

Fertilizer Use Efficiency in Organic Leafy Green Vegetable Cropping Systems



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Cool Season Vegetable Production Area

Salinas Valley, CA

- **Crops include: lettuces, spinach, cole crops, celery, spring mixes, etc.**
- **Organic production comprises 9% of total ag value**
- **Most organic ag is carried out by large scale operations (conventional/organic) that serve the mass markets**
- **Mean crops/year = 2.0 – 2.5**
- **Baby lettuces and spinach mature in 22 – 31 days**
- **Full-term crops lettuce and broccoli mature in 50 – 70 days**
- **N uptake curves by these crops are steep for a short period of time**
 - **Lettuce: 4 lbs N/A/day (35 days)**
 - **Spinach: 6 lbs N/A/day (15 days)**

Cool Season Vegetable Production Area

Salinas Valley, CA

- **Constraints:**
 - High land rents dramatically reduces the use of cover crops
 - No local source of manures
 - Compost is yard waster – Low N. Not used by some operations due to food safety concerns
- **Common Fertility Practices**
 - Chicken manure and slaughter house products from the San Joaquin Valley
 - Fertility practices have evolved based on experience and for the most part parallel conventional practices



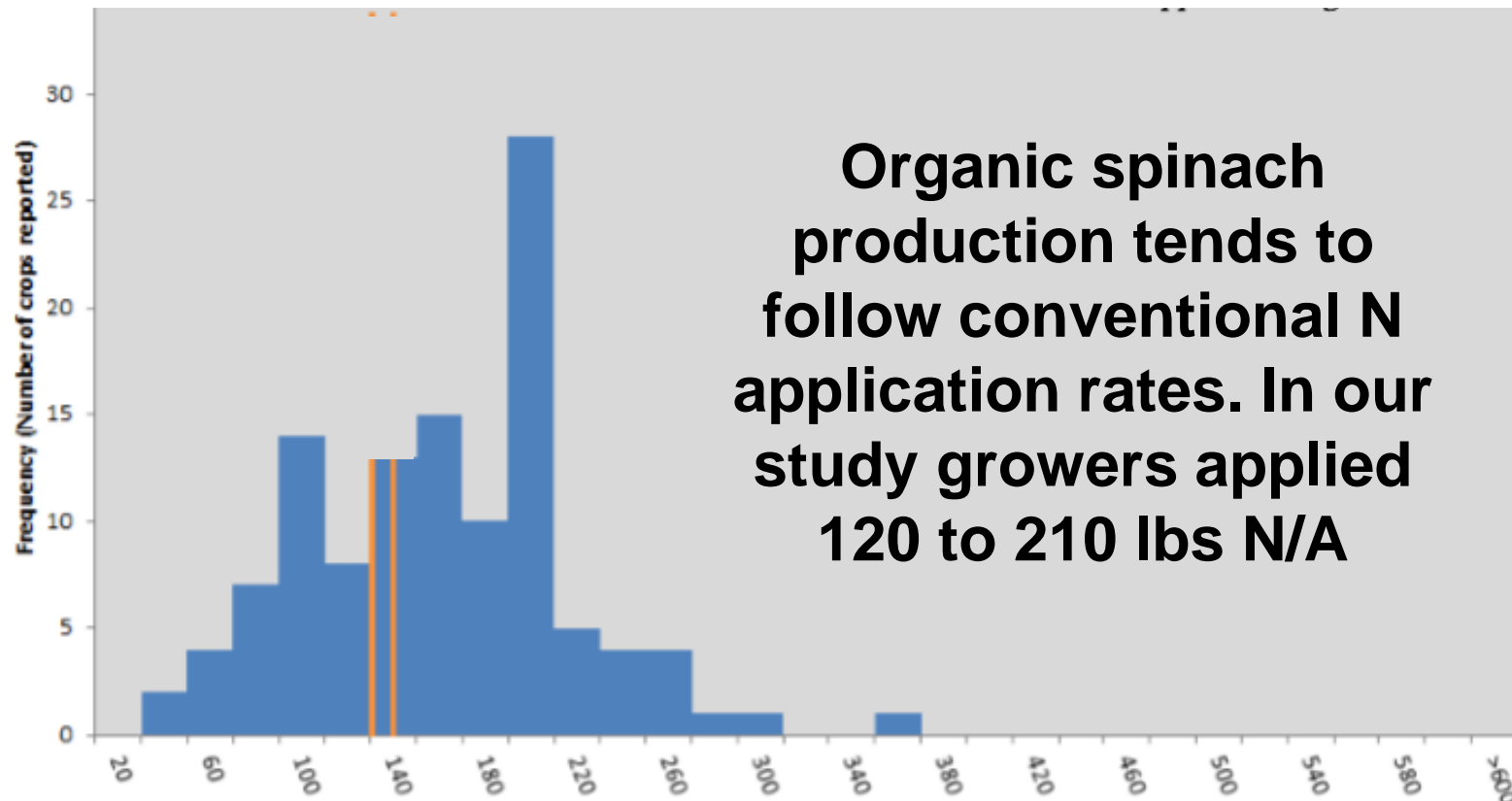
1 ton bags of 4-4-2



