Fertilization of Organic Vegetables

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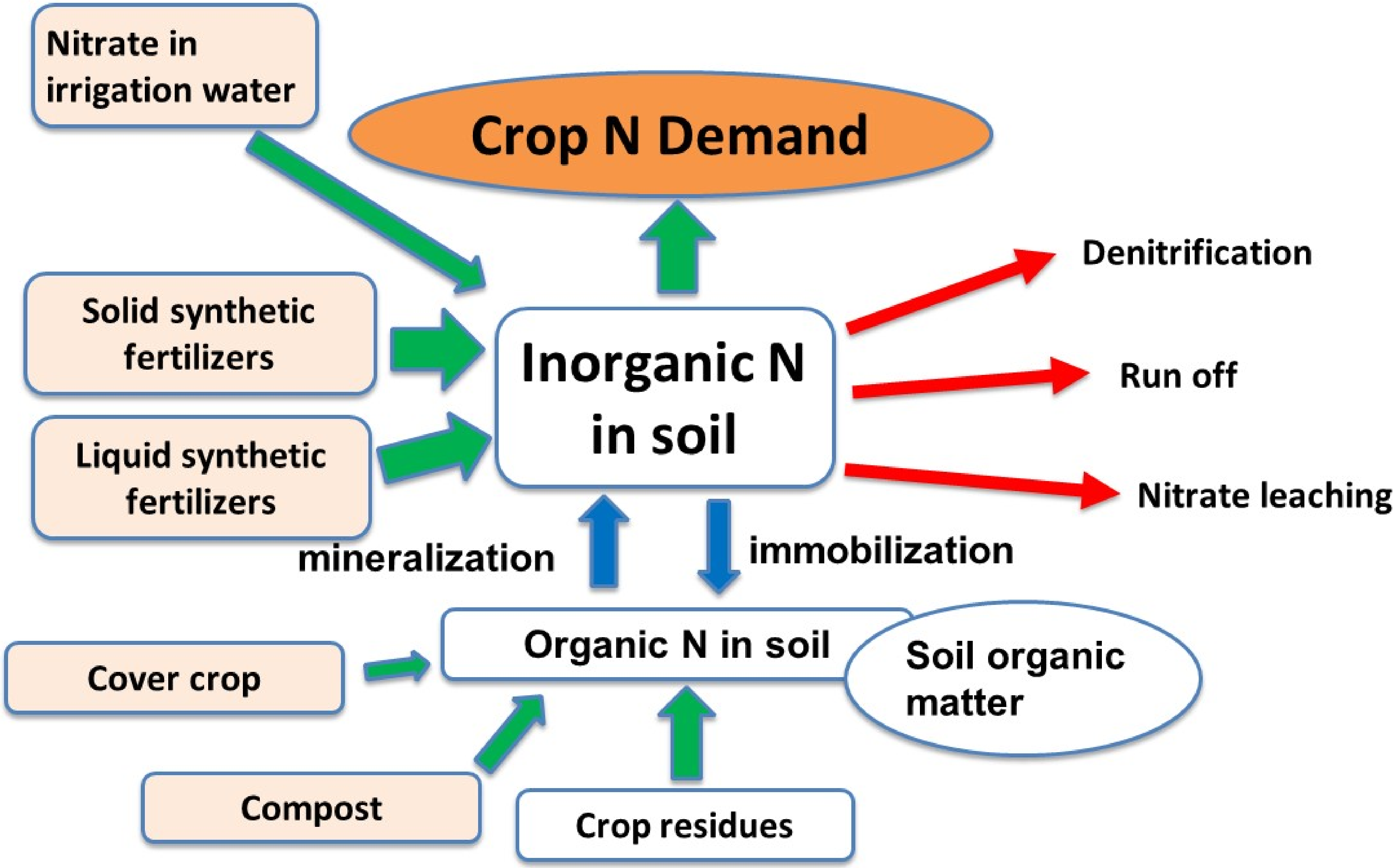
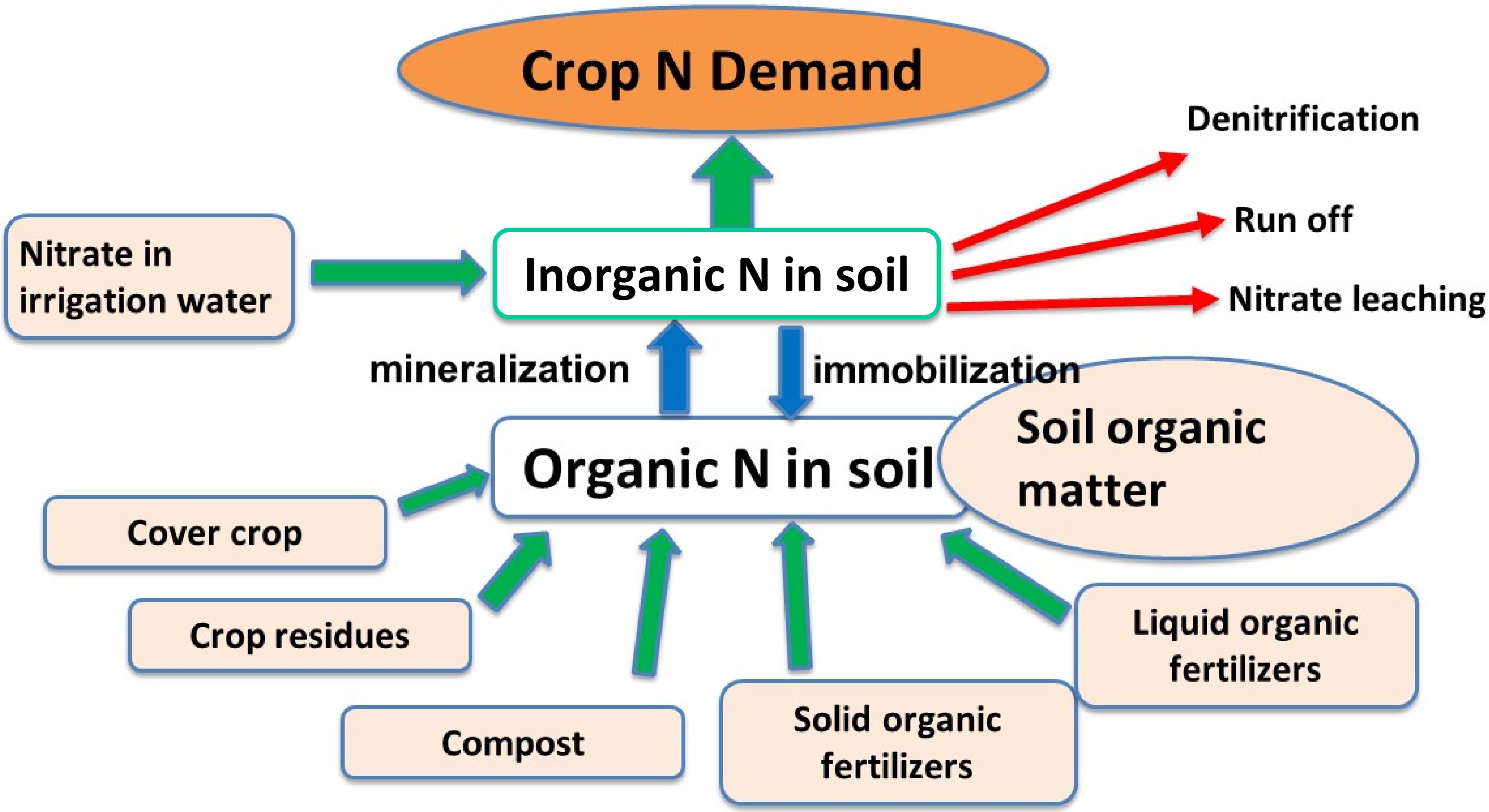
N dynamics in a conventional farming system



