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**

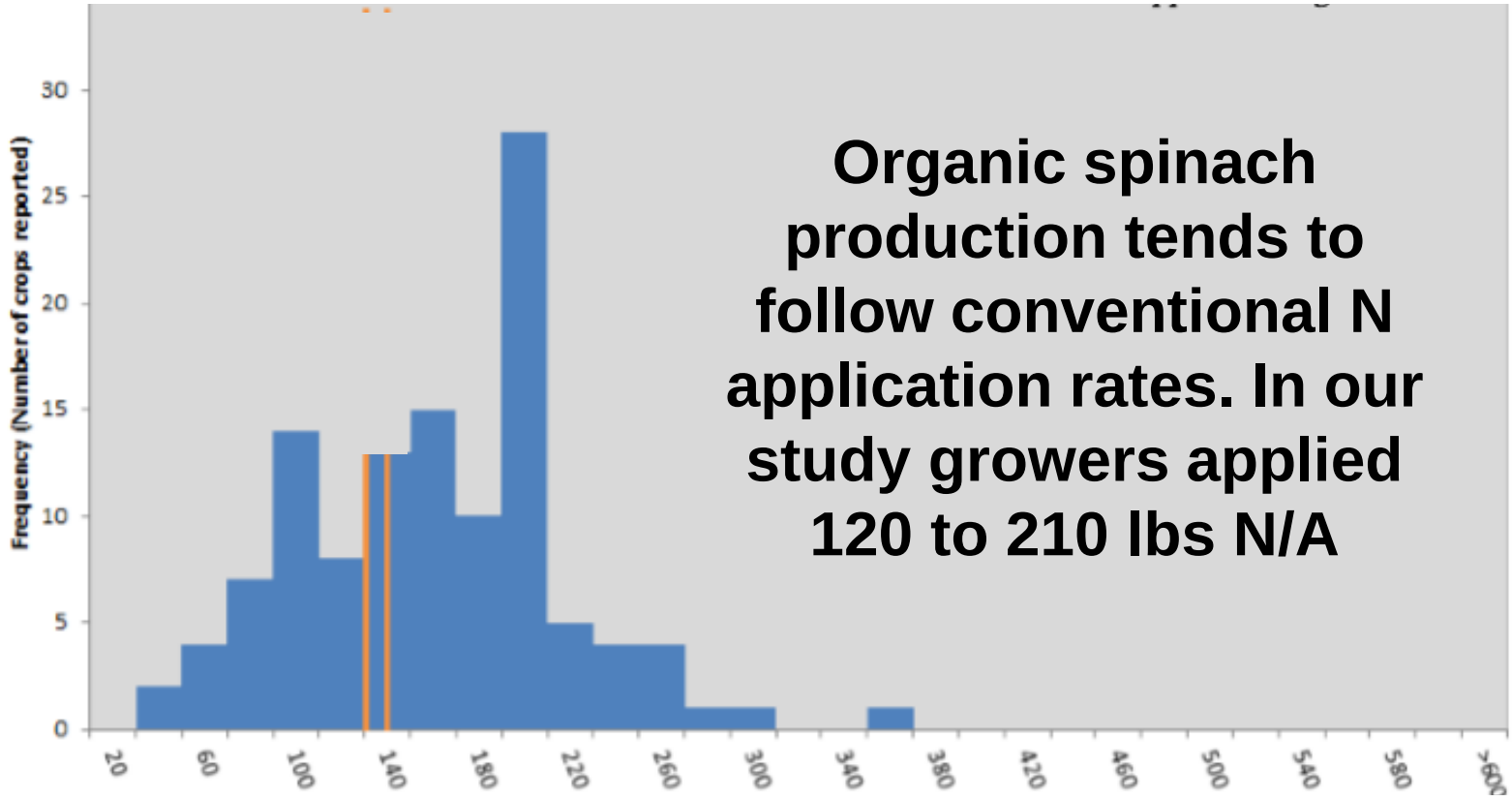
1 ton bags of 4-4-2


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



