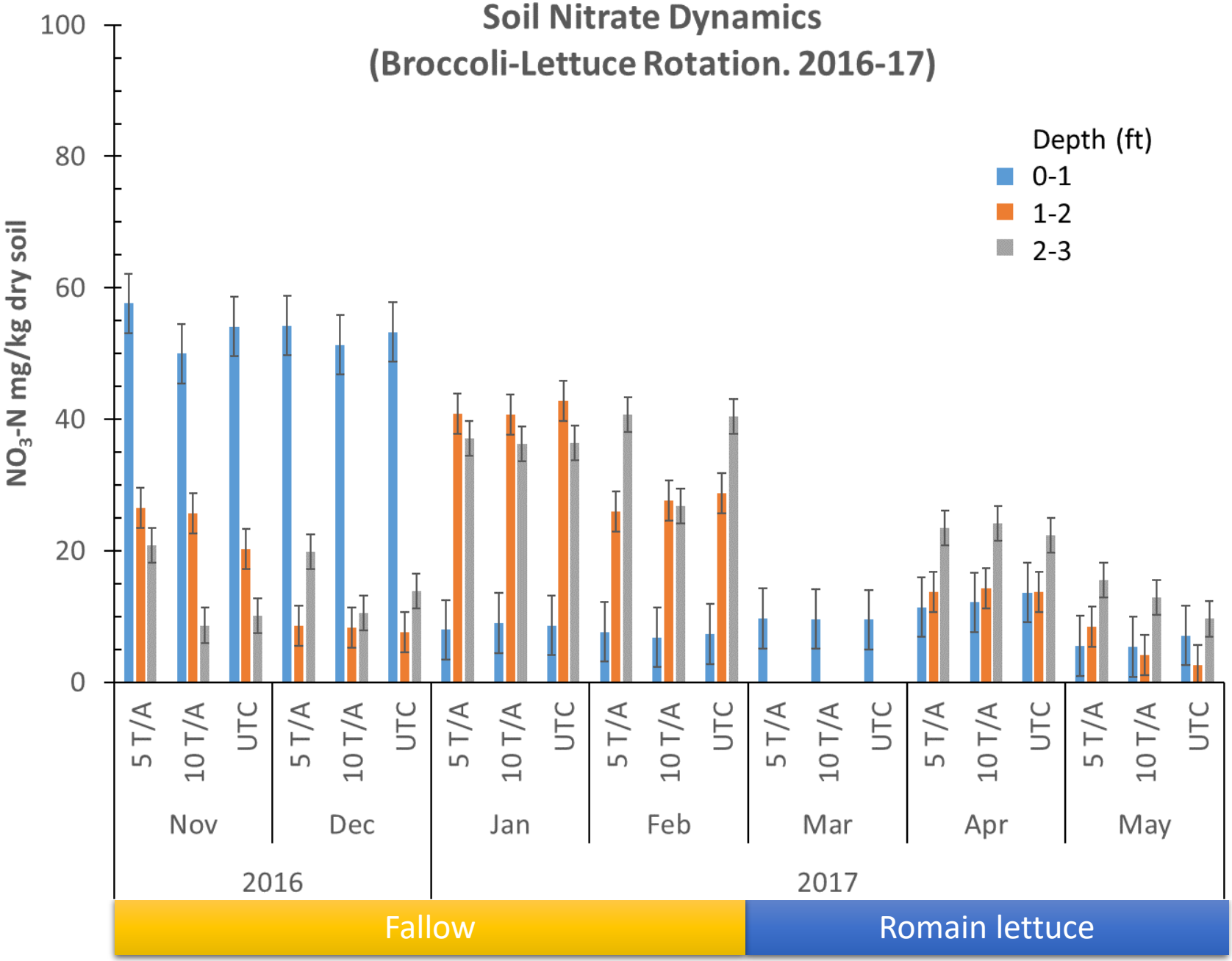

Overall N Immobilization
(Broccoli residues: 58 Tons f.w. /ac,
68°F/59°F, 60% water filled pore space)
Week 2
Overall N-immobilized %
100
80
60
40
20
0
Almond shells (ground) 5 t/ac
Almond shells (ground) 7.5 t/ac
Almond shells (ground) 10 t/ac
Olive pomace 5 t/ac
Olive pomace 7.5 t/ac
Olive pomace 10 t/ac
Glycerol 2.5 t/ac
Glycerol 5 t/ac
Glycerol 7.5 t/ac