Nitrogen dynamics in an organic farming system



Management of Fertilization of Organic Vegetables

- Completed a 4-year study funded by FREP
- In-field and lab evaluations of mineralization of soil organic matter and organic fertilizers
- Nitrogen and phosphorus balance
- Nitrogen management trials
- Impact of organic fertilizers on soil health

Management of Fertilization of Organic Vegetables

- **Organic operations will also be subject to A/R (applied to removal) regulations in Ag Order 4.0**
  - **With that in mind….**
  - **We explored how much of the applied fertilizer N was available**
  - **Explored if N applications could be fine tuned with nitrate testing (as is commonly done in conventional production)**

Management of Nitrogen Fertilizer

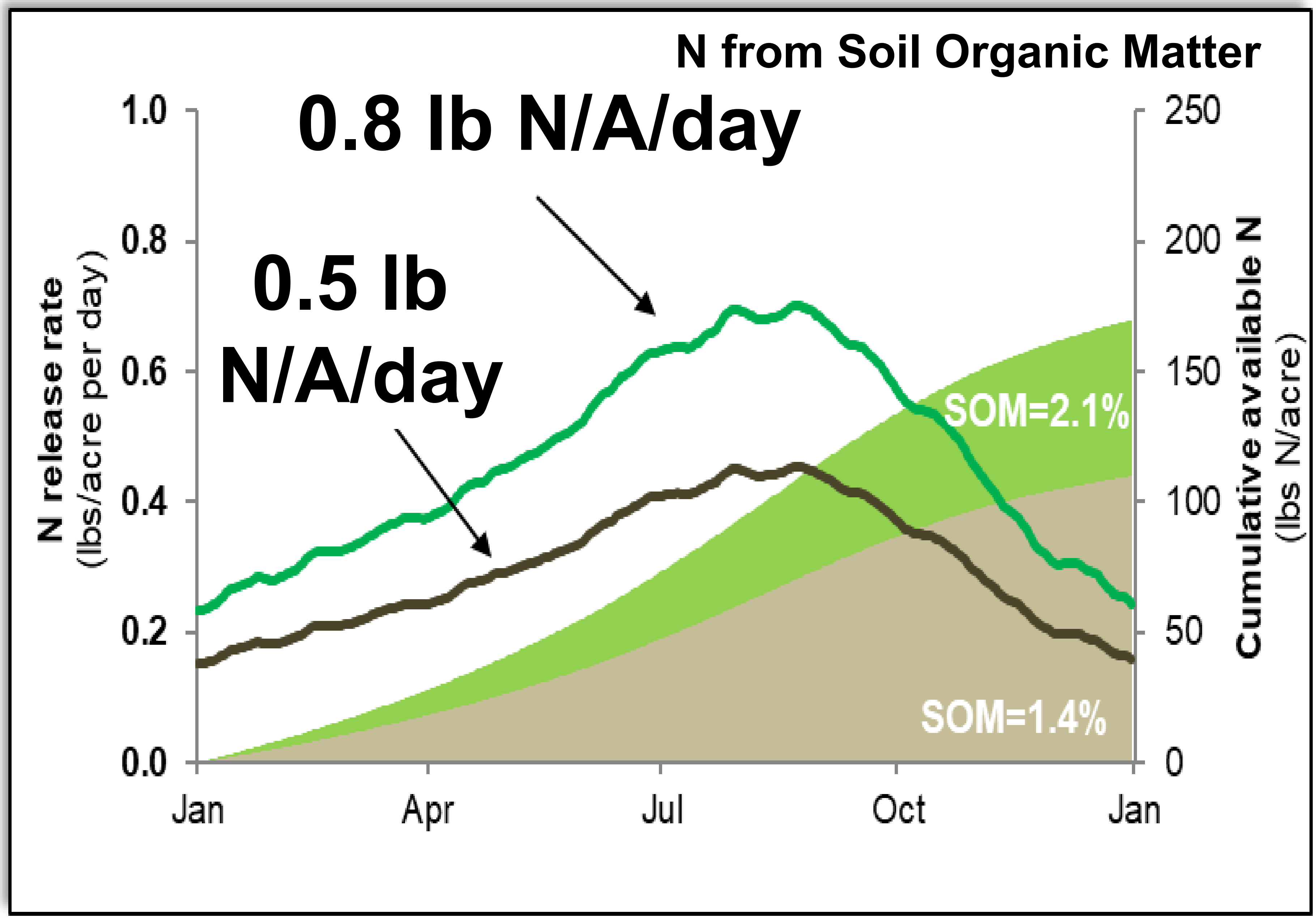
- **How much and when to apply N fertilizer for vegetable crop production is an interesting and complex question:**
  - **What is the total crop need**
  - **How much N is made available from soil organic matter, prior crop residues and irrigation water**
  - **How much and when is N made available from the current fertilizer application**