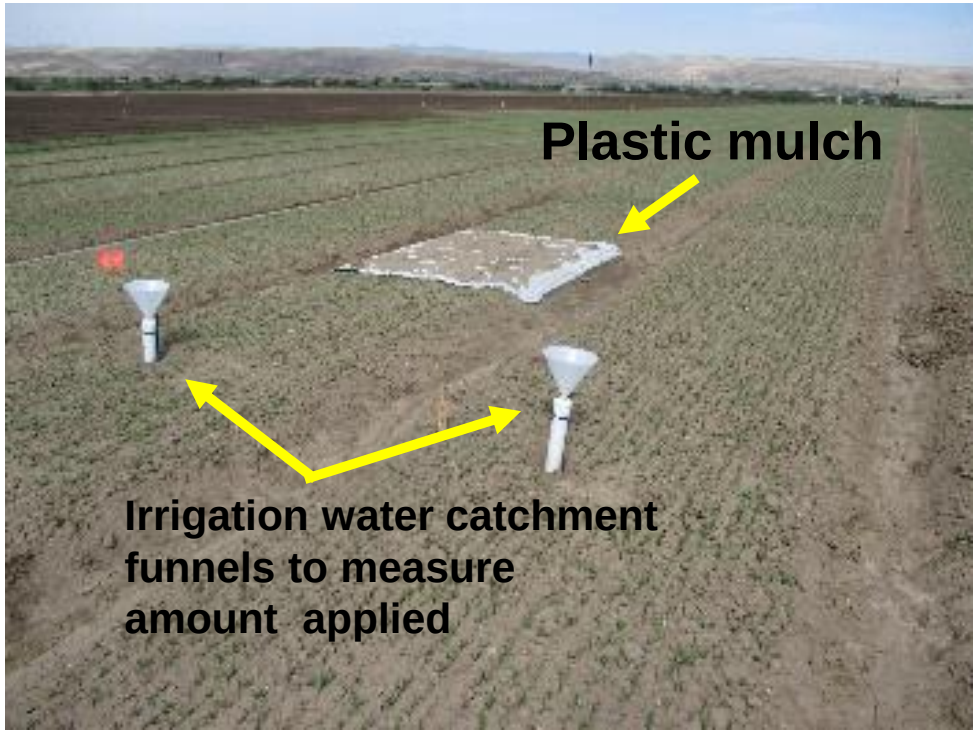
Organic spinach production tends to follow conventional N application rates. In our study growers applied 120 to 210 lbs N/A