Post plant topdress

Grower Reported N from Fertilizers (117 Crop Records) Compared to Specific Crop Nitrogen Uptake

Conventional Spinach Growers Generally Apply 140 to 200 lbs N/A



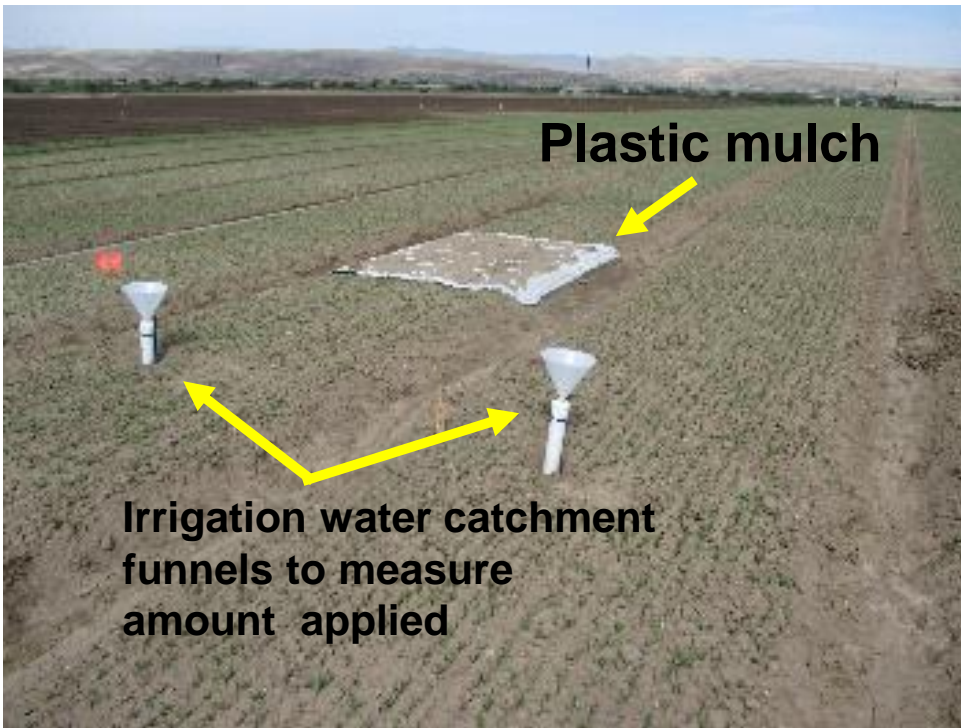
* Regional Water Quality Control Board data

Organic Soil Fertility Evaluation

- **Project funded by FREP to investigate nitrogen mineralization of soil and organic fertilizers and evaluate phosphorus dynamics in organic soils**
 - **Demonstrate and evaluate the proportion of crop N needs that are provided by soil organic matter mineralization in organic leafy vegetable production under coastal climate conditions**
 - **Demonstrate and evaluate mineralization behavior of a group of commonly used dry and liquid organic fertilizers under field conditions on the Central Coast**
 - **Demonstrate and evaluate the N and P balance of organic production fields**
 - **Refine and update algorithms of N mineralization from soil organic matter in CropManage**

Soil Organic Matter Mineralization Evaluations

- In field soil organic matter evaluations, where plant removal and leaching were removed and measurements of pre and post crop cycle soil nitrate levels were measured
- In vitro incubations were conducted at UCD at controlled temperature and moisture conditions



