Fertilization of Organic Vegetables

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Tying the Concepts Together

- **Nitrate-N is made available by mineralization of soil organic matter, amendments & fertilizer, as well as from irrigation water**
- **Why are we so concerned with getting application rates right:**
  - **More economical (organic fertilizers are expensive)**
  - **Protect groundwater resources from excess nitrate and complying with CCRWQCB regulations**

Management of Fertilization of Organic Vegetables

- Organic operations will be subject to A/R (applied to removal) regulations in Ag Order 4.0 (CCRWQCB)
- There is a need to fine tune N applications and improve N use efficiency in organic vegetable production

Management of Nitrogen Fertilizer

- It is very difficult to precisely apply N in organic systems:
  - We will try to shed a light on how to be more precise in applying fertilizer N
  - This will revolve around:
    - Grower's experience and skills
    - Soil nitrate testing
    - Plant growth characteristics

Organic Vegetable Nitrogen Nutrition

Large-Scale Organic Farms: 28 Blocks Evaluated 2016 to 2019

- Most growers used dry organic fertilizers
- 205% more N was applied than crop uptake
- However, when net N mineralized from organic fertilizer was factored: only 85% of the amount of N taken up by the crop was supplied by the fertilizer
- Why?
  - not all N in the organic fertilizer is mineralized and use of topdress applications in some crops

Organic Vegetable Nitrogen Nutrition

- It is important to understand how much of the total N applied is actually mineralized for the crop
- This factor is critical to providing the crop the amount of N that is needed

Uptake of Nitrogen by Crops:

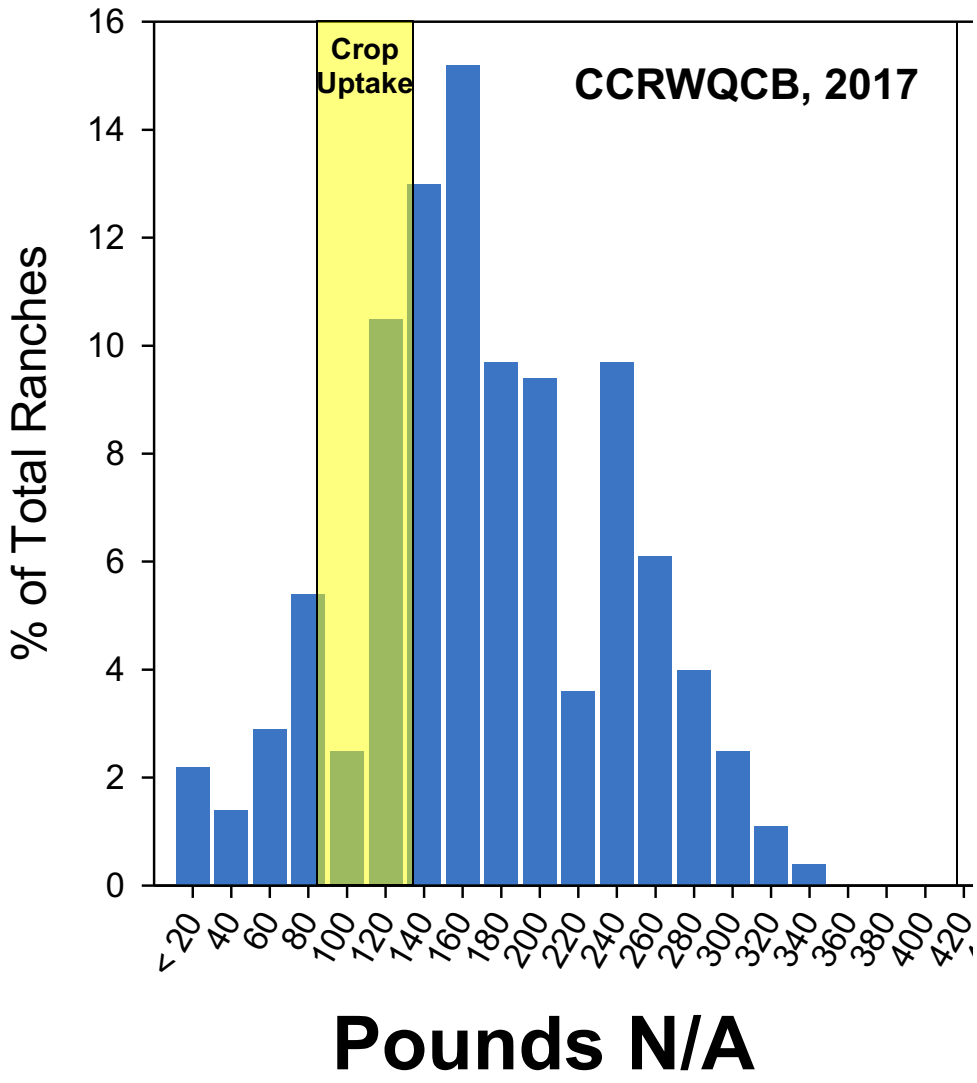
Starting point for understanding the N needs of vegetable crops

Crop	Crop Uptake lbs N/A	Percent removed in the harvested portion
Spinach	90-130	65-75
Full-term Lettuces	120-160	50-60
Broccoli	250-350	25-35
Bell pepper	240-350	65-75
Brussels sprouts	350-500	30-50
Cabbage	280-380	50-60
Cauliflower	250-300	25-35
Celery	200-300	50-65
Baby lettuces	60-70	65-75