*** 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

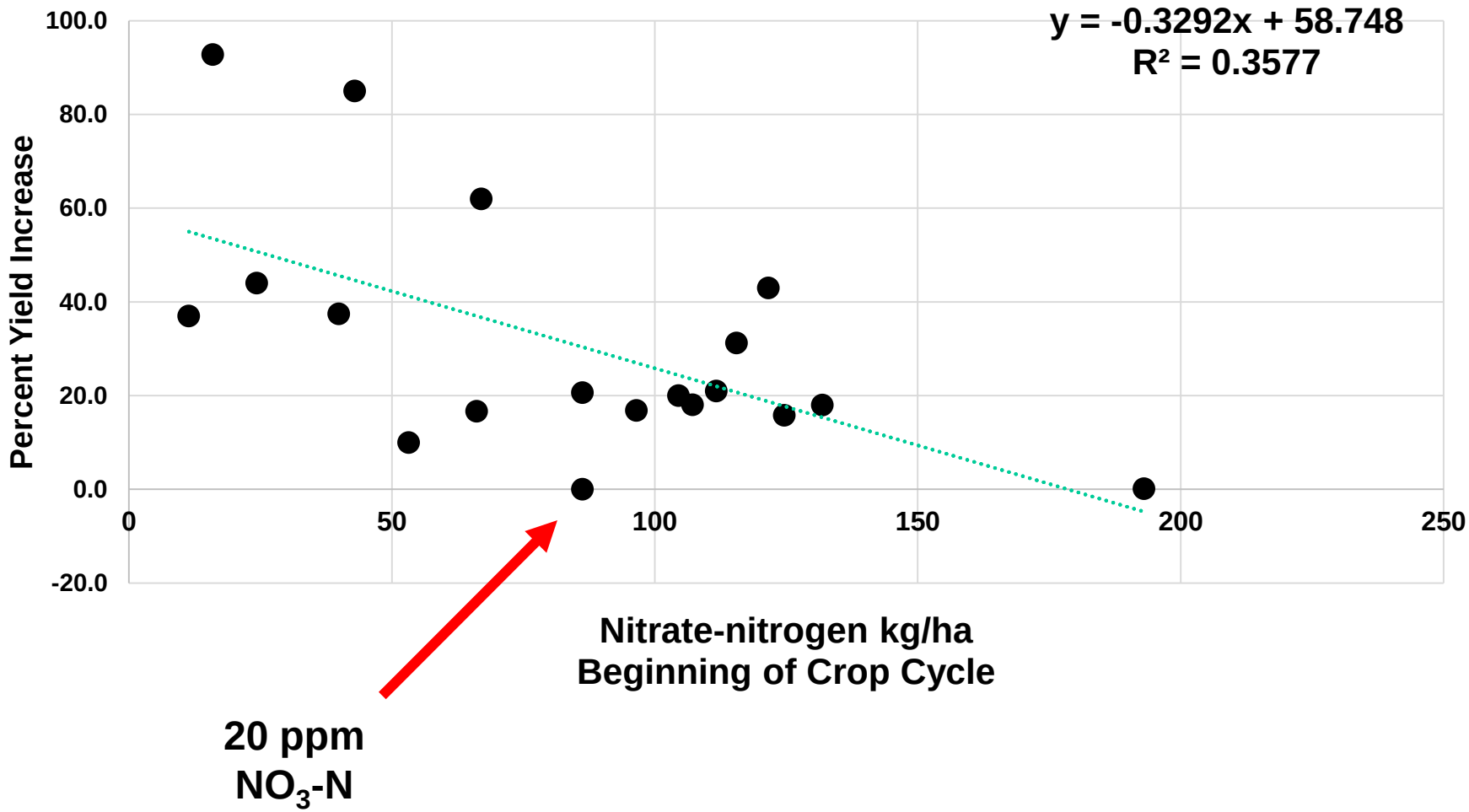
Summary of In-Field Nitrogen Mineralization Evaluations