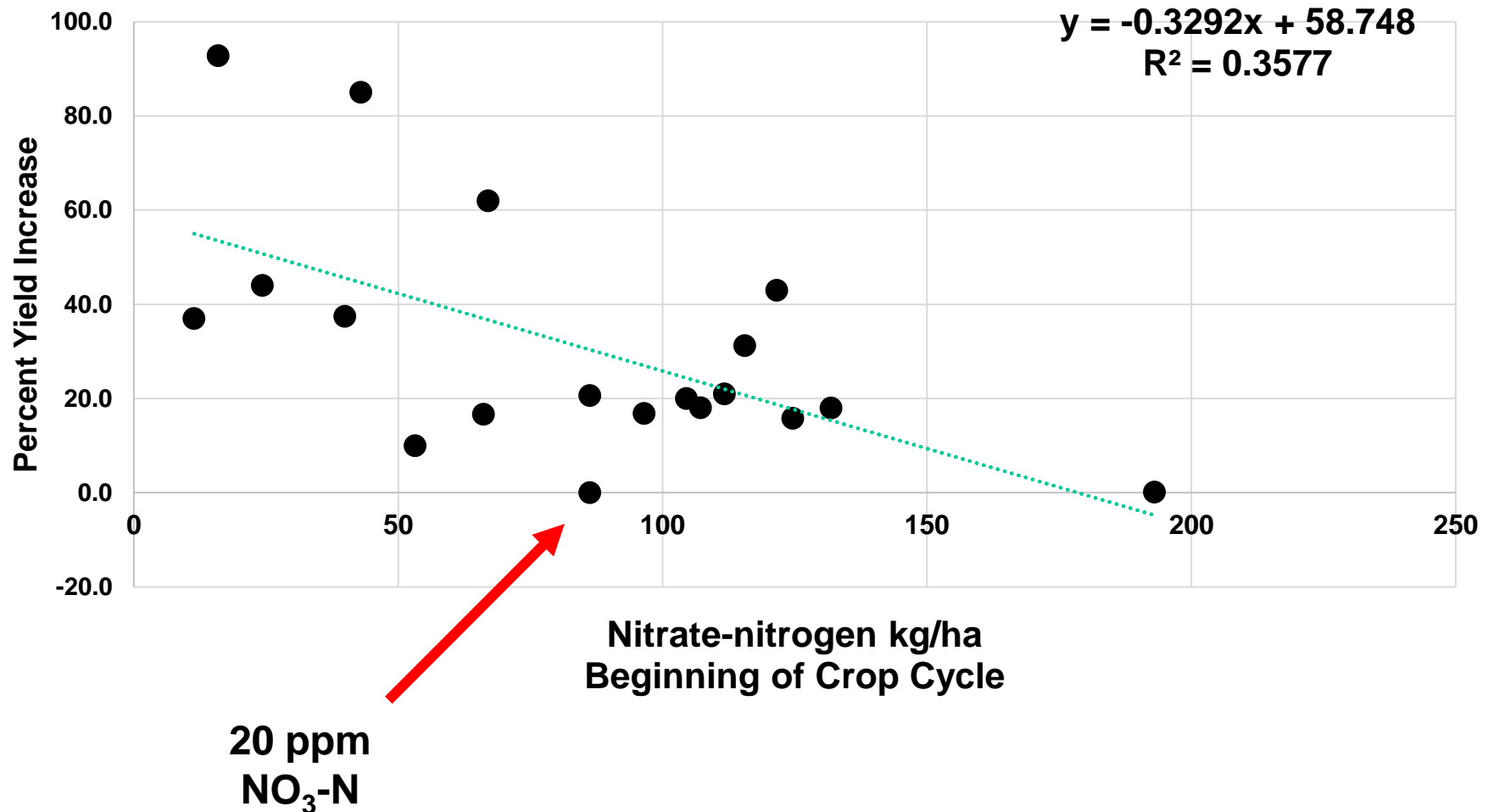
Summary of In-Field Nitrogen Mineralization Evaluations

- Estimates of N mineralization from the soil over the cropping cycle ranged from 0.3 to 3.3 lbs N/A/day; average = **1.8 lbs/A/day**
- Laboratory estimates ranged from 0.3 to 1.9 lbs N/A/day; average = **0.6 lbs/A/day**
- Regardless of which estimate is correct, it can be seen that soil organic matter by itself cannot supply sufficient N for high-N demanding crops like lettuce and spinach