Efficient Nutrient Management in CA Vegetable Production, by Tim Hartz

Spinach Nitrogen Fertilization

Conventional

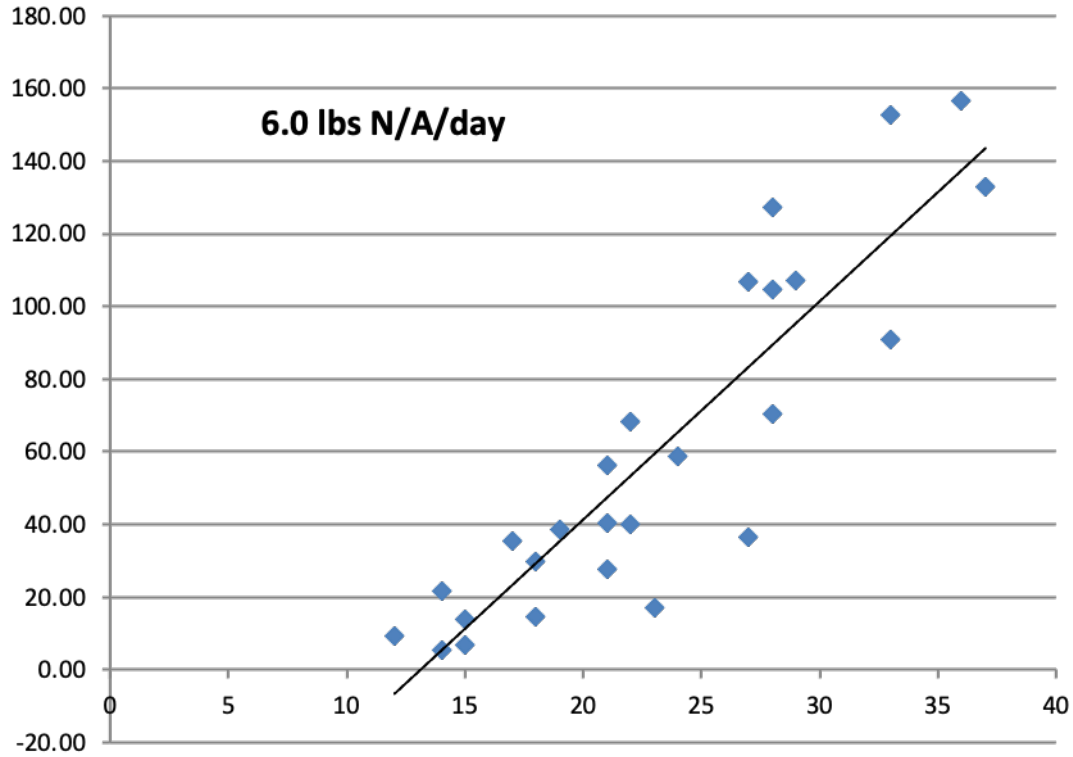


Organic Fertilizer Programs:

- Ranged from 120 to 210 lbs N/A (160 lbs N/A was common)
- Actual N mineralized from the fertilizer ranged from 36 to 126 lbs N/A
- Percent mineralized and topdressed applications

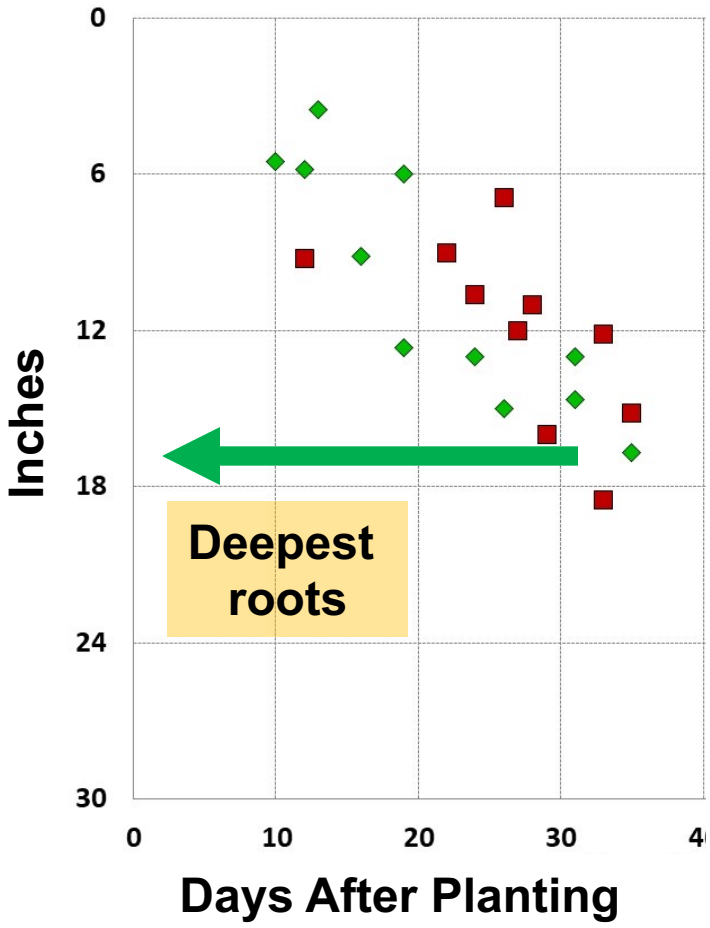
Spinach
Crop cycle typically 25-35 days

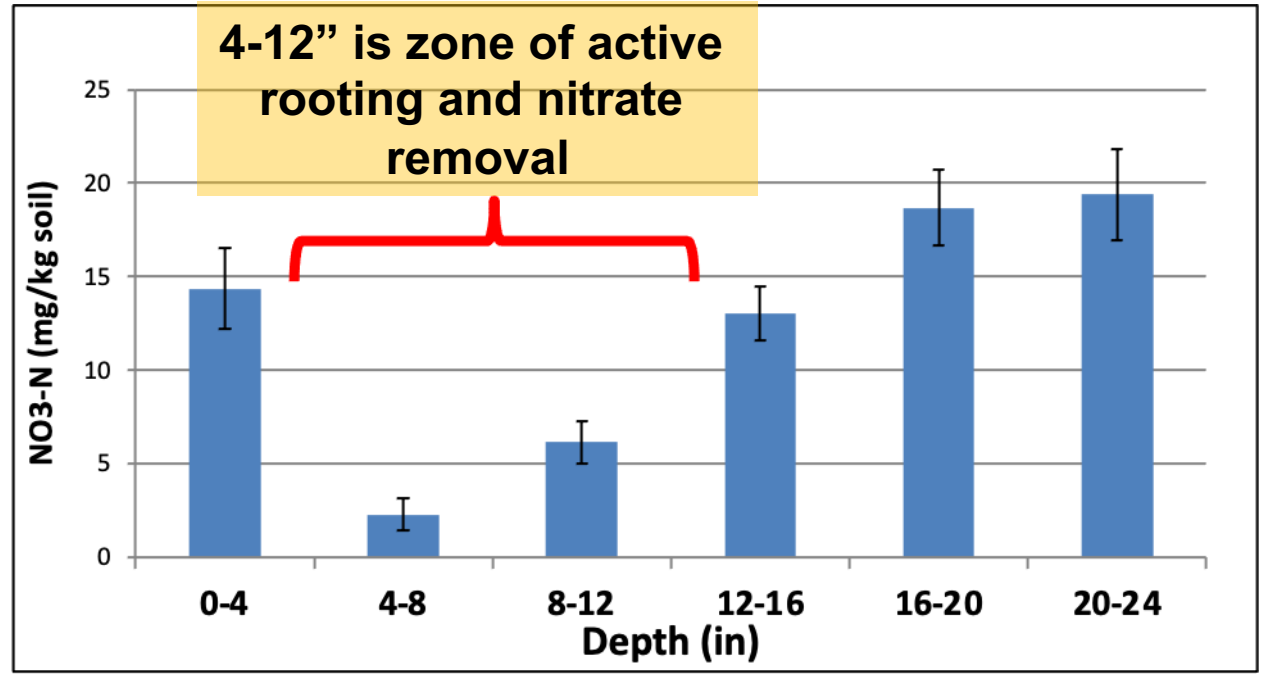
Nitrogen uptake varies by days to harvest. Baby and teenage spinach takes up 80-100 lbs N/A. Bunched spinach takes up to 130 lbs N/A