Nitrogen Uptake by Crops: A starting point for understanding the N needs of vegetable crops

Crop	Crop Uptake lbs N/A	Percent removed in the harvested portion
Broccoli	250-350	25-35
Cauliflower	250-300	25-35
Celery	200-300	50-65
Lettuces	120-160	50-60
Baby lettuces	60-70	65-75
Spinach	90-130	65-75

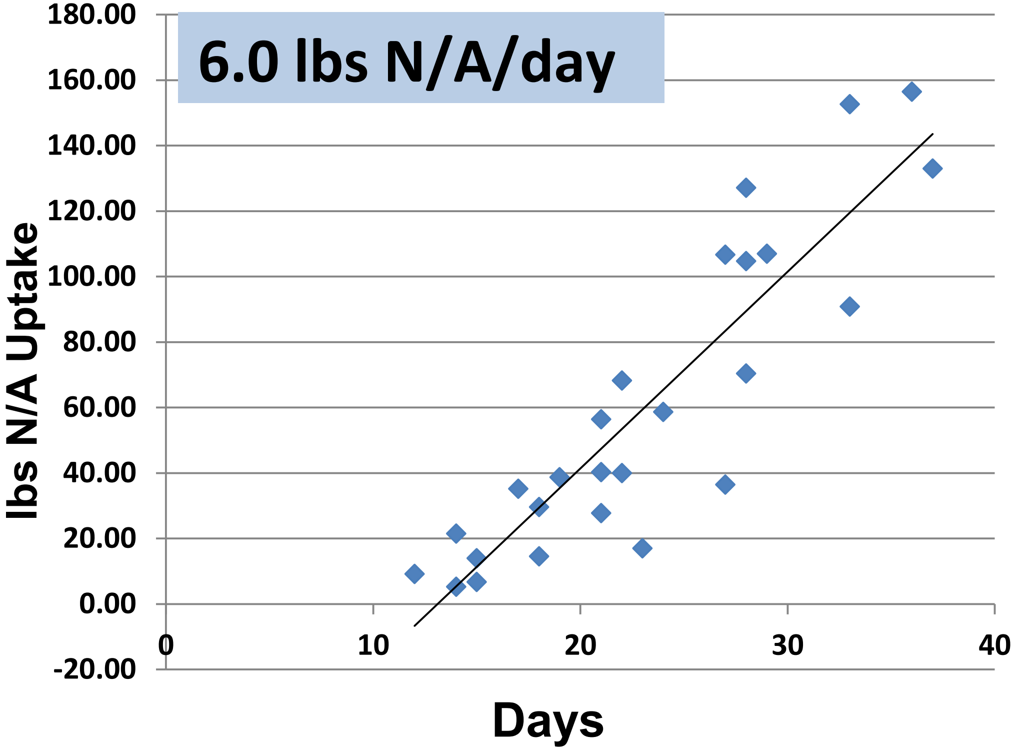
Management of Nitrogen Fertilizer

- How much N is made available for crop growth from both non-fertilizer and fertilizer sources is poorly understood
- How do we fine tune N applications under the axiom: feed the soil/feed the plant?
- For fast-growing, high N demanding vegetables, this is particularly tricky given differences in N release due to soil temperature and other factors



Patricia Lazicki

Impact of N Mineralized from Soil Organic Matter



- The amount of N from the soil organic matter provides a baseline supply
- Given the quantity it provides, the amount of supplemental fertilizer N can be modified
- In general, it will not provide all N needed

Given the Composition of Organic Fertilizers, How Much Plant-Available N is Released?

In-field Fertilizer Mineralization Studies

Polypropylene Pouches with Fertilizer

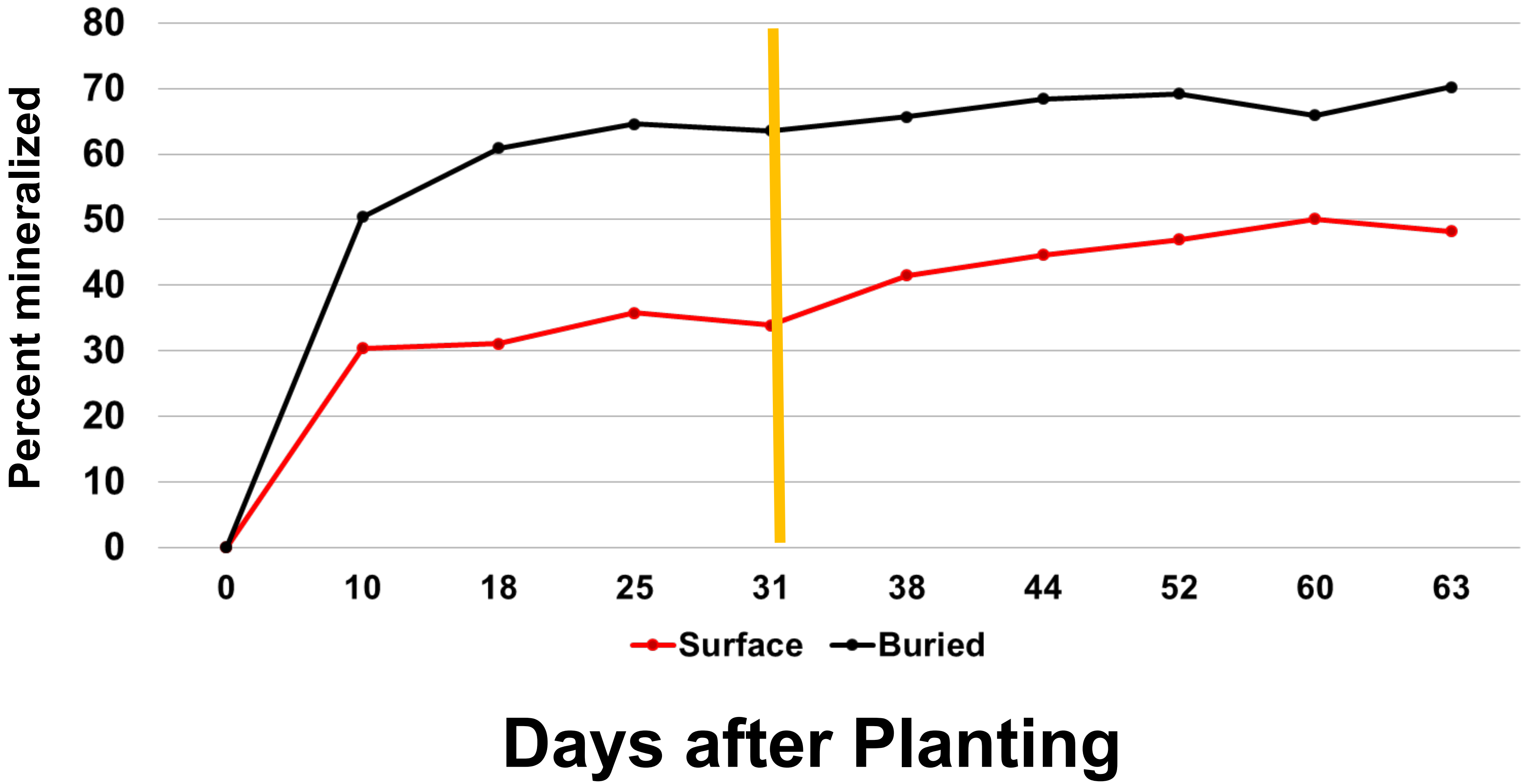
- Pouches with fertilizer were placed into the soil at the beginning of the crop cycle
- 4-4-2 (blend of chicken manure, bone and meat meals) buried and on soil surface (direct seeded romaine)
- 12-0-0 (feather meal)