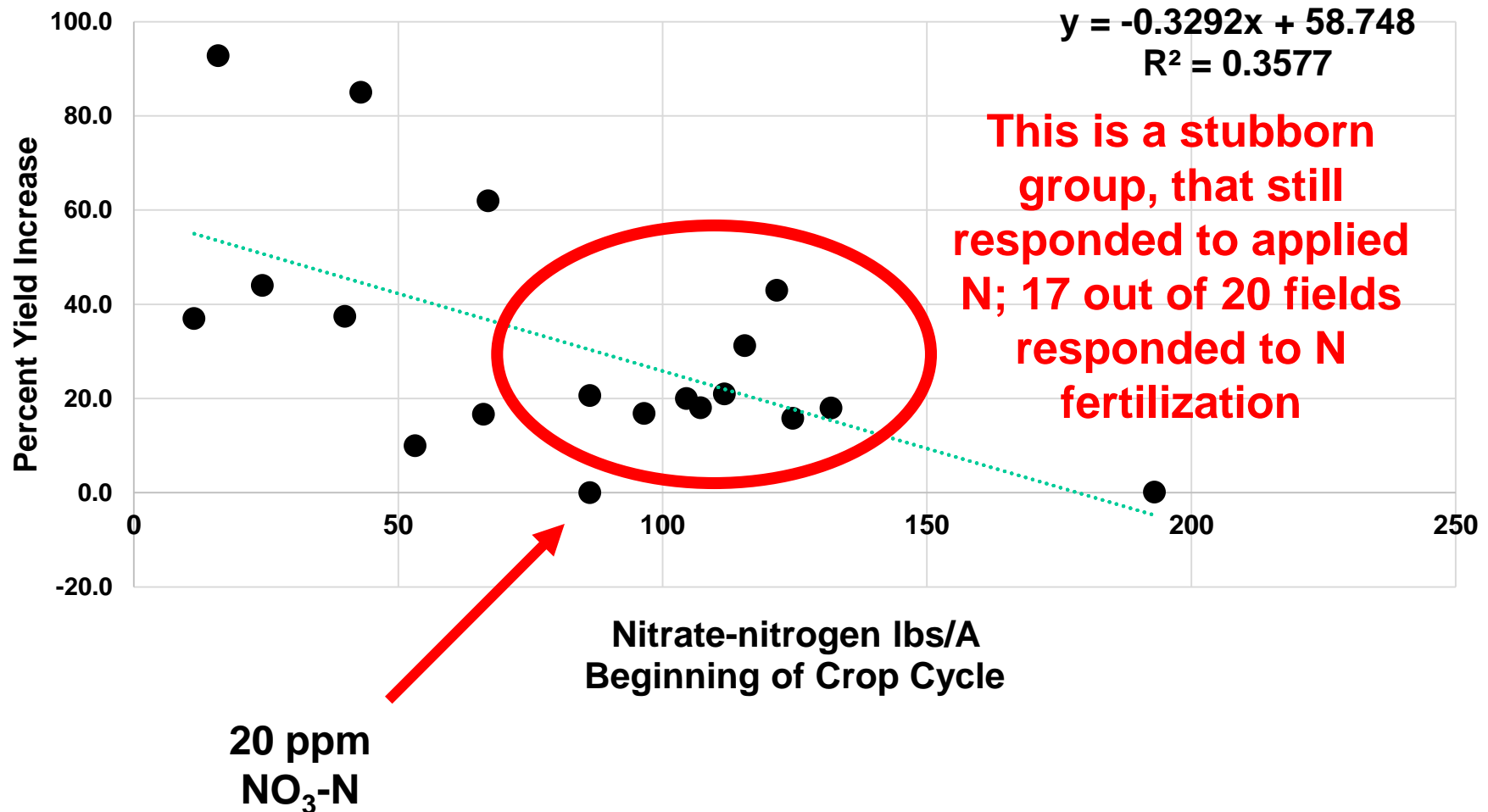
Measuring Residual Soil Nitrate

- In double cropped leafy vegetables there can be high amounts of residual soil nitrate from prior crop residues and organic matter mineralization**
- In conventional production, grower are increasingly taking this amount of N into account in fertilizer decisions**
- Accounting for residual N is not commonly done in organic vegetable production**