During the last two weeks of the crop cycle spinach takes up 6.0 lbs of N/A/day

Rooting Depth of Spinach Over the Crop Cycle and Zone of Nitrate Uptake





Irrigation management becomes critical to maintain nitrate in this narrow zone in the soil so the plant can access it

Importance of the Pool of Residual Soil Nitrate in the Soil

- **The residual pool of soil nitrate integrates the nitrogen that comes from mineralization of organic matter, prior crop residues and fertilizers, compost, etc**
- **Testing for residual soil nitrate-N is the key tool used in conventional production to determine if there is sufficient residual soil nitrate in the soil to determine the amount of fertilizer nitrogen needed for optimal crop growth**

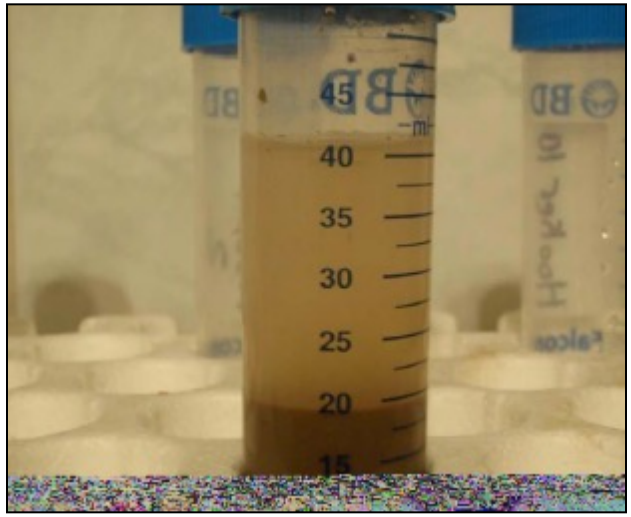
Measuring Residual Soil Nitrate in the Soil

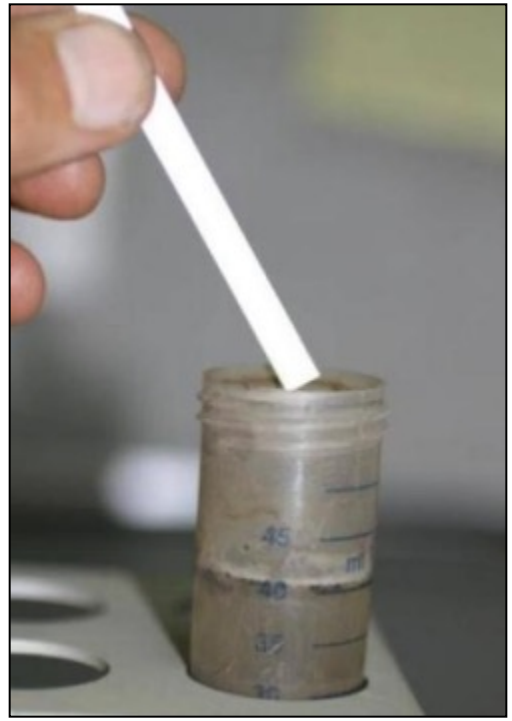
- 20 ppm nitrate-N is a threshold for vegetables
- It is about 70-75 lbs of N/A and is sufficient to supply the crop for 1-2 weeks
- Typically, the tests are done prior to a fertilization event in order to know if the fertilizer rates can be adjusted up or down
- In conventional systems this works well because the fertilizers are immediately available for crop growth

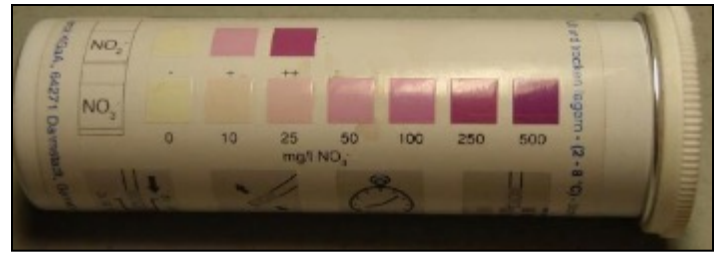
Measuring Residual Soil Nitrate in the Soil

- The nitrate test can also be useful in organic
- However, for fast maturing crops such as spinach is challenging
- Tests have to be done in advance of the need to allow sufficient time for the fertilizer to mineralize (e.g. typically, preplant)
- Later in the crop cycle is too late for the fertilizer to be effective for a fast-growing crop like spinach

Using a lab analysis or the nitrate quick test you can determine the quantity of residual soil nitrate







Go to Salinas Valley Agriculture Blog:

Details on the Nitrate Quick Test

April 1, 2019

Spinach Fertilizer Evaluations

- **It is the most challenging of all crops to efficiently fertilize due to:**
  - **Fast crop cycle**
  - **Shallow roots**
  - **Highly susceptible to low N**
  - **80” inch beds with high plant populations**
  - **Exclusive use of sprinkler irrigation (no drip currently used)**

Trial No. 1: Clay Loam Soil

Timing	Fertilizer N/A	Net Fert. N/A	Yield Tons/A
---	0	0	6.4
Listing	80	52	7.1
Planting	80	32	6.7
Listing Planting	160	52 32	6.9

- 18 ppm Nitrate-N at planting (64 lbs N/A)
- No yield difference between 80 or 160 lbs N/A
- Probably low leaching over the season