In-field Fertilizer Mineralization Studies

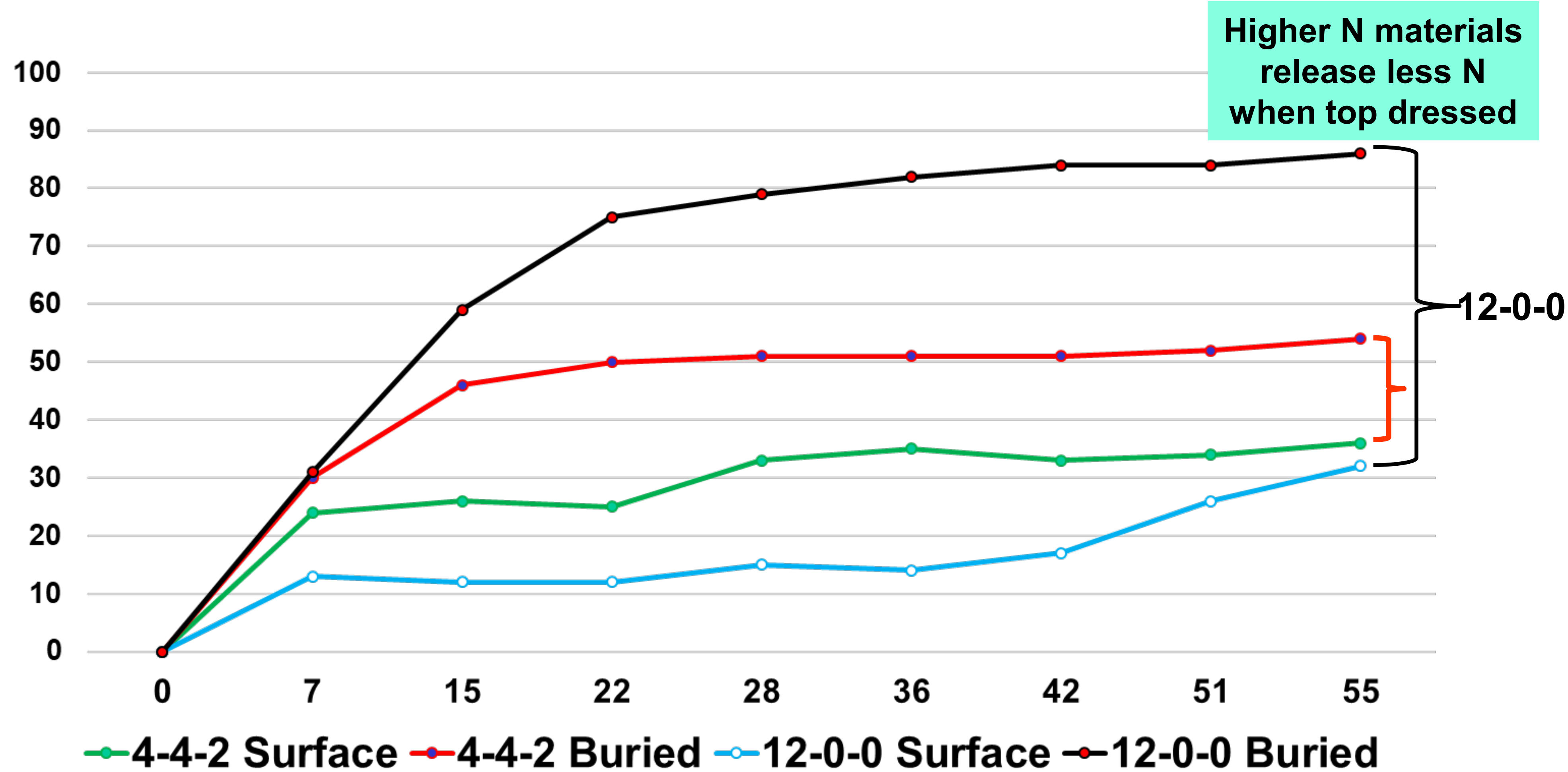
Buried in soil

Place on top of soil

4-4-2
Percent N Mineralized from Pouches
Buried vs Surface



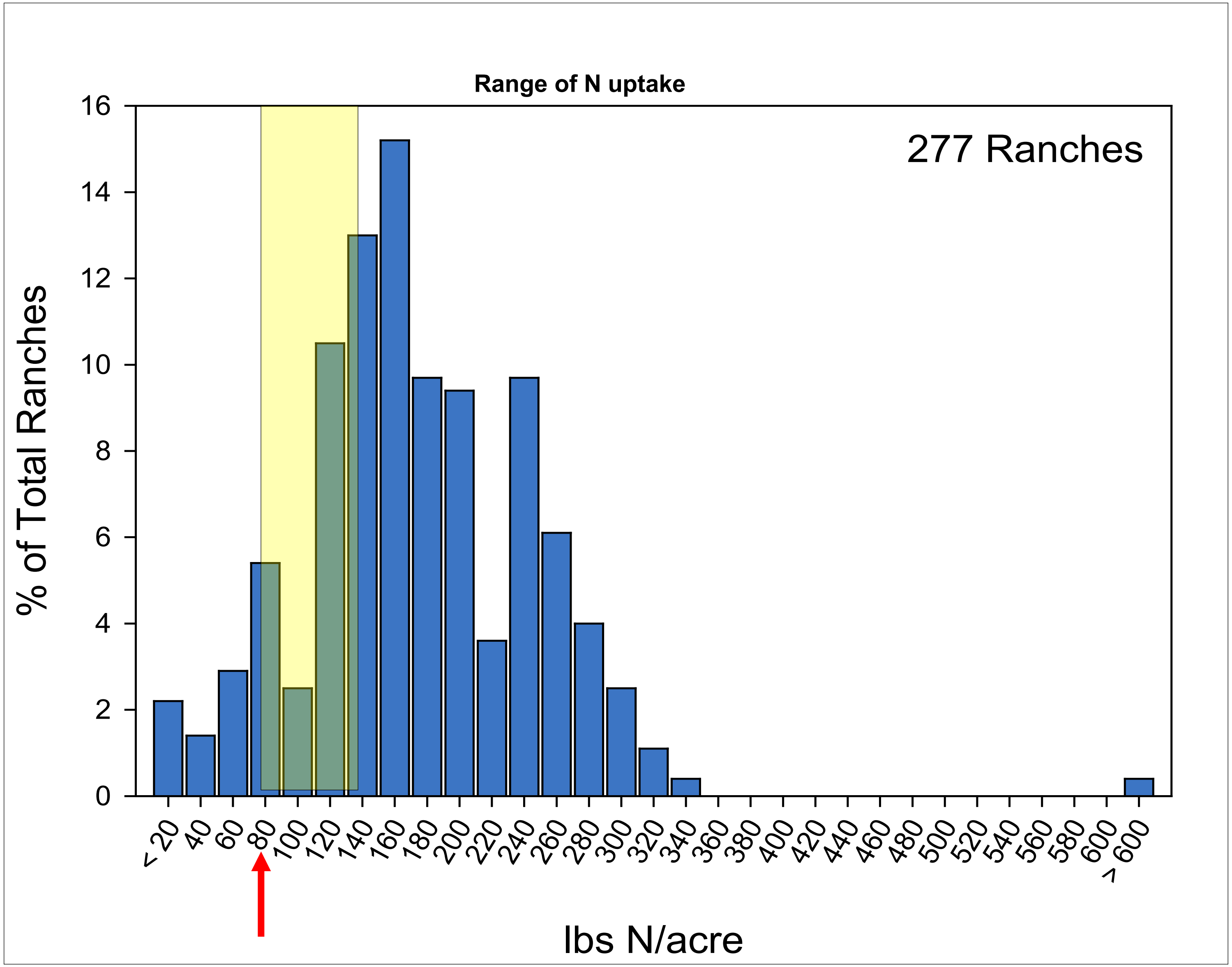
Different N Release Between 4-4-2 & 12-0-0 in Surface and Buried Placement



Pouch Evaluations

- **Placement of the material affects the speed of mineralization of N and affects the amount of material needed for optimal growth**
- **How much nitrogen fertilizer is needed for clipped spinach production?**

2017 Clipped Spinach Application Data



Spinach is the trickiest crop to manage N due to the shallow rooting, high N demand curve and exclusive use of sprinkler irrigation

CC Regional Water Quality Control Board Report; Cahn and Qin

Spinach: Impact of Residual Soil Nitrogen

Listing lbsN/A	At-planting lbsN/A	Total lbsN/A	At plant soil NO_3-N	Harvest soil NO_3-N	Harvest crop Tons/A
0	0	0	18	5	6.4
0	80	80	18	8	6.7
80	0	80	18	11	7.1
80	80	160	18	9	6.9

- Clay loam soil (3.2% OM) with moderate residual soil N
- Weak yield increase with fertilization with either 80 or 160 lbs N/A
- Probably low leaching over the season

Spinach: Impact of Residual Soil Nitrogen

Listing lbsN/A	At-planting lbsN/A	Total lbsN/A	At plant soil NO_3-N	Harvest soil NO_3-N	Harvest crop Tons/A
0	0	0	33	21	10.1*
40	40	80	33	38	9.3
80	80	160	33	44	8.8