Initial Nitrate-N and Percent Yield Increase with Fertilization



Initial Nitrate-N and Percent Yield Increase with Fertilization



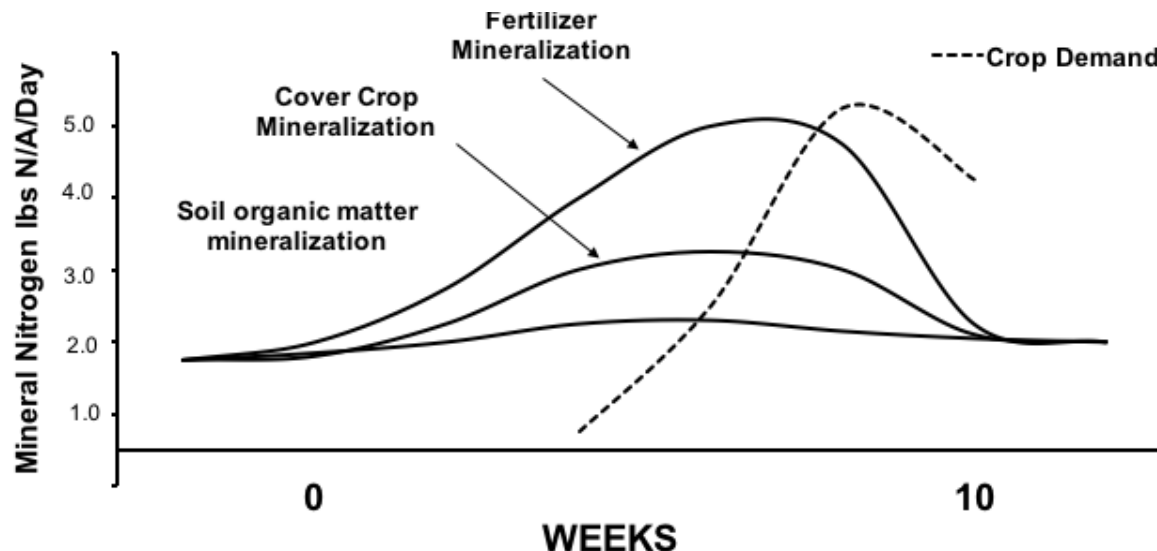
Dry Organic Fertilizers

- One of the great challenges is achieving synchrony between the release of mineral N from the organic fertilizers and crop demand
- Given that the materials must be physically applied, there are set numbers of times that the materials can be applied:
 - Preplant, post planting, top/sidedressing(s)



Dry Organic Fertilizers

- The timing of the fertilizer applications must be done far enough in advance of demand curve of the crop, but not so far in advance that the resulting pool of nitrate would be at risk for nitrate leaching



Nitrogen Fertility Trial 1

Planting lbs N/A	Topdress lbs N/A	Total lbs N/A	Initial NO ₃ -N ppm	Fresh wt tons/A
80	80	160	21	6.9
40	80	120	21	6.9
0	0	0	21	6.4