Overall N Immobilization
(Broccoli residues: 58 Tons f.w. /ac,
68°F/59°F, 60% water filled pore space)
Week 16
Clear rate response, consistent immobilization
Clear rate response, immobilization short lived
Overall N-immobilized %
100
80
60
40
20
0
Almond shells (ground) 5 t/ac
Almond shells (ground) 7.5 t/ac
Almond shells (ground) 10 t/ac
Olive pomace 5 t/ac
Olive pomace 7.5 t/ac
Olive pomace 10 t/ac
Glycerol 2.5 t/ac
Glycerol 5 t/ac
Glycerol 7.5 t/ac

Field Trials (randomized complete block design)

- **Broccoli – Lettuce rotations (Gonzales. 4 reps)**
  - 2016-17; green waste compost 5, 10t/ac
    untreated control (UTC)
  - 2017-18; ground almond shell (GAS)5, 10t/ac
    glycerol 2.5 t/ac, GAS 5t/ac + glycerol 1.25 t/ac
    UTC
- **Broccoli – Strawberry rotation (Pajaro. 3 reps)**
  - 2017-18; GAS 5t/ac, ground olive pomace (GOP) 5t/ac, UTC

Examine effects on soil/plant N dynamics and lettuce or strawberry crop yield


Soil Nitrate Dynamics
(Broccoli-Lettuce Rotation. 2016-17)
Depth (ft)
0-1
1-2
2-3
NO_3-N mg/kg dry soil
100
80
60
40
20
0
5 T/A
10 T/A
UTC
Nov
Dec
Jan
Feb
Mar
Apr
May
2016
2017
Fallow
Romain lettuce