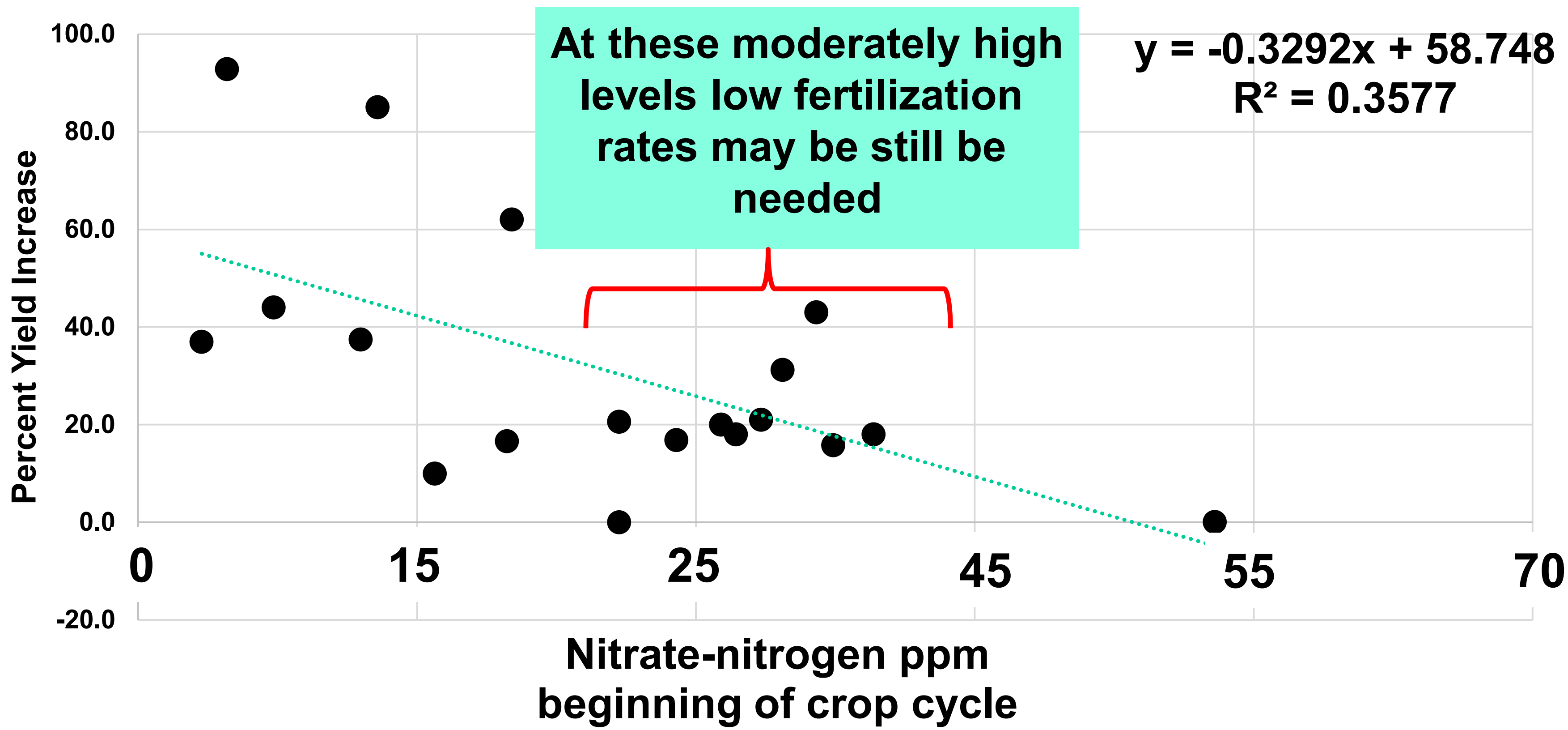
- Clay loam soil (3.5% OM) with high residual soil nitrate-N
- No yield increase with fertilization – yield decrease
- Combination of high mineralization and residual N
- Probably low leaching

Spinach: Impact of Residual Soil Nitrogen

At-Plant lbsN/A	Top dress lbsN/A	Total lbsN/A	Total Net lbsN/A	At plant soil NO_3-N	Harvest soil NO_3-N	Harvest crop Tons/A
0	0	0	0	28	17	6.1
0	80	80	40	28	19	6.5
80	0	80	40	28	21	6.9
160	0	160	80	28	25	7.7

- Sandy loam soil (1.2% OM)
- High residual soil N, but low mineralization from organic matter; moderate net N release from fertilizer, which puts these crops on the edge
- Probably greater leaching of residual N on sandy soil

Initial Nitrate-N and Percent Yield Increase with Fertilization



If taking net mineralized fertilizer N into account many organic spinach fertilizer programs are quite modest: A/R around 1.0

Testing for Residual Nitrate-Nitrogen to Guide Fertilizer Applications

- Testing for residual soil nitrate-N is common in conventional production