Clay loam soil

Nitrogen Fertility Trial 2

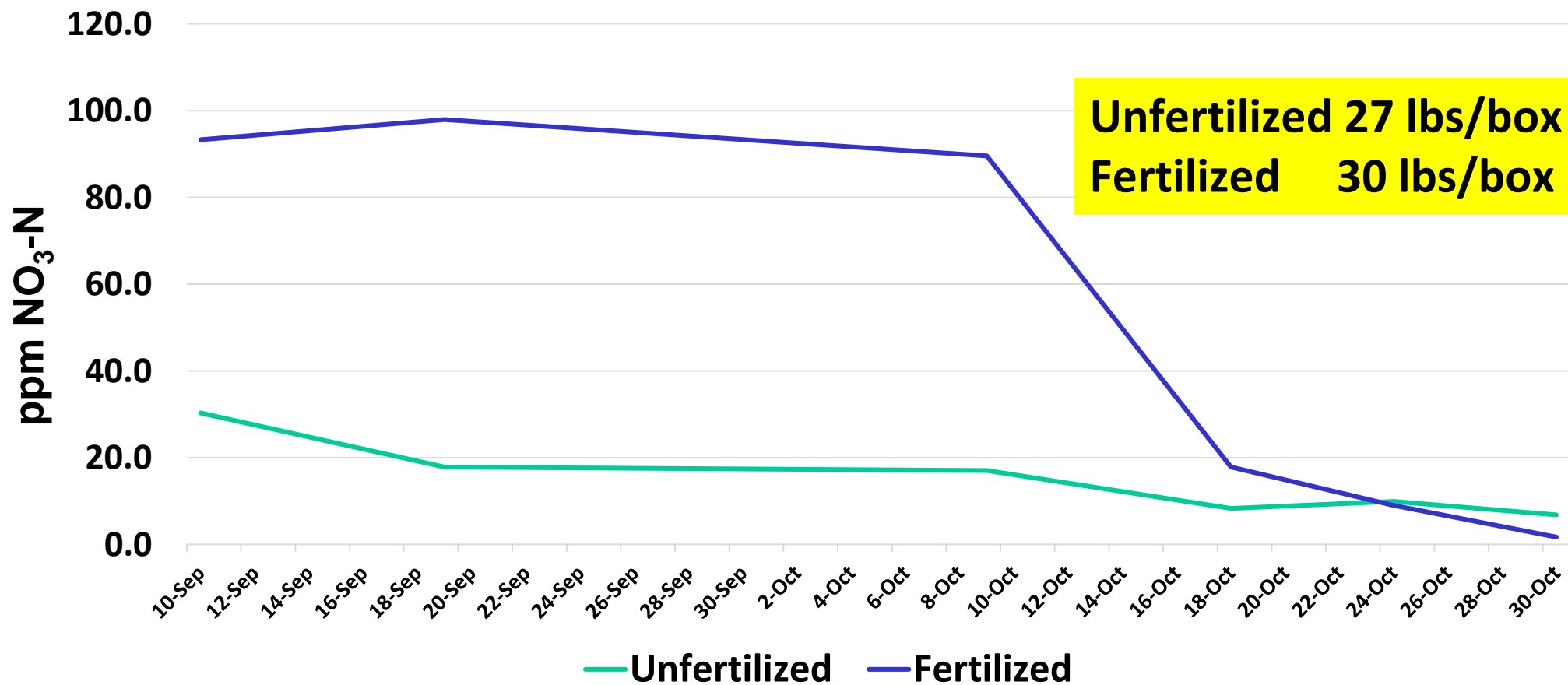
Planting	Topdress	Total	Initial NO ₃ -N	Fresh wt
lbs N/A	lbs N/A	lbs N/A	ppm	tons/A
160	0	160	27	7.7
120	0	120	27	6.8
0	120	120	27	5.7

Sandy loam soil

Romaine Lettuce Fertility Trial

Long-term Organic Farm

400 lbs 12-0-0 (48 lbs N/A); Preplant application



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) & 12-0-0 (feather meal)
- Pouches were buried & placed on soil surface to simulate application methods