Compost original

C:N 30

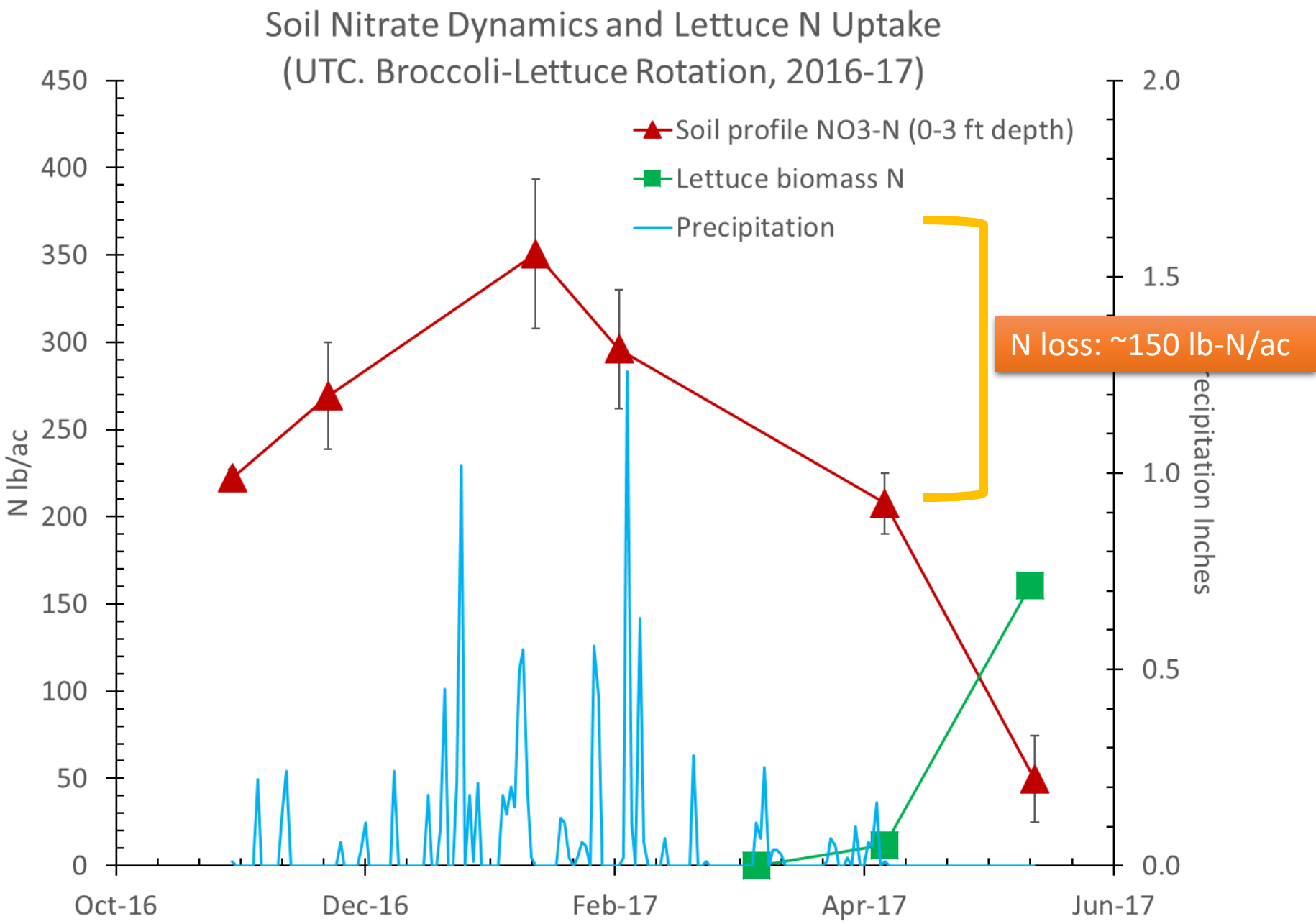
Compost <4.75mm fine materials

C:N 19 (35%)

+

Compost >4.75mm coarse materials

C:N 54 (65%)


Soil Nitrate Dynamics and Lettuce N Uptake
(UTC. Broccoli-Lettuce Rotation, 2016-17)
Soil profile NO3-N (0-3 ft depth)
Lettuce biomass N
Precipitation
N loss: ~150 lb-N/ac
N lb/ac
Precipitation Inches
450
400
350
300
250
200
150
100
50
0
2.0
1.5
1.0
0.5
0.0
Oct-16
Dec-16
Feb-17
Apr-17
Jun-17