- It can also be useful in organic, but for intensive fast maturing crops such as spinach, the tests have to be done prior to planting to have sufficient time to make fertilizer applications
- Later in the crop cycle is too late for the fertilizer to be effective in spinach

Testing for Residual Nitrate-Nitrogen to Guide Fertilizer Applications

- Early testing creates an issue with potential leaching losses with the germination water (3+ inches)
- On sandy soils nitrate tests may not be useful if leaching reduces residual nitrate-N
- On heavier soils, with less leaching, N applications can be reduced if sufficient residual nitrate-N is present

IRRIGATED LANDS REGULATORY PROGRAM

TOTAL NITROGEN APPLIED REPORT FORM

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March 19, 2018 Version

CENTRAL COAST REGIONAL WATER QUALITY CONTROL BOARD

EMAIL FILLABLE ELECTRONIC FORM AS AN ATTACHMENT: Attach completed and saved fillable ("live") electronic form and send to AgNOI@waterboards.ca.gov

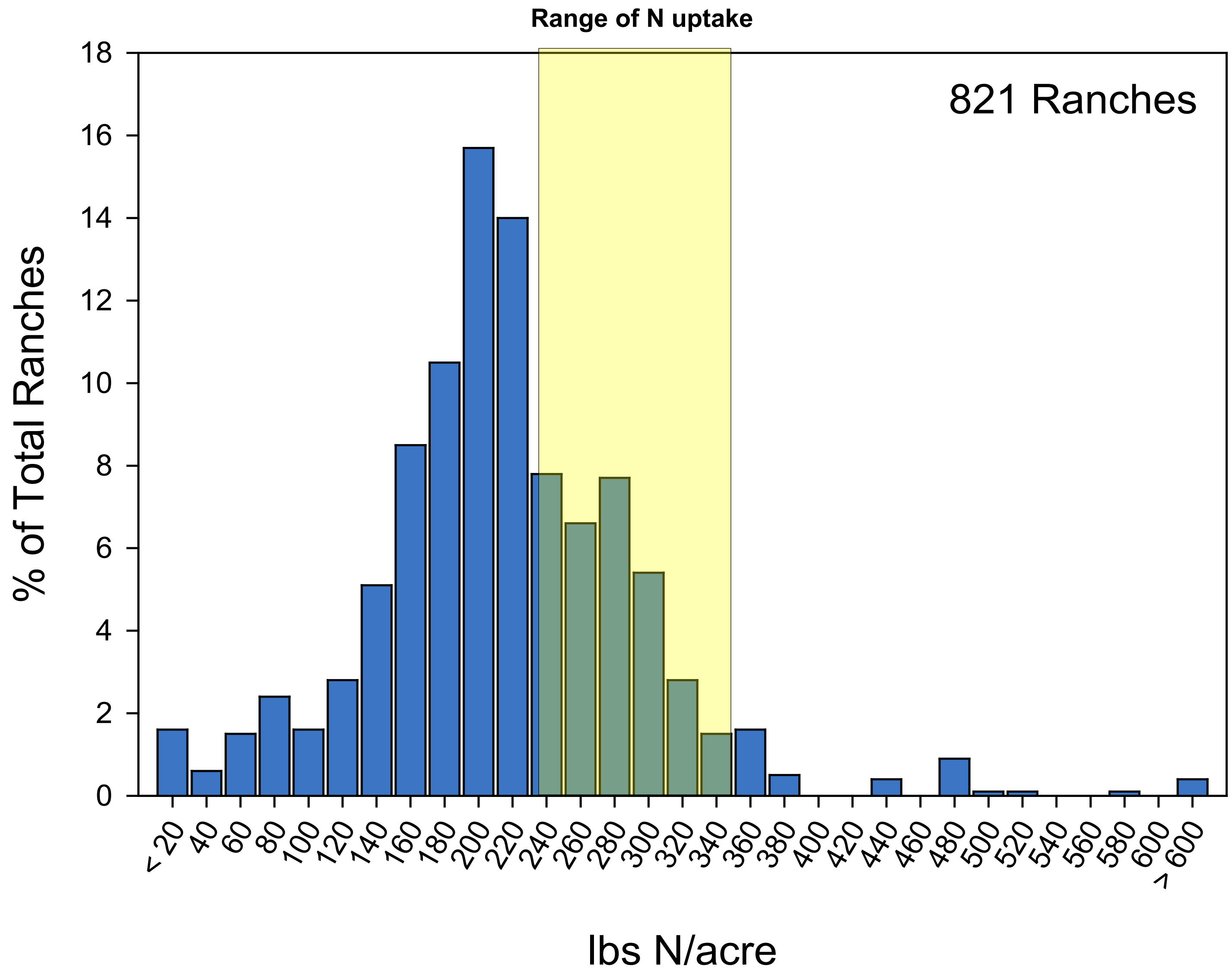
Reporting Period: 01/01/2017 to 12/31/2017