- 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



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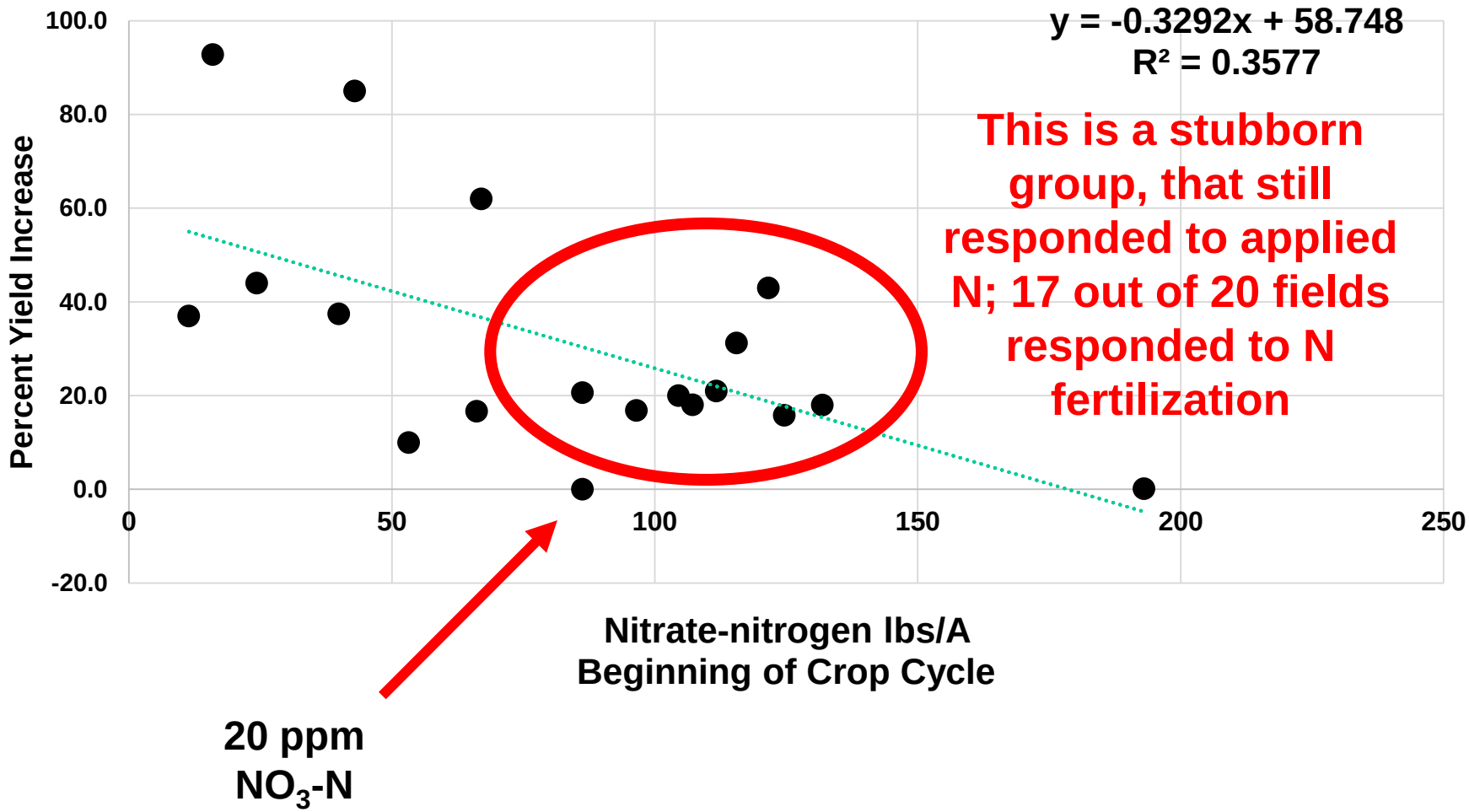
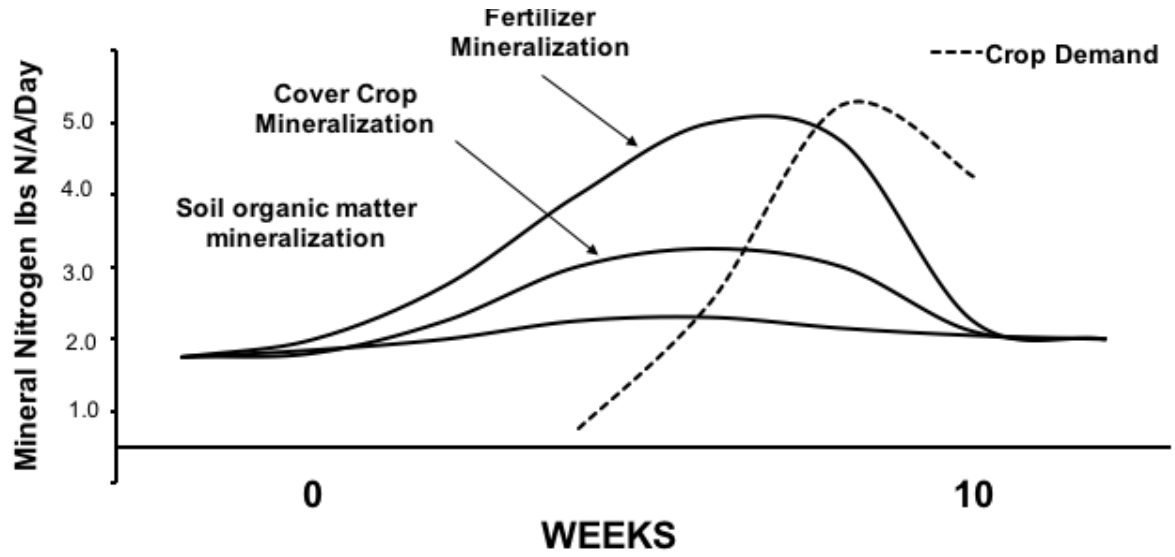