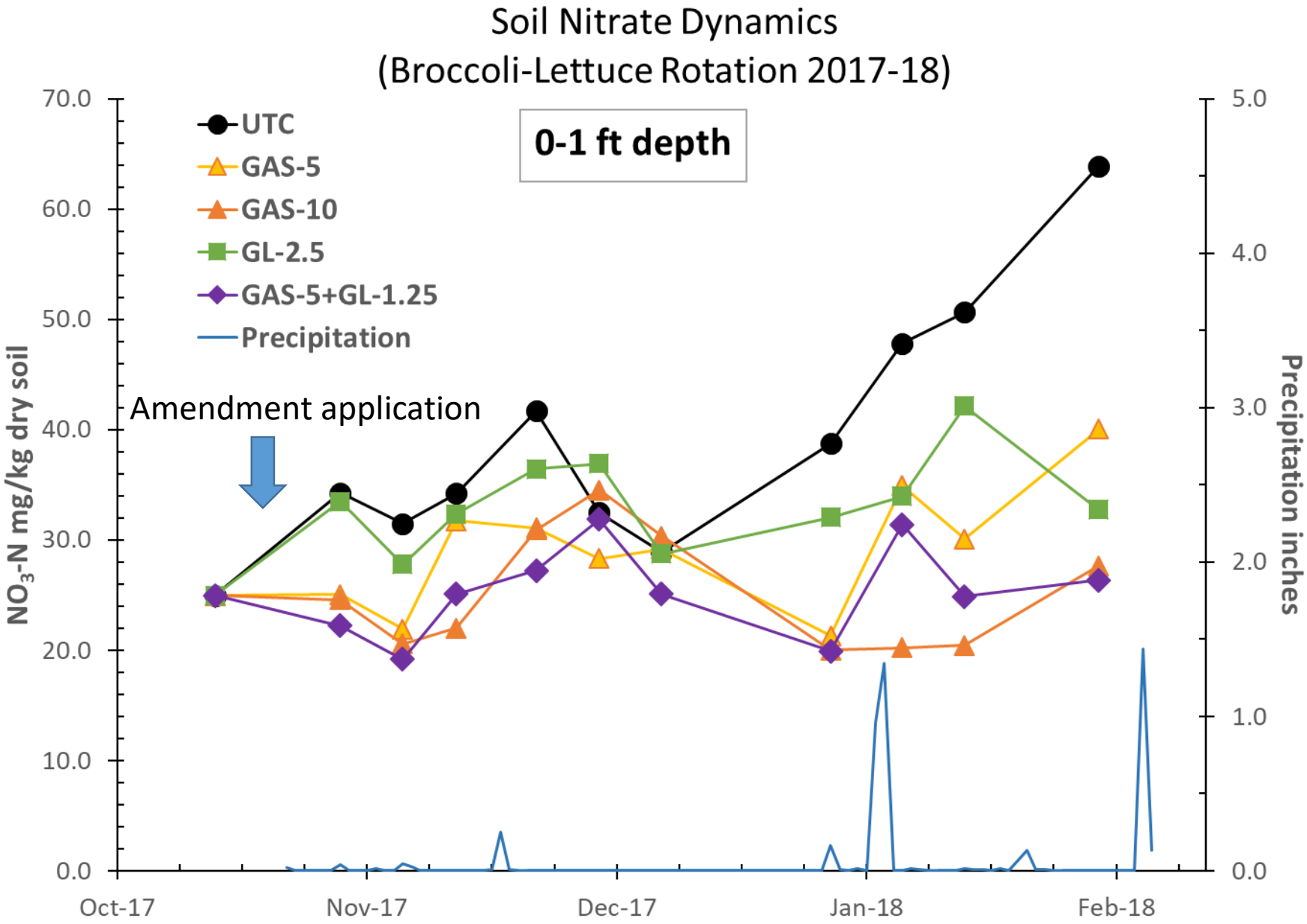
Broadcasting ground almond shell and ground olive pomace (Broccoli-Strawberry Rotation 2017-18)