Trial No. 2: Sandy Loam Soil

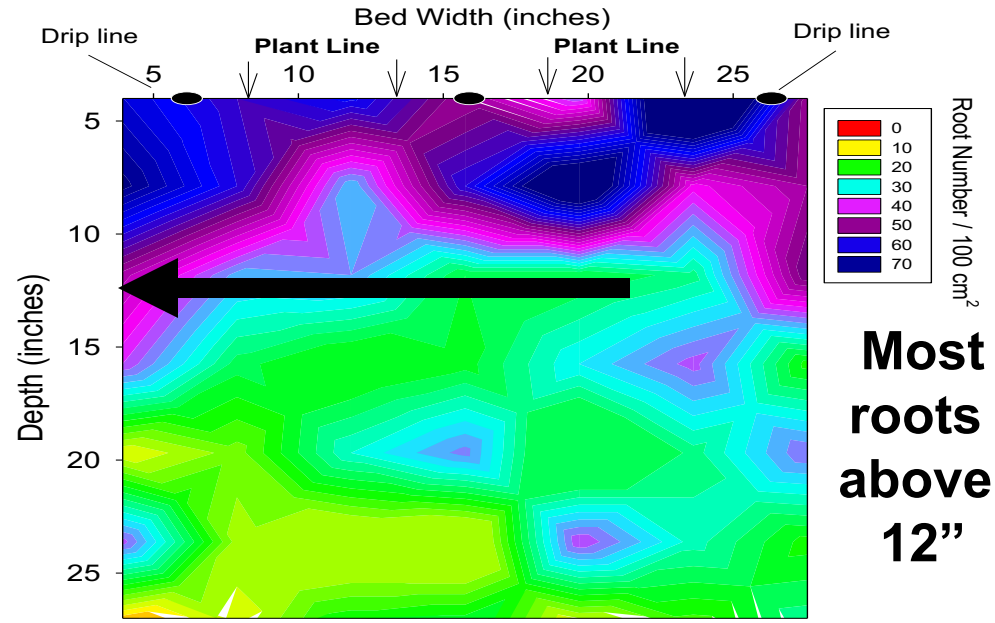
Timing	Fertilizer N/A	Net Fert. N/A	Yield Tons/A
---	0	0	6.1
Planting	80	28	6.9
Planting	160	56	7.7

- 28 ppm Nitrate-N at planting (99 lbs N/A)
- Significant yield increase with fertilization with 160 lbs N/A
- Probably significant leaching over the season

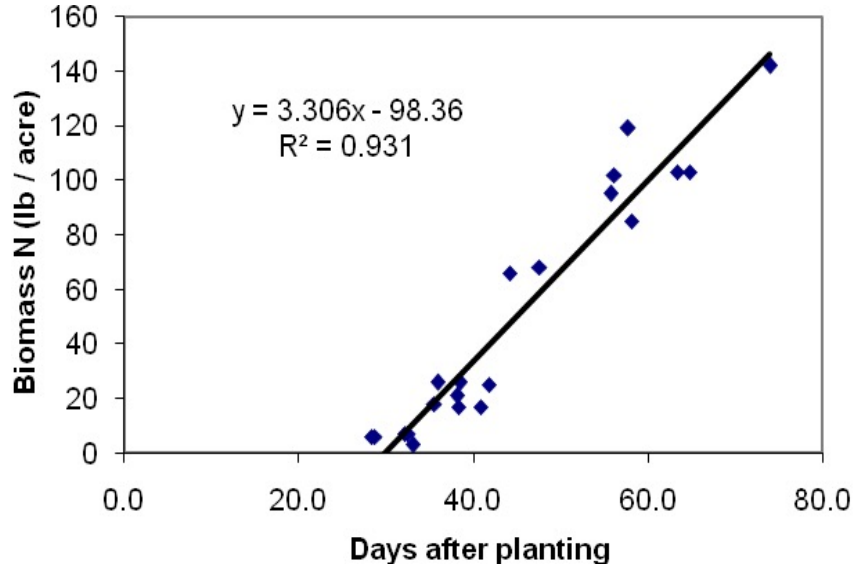
What is the Bottom Line

- **A crop with characteristics like spinach (high N demanding, shallow rooted) needs a robust amount of fertilizer in the root zone for 2 weeks**
- **Soil tests for residual soil nitrate can be useful**
- **Preplant or at-planting are the only two times to effectively make applications (after crop establishment was too late)**
- **Leaching probably reduced the amount of nitrate-N in the root zone on sandy soils**
- **Use of nitrate tests to guide fertilization in organic production needs more research**

Full-term Lettuce – 60 days



Most roots above 12”



Depending on the planting configuration full term lettuce take up 120-170 lbs N/A, most of it after thinning.

Romaine Lettuce Fertility Trial
Long-term Organic Farm

- Grower was not planning to fertilize because N-rich prior crop (snap beans)
- At planting soil nitrate-N was 11.9 ppm