Dry Organic Fertilizers

- **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

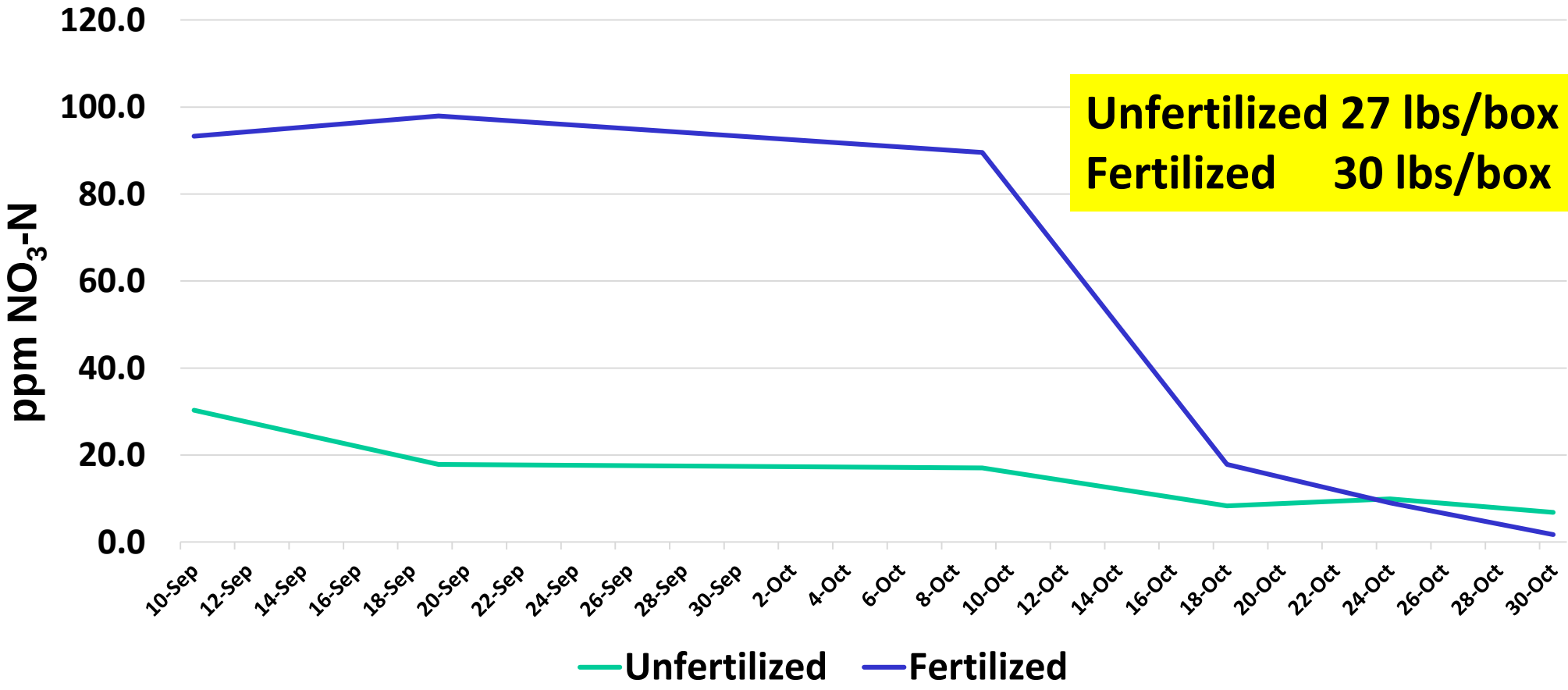
Nitrogen Fertility Trial 2

Planting lbs N/A	Topdress lbs N/A	Total lbs N/A	Initial NO_3-N ppm	Fresh wt 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