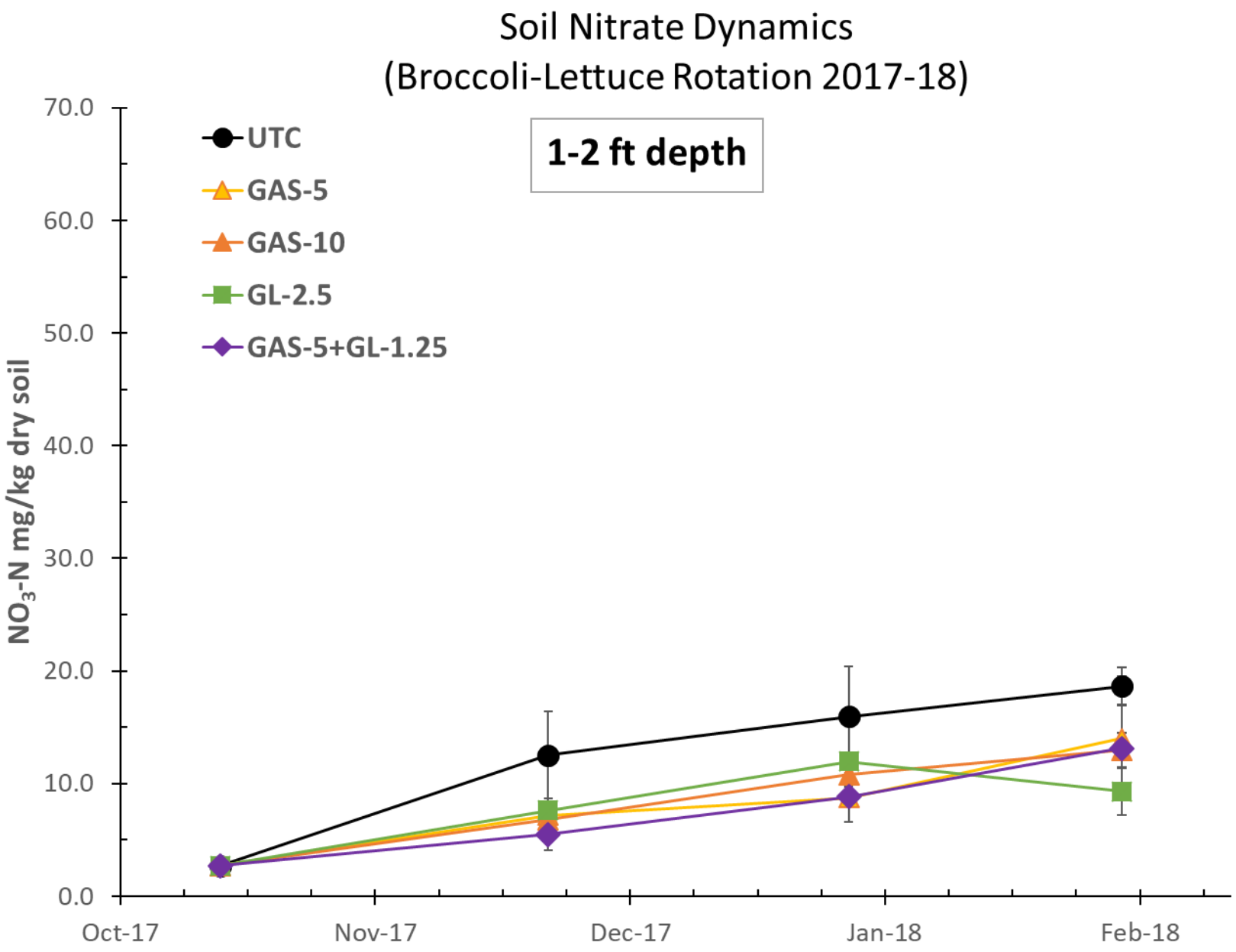
Spraying 1:1 diluted glycerol (Broccoli-Lettuce Rotation 2017-18)