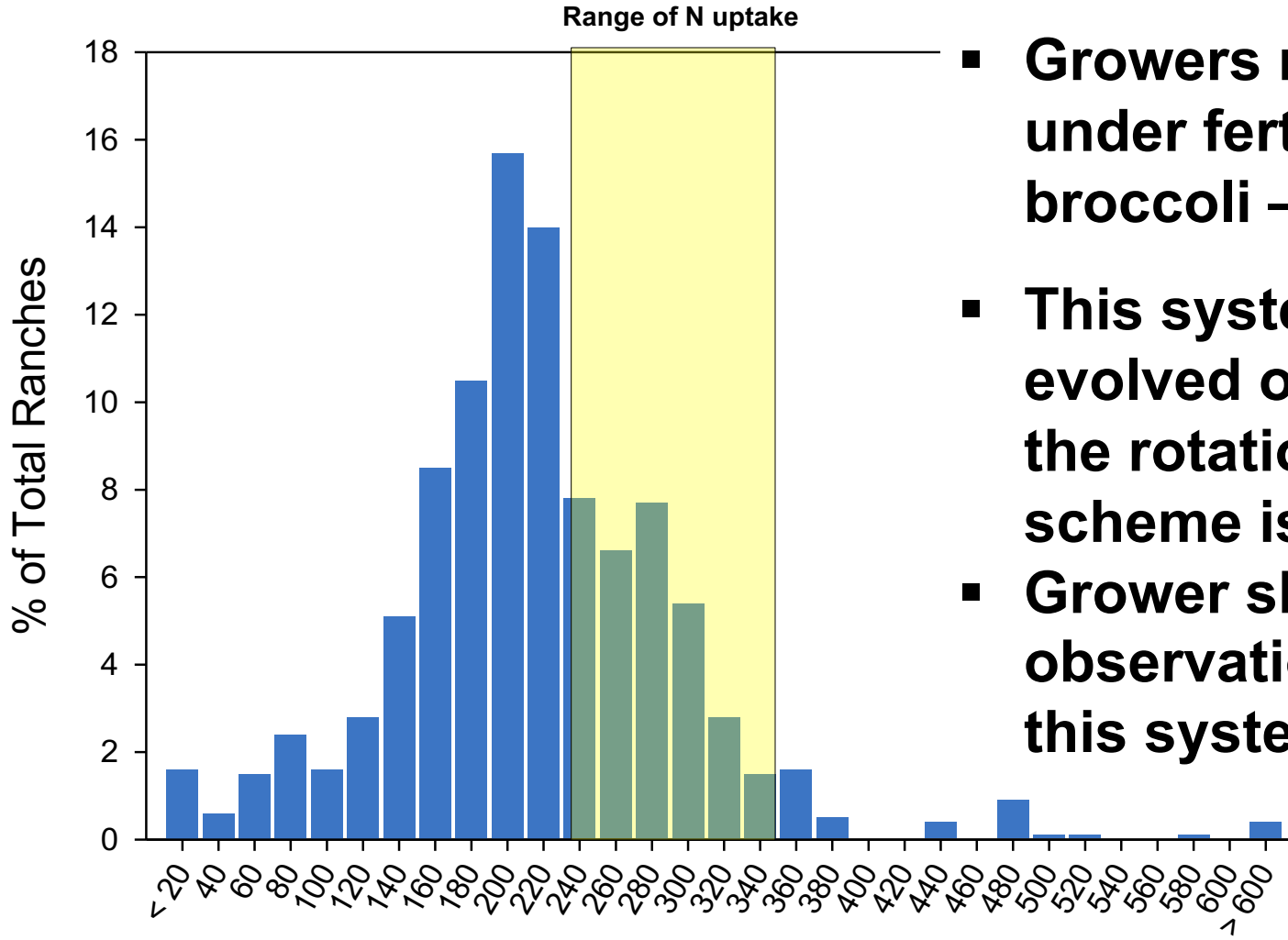
Treatment	Soil Nitrate-N	Yield boxes/A
Unfertilized	8.2	27
Fertilized	71.8	30

- Fertilized with 400 lbs 12-0-0 (48 lbs N/A incorporated at planting)
- The yield response was subtle but measurable

Broccoli – 75 days

Crop	Fertilizer applied	Crop Uptake	Scavenged from soil
Broccoli	181	337	155
Cauliflower	260	285	21
Cabbage	215	337	97

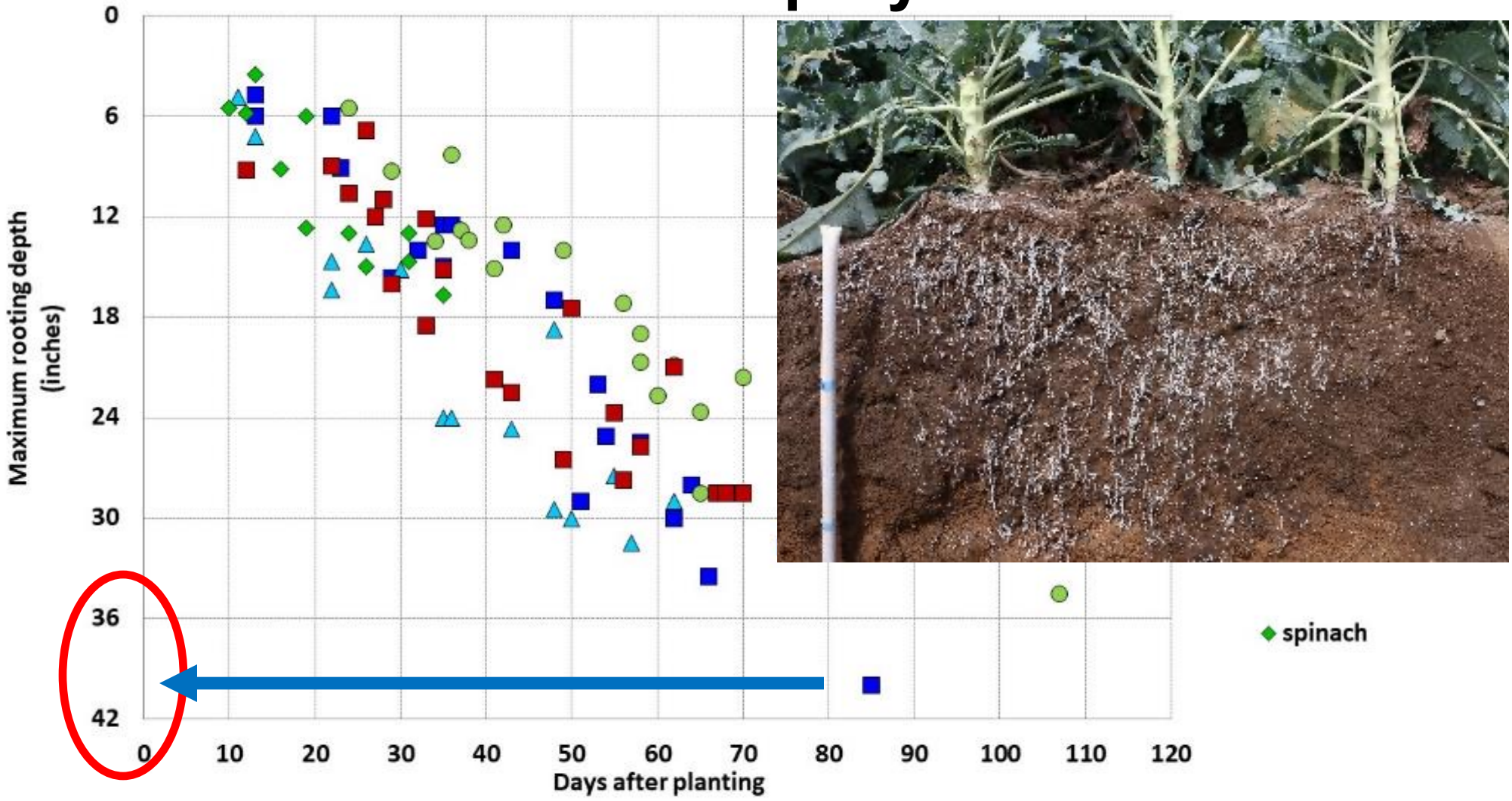
2017 Broccoli Application Data



- **Growers routinely under fertilize broccoli – Why?**
- **This system evolved over time, the rotational scheme is rich in N**
- **Grower skills of observation honed this system**