In-field Fertilizer Mineralization Studies



Buried in soil

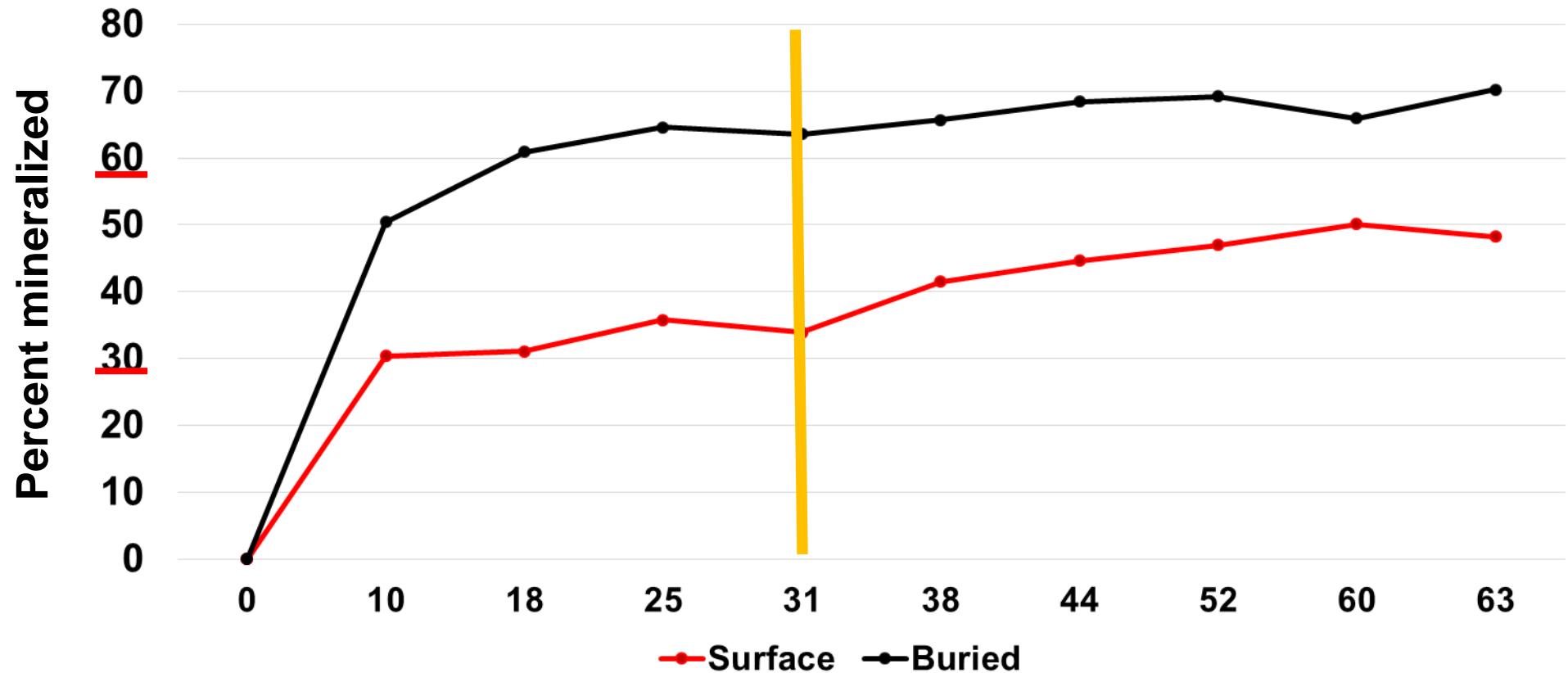


Place on top of soil

4 pouches collected weekly and analyzed for N, P & K over the crop cycle of lettuce or spinach

4-4-2

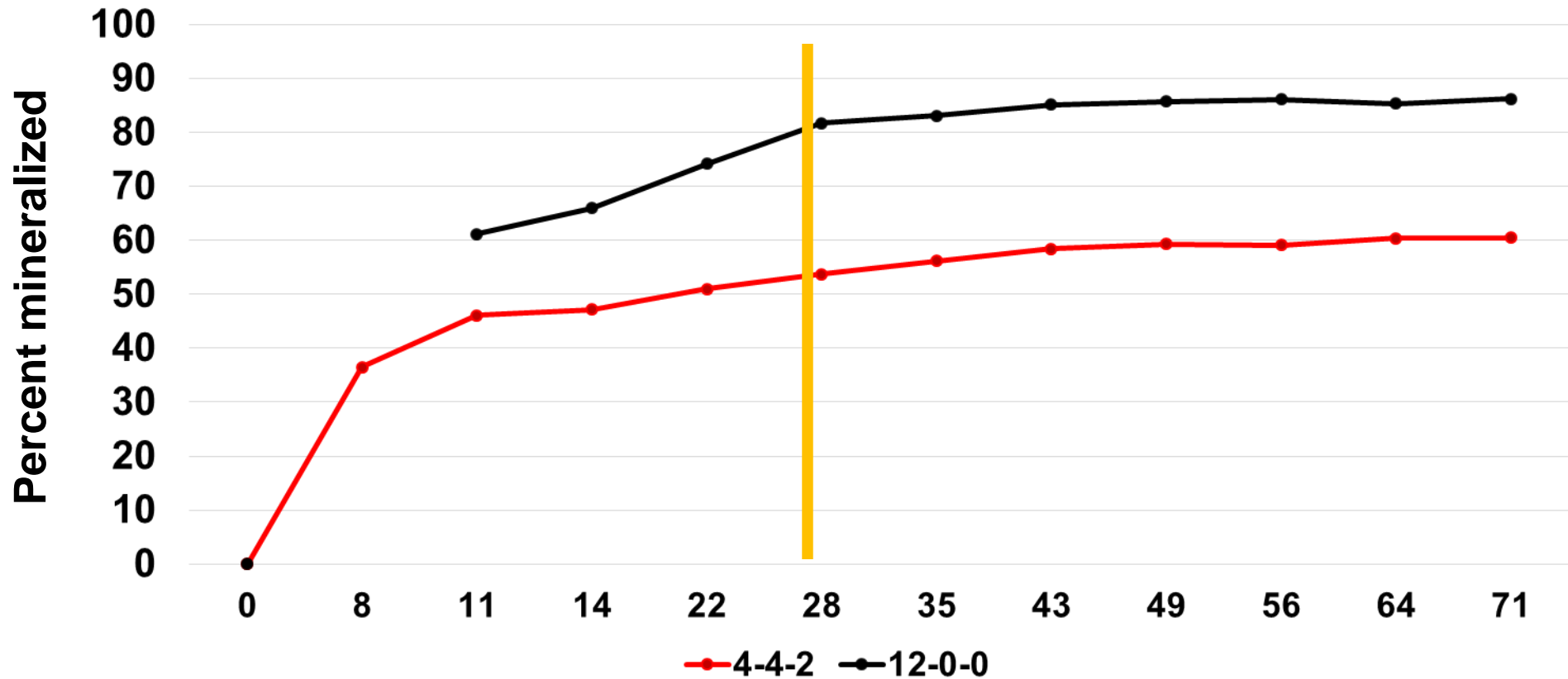
Percent N Mineralized from Pouches Buried vs Surface 2016