Water Quality Implications For Organic Fertilizer

- The A/R regulations in Ag Order 4.0 will have implications for organic production
- A percent of the applied fertilizer N is recalcitrant and not a leaching hazard
- Ag Order 4.0 needs to take into account actual mineralization of organic fertilizers in the A/R evaluations

Fertilization of Organic Broccoli

2017 Broccoli Application Data



CC Regional Water Quality Control Board Report; Cahn and Qin

Broccoli Nitrogen Evaluations

Field	Soil Organic Matter	Fert. N applied	Net from fertilizer	Nitrate N in water	Soil N mineralized over cycle	Total available N	Crop N uptake
1	1.6	437	219	20	67	306	376
2	1.3	451	163	10	109	326	326

- Both fields used drop on top applications which reduced the amount of N released by the fertilizer

Broccoli Nitrogen Evaluations

Field	Fert. N applied	Net from fertilizer	Crop N uptake	Crop R*	A/R N applied	A/R Net N released
1	437	219	376	113	3.9	1.9
2	451	163	326	98	4.6	1.7

- Crop R for broccoli is approximately 30% of uptake
- The N not mineralized becomes part of the soil organic N fraction and acts like soil organic matter and releases at a slow steady rate

Preliminary Observations of Nitrate Leaching

- We examined nitrate levels down to 7 feet deep at the beginning and end of the cropping cycle on three fields
- In two of the fields, there was little evidence of movement of nitrate downward in the soil profile
- In one field there was some slight enrichment of nitrate levels down to 4 feet deep

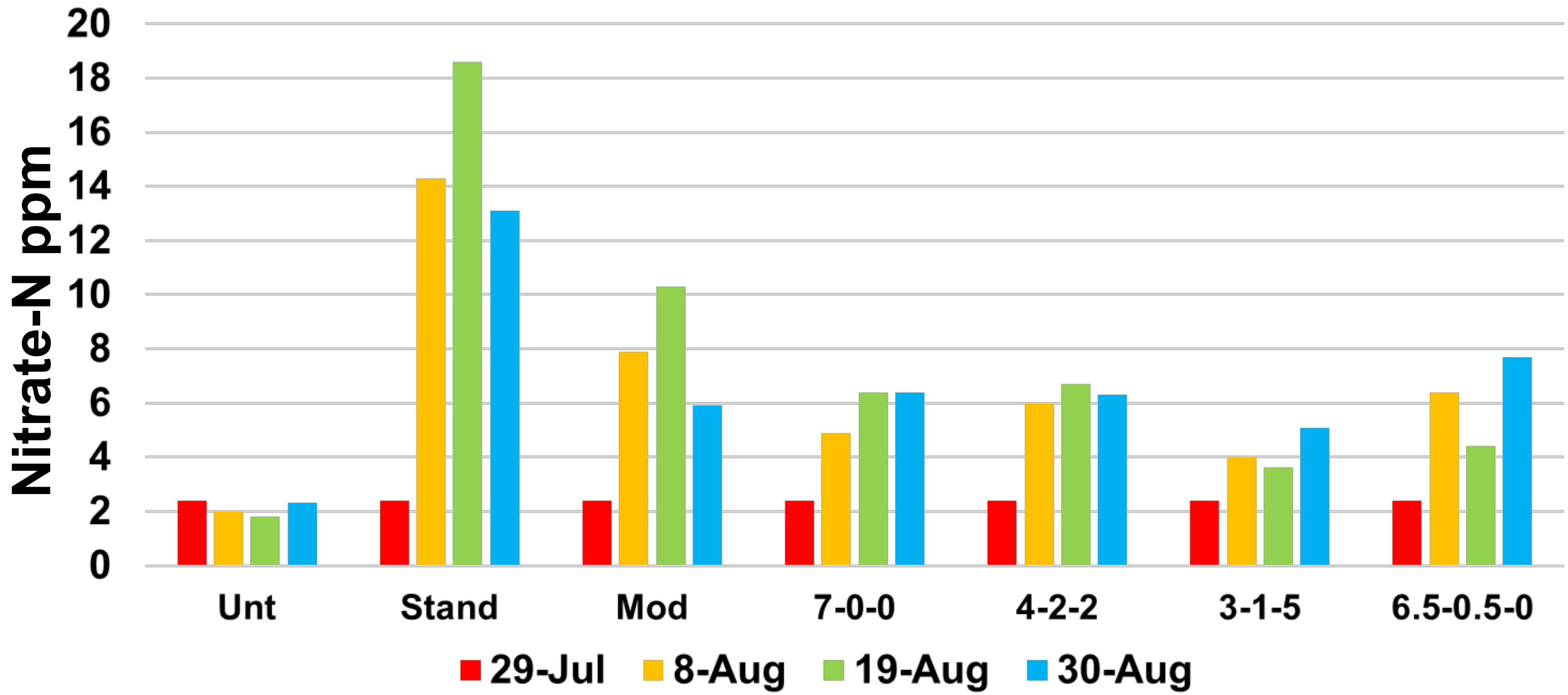
Liquid Fertilizers Tested

Material	Source
7-0-0	Soybean hydrolysate
4-2-2	Beet extract and corn steep liquor
3-1-5	Sugar molasses & acidulated fish tankage
6.5-0.5-0	Fish protein hydrolysate