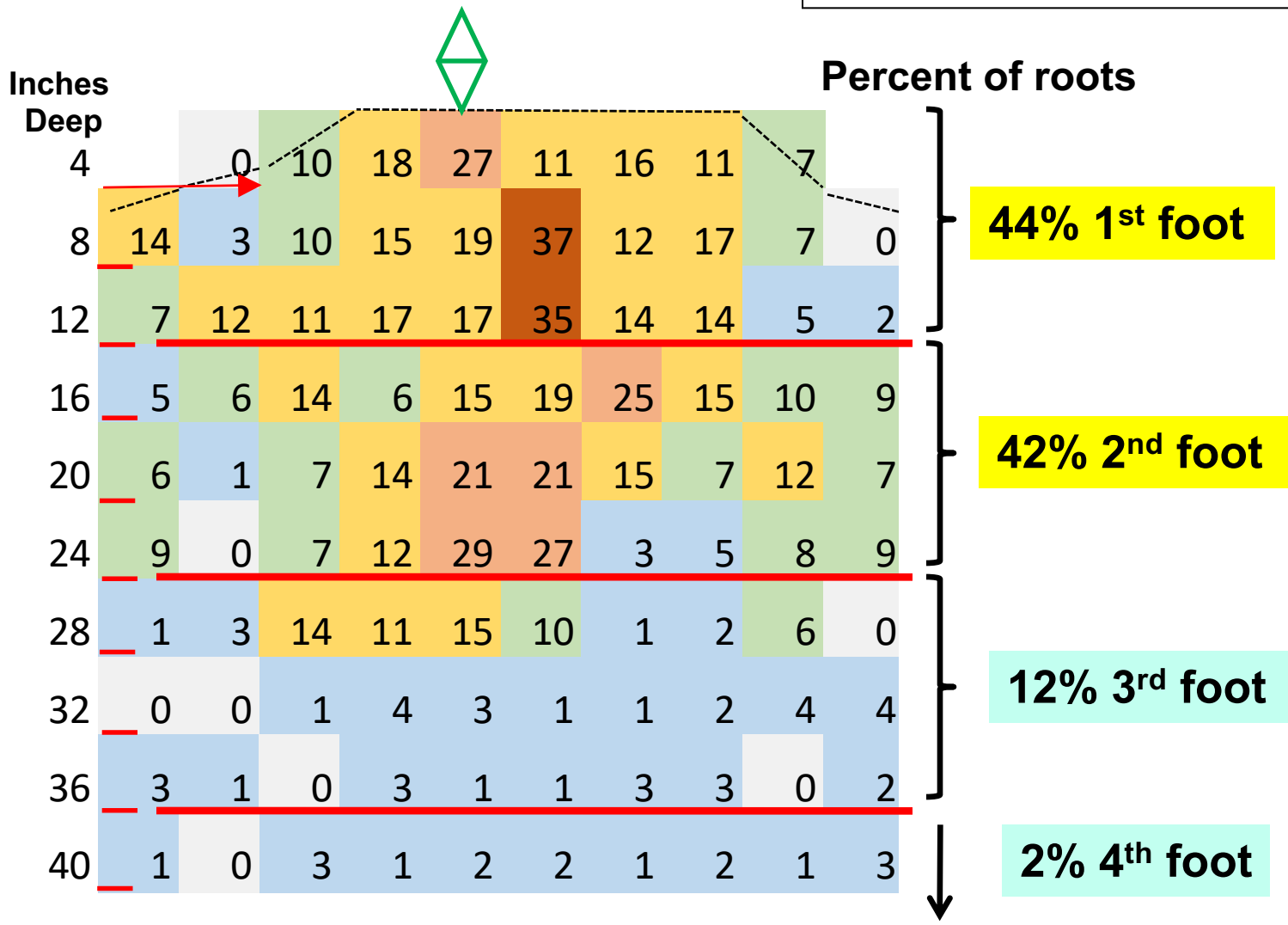
CC Regional Water Quality Control Board Report

Rooting Depth of Broccoli and Other Crops Over the Crop Cycle



Cauliflower
113 days after planting

Later in the crop cycle a greater portion of roots occur deeper in the soil profile



Organic Nitrogen Evaluations
Sandy Soils

Field	Initial Min. N	Fert. N applied	Net from fertilizer	N from water	Soil N mineralized over cycle – top foot	Total available N	Total Crop N uptake
1	90	437	219	20	67	396	376
2	61	451	163	10	109	343	326