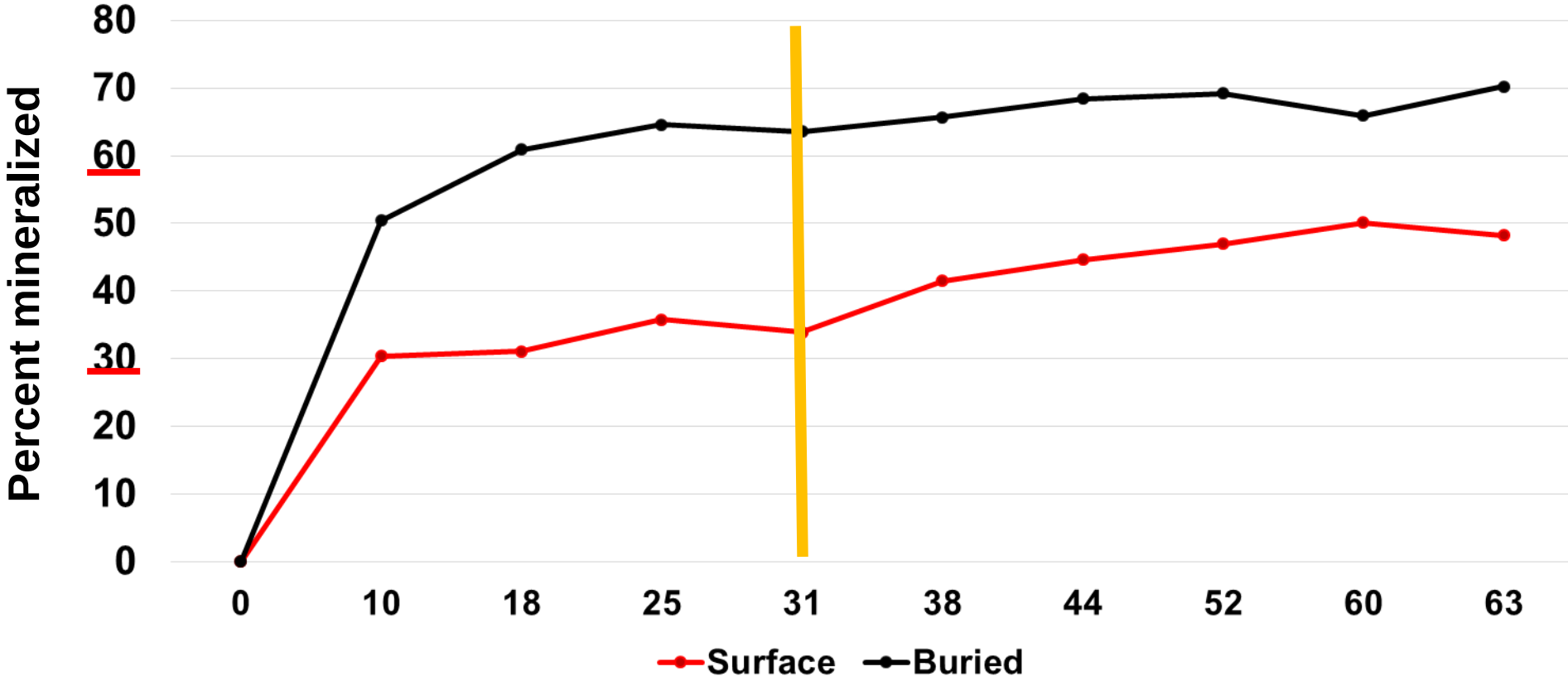
Place on top of soil

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

4-4-2

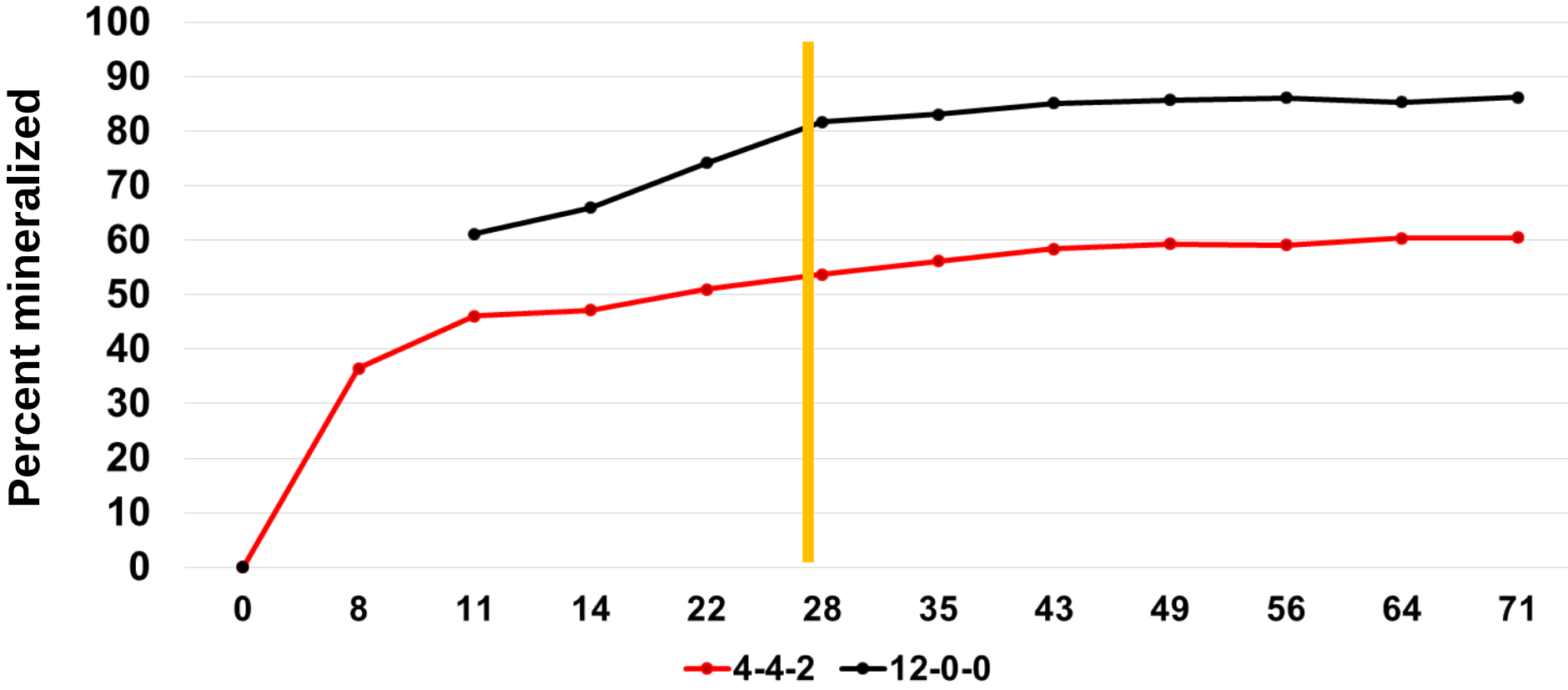
Percent N Mineralized from Pouches

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**

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