Days after Planting Lettuce

Buried 4-4-2 vs 12-0-0

Percent N Mineralized from Pouches



Days after Planting Lettuce

Fate of Unused Applied N

- **Double or triple cropping may be leaving a significant amount of N from the unmineralized fertilizer in the soil**
- **What is the fate of this N?**
- **It is recalcitrant and adds to total N in the soil and probably continues to slowly mineralize**
- **In a survey of 20 pairs of organic and conventional fields we did not detect a build up of total N in organically managed fields**
- **However, soil microbial activity was higher in organic fields (FDA enzyme)**

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
Total Carbon %	1.01	1.03
Phosphorous (Olsen) ppm	37	42
Phosphorous (Total) ppm	0.10	0.09

Organic Fertilizer Programs

- **The amount of N applied to the crops ranged from 1.2 to 5.7 times N uptake**
- **Taking into account N mineralized from organic fertilizer over the crop cycle, the amount applied to crop uptake ranged from 0.4 to 2.8 times N uptake**

IRRIGATED LANDS REGULATORY PROGRAM

TOTAL NITROGEN APPLIED REPORT FORM

Page 1 of 3
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

Click below to clear the corresponding section of the form.
Section I Section II Section III Section IV All

SECTION I: GENERAL RANCH INFORMATION (Space for more parcels and multiple counties on page 2)

AW: <input type="text"/>	Ranch Global ID: <input type="text"/>	Ranch Name: <input type="text"/>	Physical Ranch Acres Reporting: <input type="text"/>
County: <input type="text"/>	APN(s): <input type="text"/>	Fallow Acres: <input type="text"/>	(if follow entire reporting period)
If ranch is a greenhouse, nursery, or hydroponic, select from the dropdown: <input type="text"/>		Sum of Total Crop Acres: 0	(Auto-calculates from Section IV)

SECTION II: NITROGEN APPLIED WITH IRRIGATION WATER (Include all irrigation water applied, including well/city water, surface water, etc.)

Section II-A: Water source(s)	Section II-B: Purple pipe water applied	Section II-C: Well/City water applied	Section II-D: Surface water applied	Section II-E: Volume check	Section III: NITROGEN APPLIED WITH COMPOST & AMENDMENTS
Select the option that includes all sources of irrigation water used during the reporting period. Select the first option in the dropdown menu unless purple pipe water is used for irrigation.	Estimated Total Volume of Purple Pipe Water Applied to Entire Reporting Acres	Average Nitrate Concentration in Well/City Water	Estimated Total Volume of Well/City Water Applied to Entire Reporting Acres	Nitrogen Applied with Irrigation Water	Physical Acres Receiving Compost & Amendments
					Nitrogen Applied in Compost & Amendments (total lbs)

SECTION IV: NITROGEN APPLIED WITH FERTILIZERS & OTHER MATERIALS AND NITROGEN PRESENT IN THE SOIL (The Excel tool from fertilizers assists with calculations in this section)

Specific and Harvested During Reporting Period (Select from List on Page 3)	Crop(s) Grown	Nitrogen Applied in Fertilizers and Other Materials	Nitrogen Present in the Soil	Additional Information
1.				
2.				
3.				
4.				
5.				

Water Quality Implications For Organic Fertilizer

- In Ag Order 4.0, the A/R regulations may have implications for organic production, if a percent of the applied fertilizer N is recalcitrant and not a leaching hazard
- Data from this project indicates that water quality regulations affecting organic production will need to take into account actual mineralization

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

Thank You for Your Attention



**Thank you to cooperating growers, research assistants and
to the Fertilizer Research and Education Program for Funding**