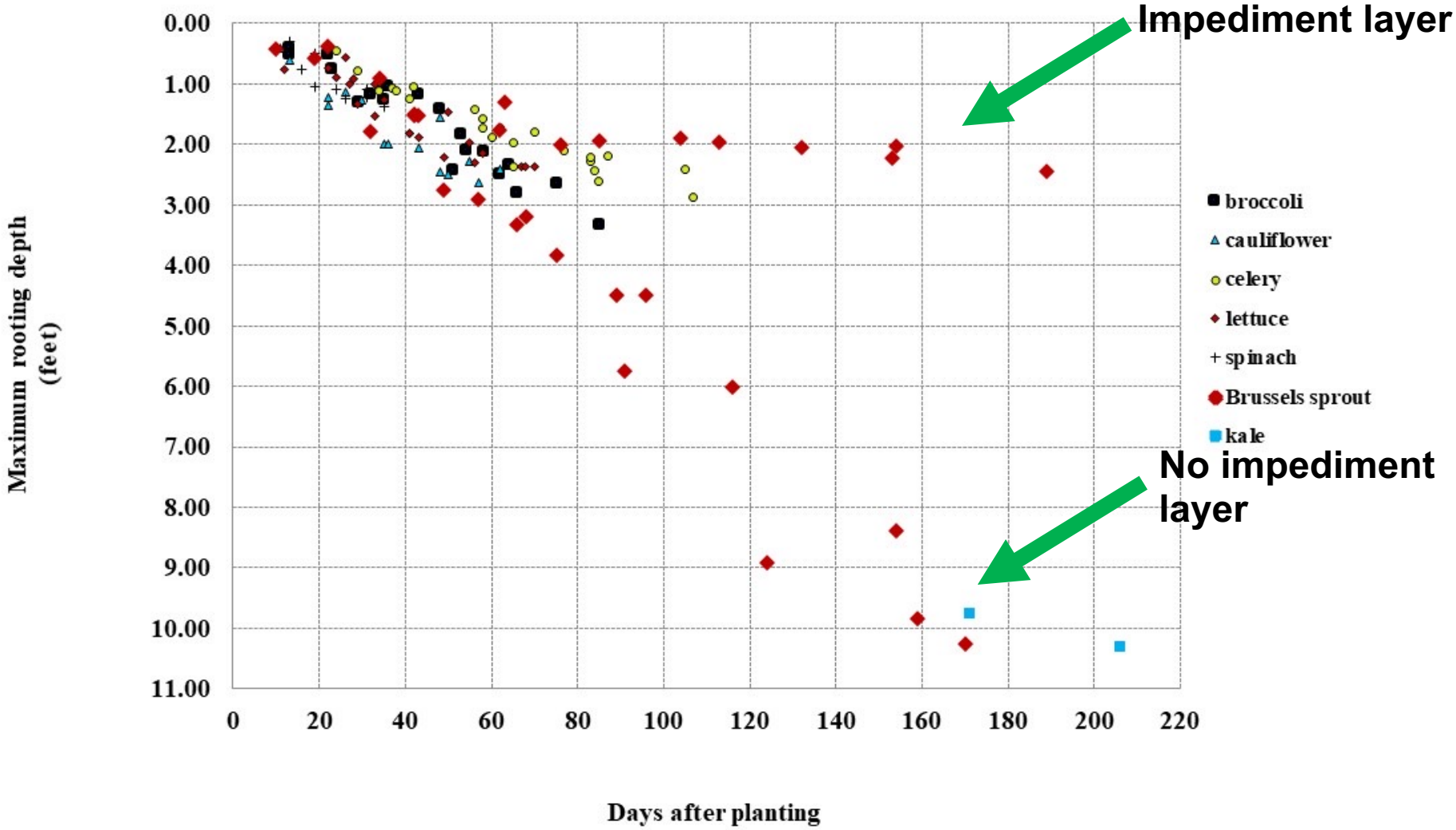
- Both fields used topdress applications
- More N was probably mineralized in the 2nd foot of soil
- Adequate N early in the crop cycle is critical

Broccoli Scavenging

Site	Initial residual soil nitrate[1] lbs N/A	Nitrogen applied lbs N/A	Total available lbs N/A	Percent N taken up by Broccoli crop
1	146	178	324	97
2	372	178	550	67
3	134	190	324	82
4	183	190	373	99
5[2]	257	240	497	44