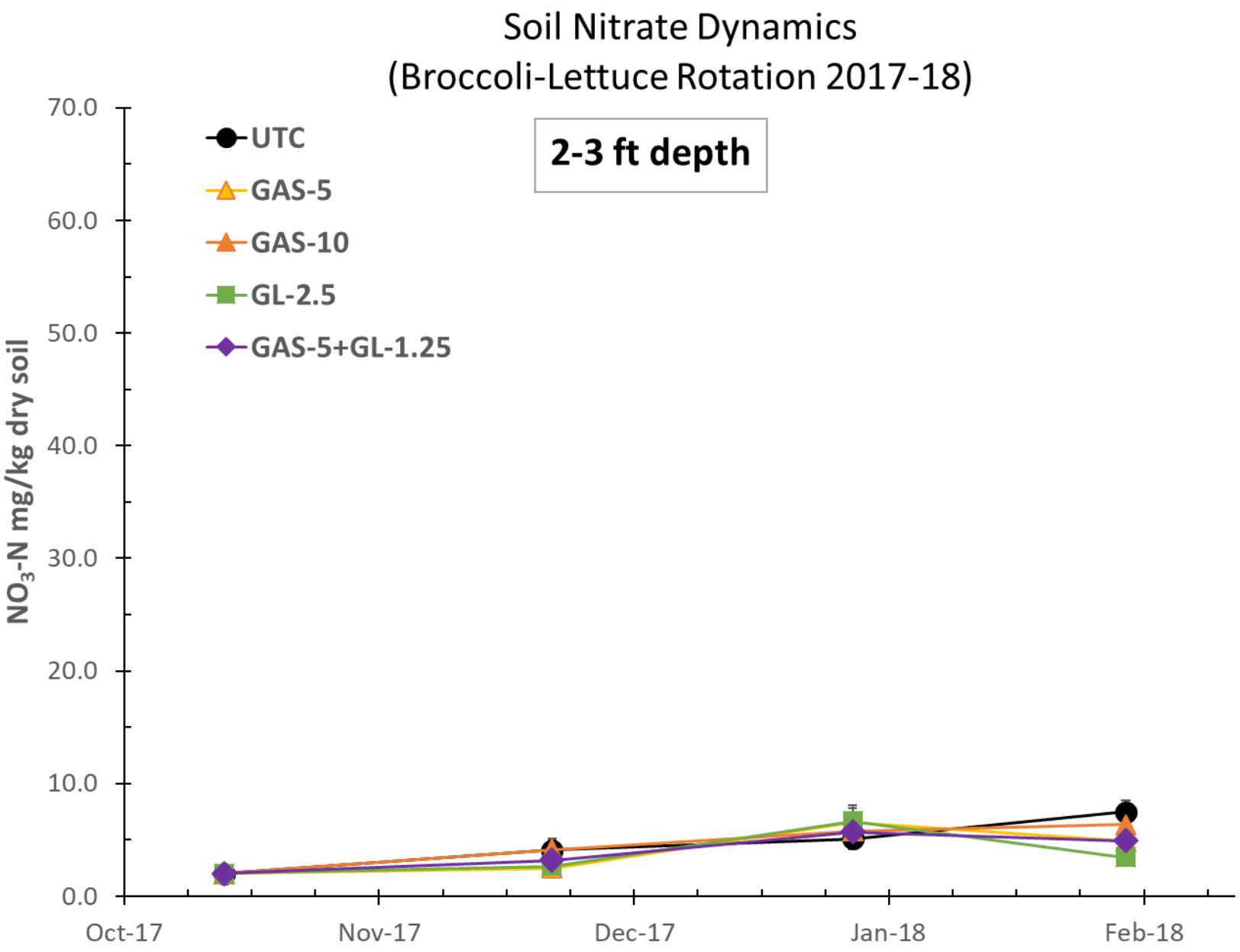
Leachate N monitoring by CSUMB team (Broccoli-Lettuce Rotation 2017-18)

- Monitoring NO_3-N, NH_4-N, TN in leachates at 6’ depth using drain gauge G3 passive capillary lysimeters
- Ground almond shell 10 t/ac and UTC plots

(Photos by Jason Dextor)


Soil Nitrate Dynamics
(Broccoli-Lettuce Rotation 2017-18)
0-1 ft depth
UTC
GAS-5
GAS-10
GL-2.5
GAS-5+GL-1.25
Precipitation
Amendment application
NO3-N mg/kg dry soil
Precipitation inches
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
Oct-17
Nov-17
Dec-17
Jan-18
Feb-18


Soil Nitrate Dynamics
(Broccoli-Lettuce Rotation 2017-18)
1-2 ft depth
UTC
GAS-5
GAS-10
GL-2.5
GAS-5+GL-1.25
NO_3-N mg/kg dry soil
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Oct-17
Nov-17
Dec-17
Jan-18
Feb-18


Soil Nitrate Dynamics
(Broccoli-Lettuce Rotation 2017-18)
2-3 ft depth
UTC
GAS-5
GAS-10
GL-2.5
GAS-5+GL-1.25
NO_3-N mg/kg dry soil
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Oct-17
Nov-17
Dec-17
Jan-18
Feb-18

Summary & Future Plan

- Fall incorporation of cole crop residues can cause significant nitrate leaching in a rainy winter
- High C:N amendments including ground almond shell, olive pomace and glycerol have a potential to immobilize residual soil nitrate and reduce N leaching
- C:N ratio, particle size, and labile C content appear to affect N immobilizing capacity of amendments
- Effects of amendment application on successive lettuce and strawberry crops are to be determined
- Economic analysis is in progress
- If proven to be effective without harming successive crops and be economically viable, this approach may become a part of best management practices

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