- Two applications were made for a total of 80 lbs N/A
- Compared with 80 and 150 lbs N/A of UN32

Liquid Fertilizer Evaluation

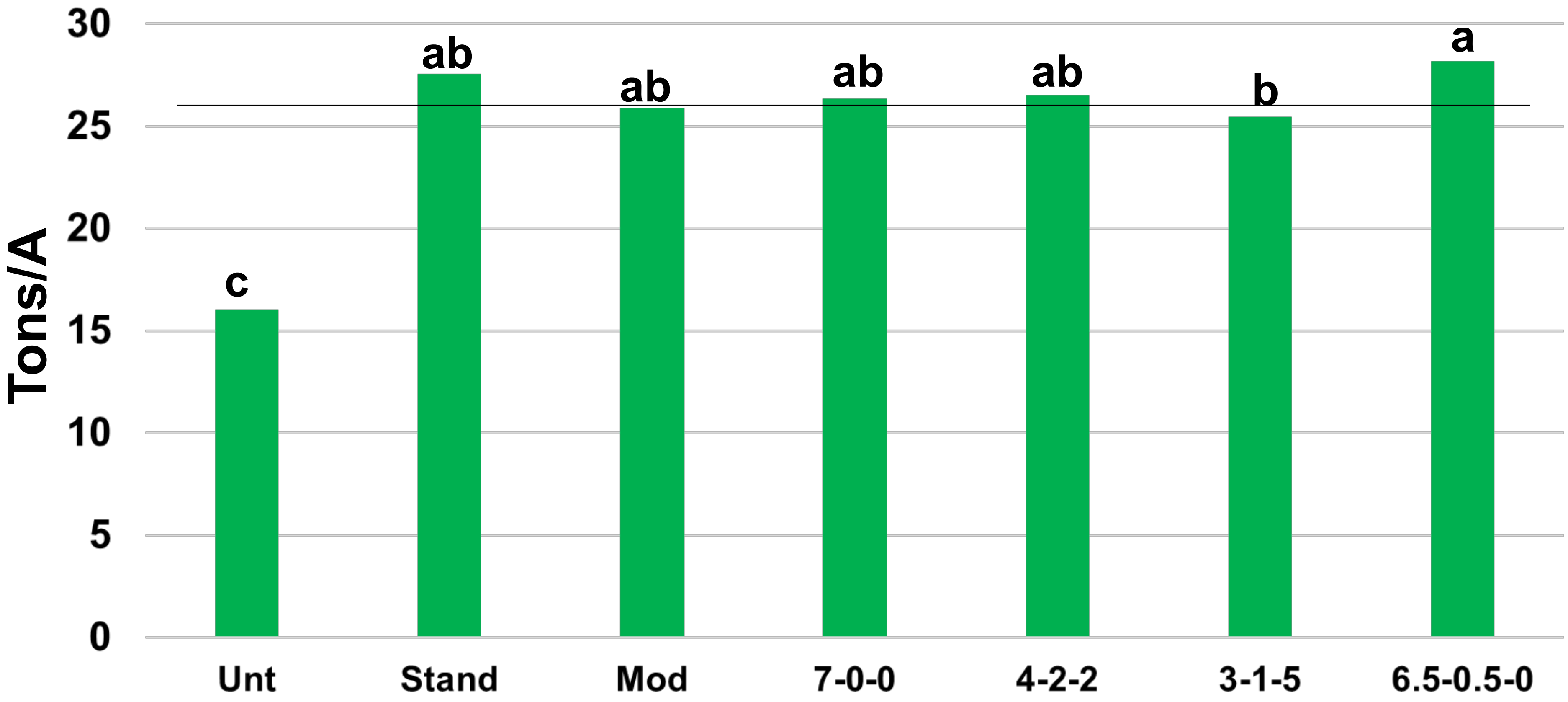
Soil Nitrate-N Over Crop Cycle



Standard = 150 lbs N/A; all other 80 lbs N/A

Liquid Fertilizer Evaluation

Fresh Biomass



Standard = 150 lbs N/A; all other 80 lbs N/A

Substituting Liquid Organic Fertilizers for Dry

- **Given high residual soil N where only moderate amounts of N are needed to achieve maximum yield – could liquids finish out the crop economically??**
- **Given the excellent performance of the new generation of liquid fertilizers, could they provide a viable fertilization option?**

Substituting Liquid Organic Fertilizers for Dry

Material	Cost/lb N	Cost/40 lbs N	Efficiency of N release
Hydrolysates	$13-18	$520-720	70-80+
Traditional Liquids	$9-10	$360-400	70-80+
4-4-2 dry	$3.50	$140	55

Does the new liquid organic fertilizer technology open new opportunities for making more precise N applications??

Acknowledgements

- Cooperating growers
- Crop consultants
- Student Assistants
- Funding provided by FREP

Input of Carbon

Material	Biomass lbs/A	Carbon content percent	Total carbon lbs/A
Compost	10,000[1]	29%	2,146
Cover crop	6,000	44%	2,640
4-4-2 2 baby crops @ 3000 each	5,400[2]	29%	1,566
8-5-1 1 broccoli crop	5,000[3]	41%	2,050

1 – 10,000 lbs/A @ 74% oven dry weight
2 – 6000 lbs/A (2 baby crops @ 3000 lbs/A each) @ 90% oven dry weight;
3 – 5650 lbs/A @ 90% oven dry weight

Comparison of 20 Pairs of Conventional and Organic Fields

Soil Constituent	Conventional	Organic
Organic Matter %	2.0	2.1
Total Nitrogen %	0.12	0.12
Phosphorous (Olsen) ppm	37	39
Water Extractable Organic N ppm	14	17
FDA Enzyme kg/hr	12	19

4-4-2
Percent Phosphorus Removed from Pouches
Buried vs Surface