1 - In the top three feet of soil; 2 – loamy sand soil

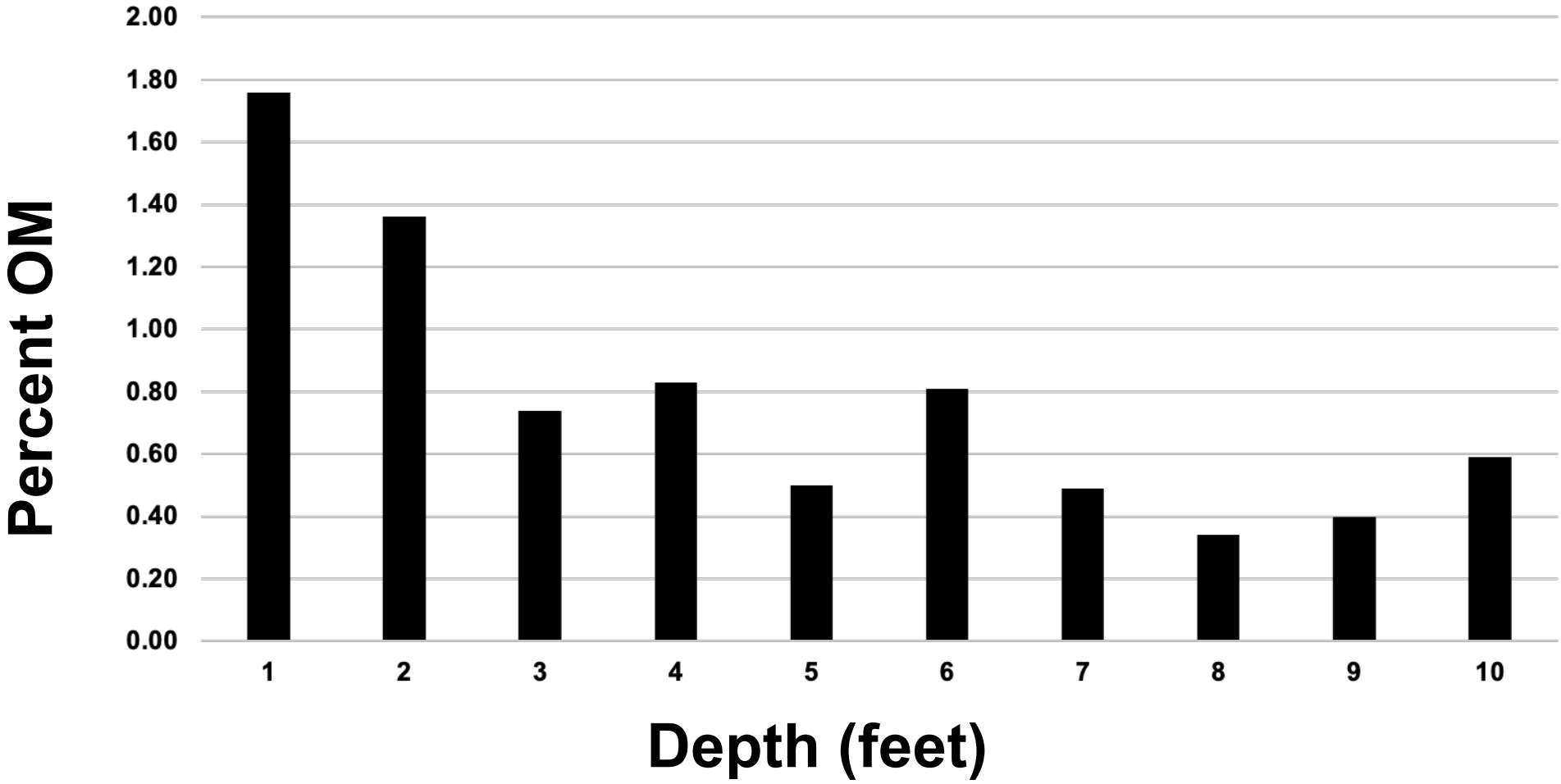
Vegetable Crop Rooting Depth

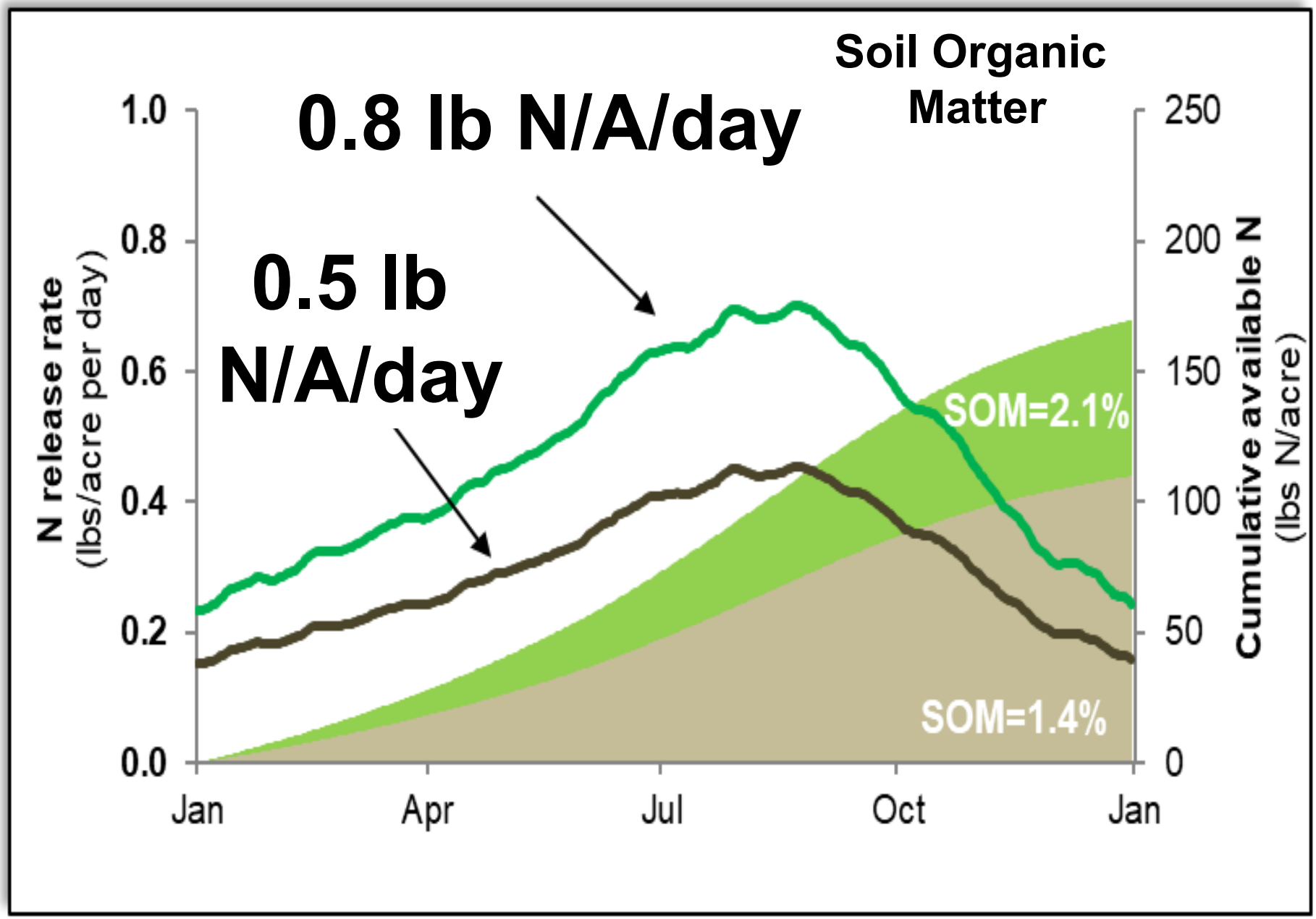


Roots grew about ½ inch per day

Soil Organic Matter by Depth

Organic Farm 28 Years





Patricia Lazicki

Deeper Rooted Crops

- It turns out that the 2nd and 3rd foot of soils may provide more N from mineralization of soil organic matter for crop growth than we realized
- This is particularly true for deep-rooted, long-season crops on soils that do not have impenetrable layers
- This is a difficult area to research because of the difficulties in deep soil sampling
- It needs further research

Two Side Thoughts

- **How much nitrate leaching in these organic systems?**
  - **No good answer at this point, needs research**
- **What is the impact of the use carbon rich organic fertilizers in these systems that do not routinely use cover crops and composts?**

Input of Carbon

Material	Biomass lbs/A	Carbon content percent	Total carbon lbs/A
Compost	10,000[1]	29%	2,146
Cover crop	7,000	44%	3,080
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 – 6,000 lbs/A (2 baby crops @ 3000 lbs/A each) @ 90% oven dry weight;
3 – 5,650 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
Water Extractable Organic N ppm	14	17
FDA Enzyme kg/hr	12	19

- Higher WEON and FDA analysis indicates greater microbial activity, statistically different
- Greater microbial activity can tighten nitrogen cycling in the soil – the impacts of that can be significant

Given the complexities of fertility management of organic vegetable systems:

- We are entering a new era in nitrogen management: Adding a bit extra will now be less of an option under the new regulations
- It is critical to be a keen observer of how the plants are growing – how fast and their color
- It is critical to experiment
- Evaluate the use of tests for residual soil nitrate to see if you can utilize them to improve N use efficiency
- Make improvements in irrigation efficiency where possible; especially critical on sandy soils

Summary:

- Organic soil fertility is more complex than conventional
- It takes careful observation to develop skills and expertise to manage nitrogen fertilization
- The new regulations that will be set forth by the Regional Water Board, put pressure on growers to make sure their fertilizer programs are efficient in compliance
- Compliance should be achievable
- Tools like the nitrate test can be helpful
- There is a great deal about managing organic crops that we do not know, and more research is needed


Thank you for your attention
Thank you cooperating growers and the FREP Project for funding