Nitrogen Technology for Improving N Use Efficiency in Leafy Green Vegetable Production

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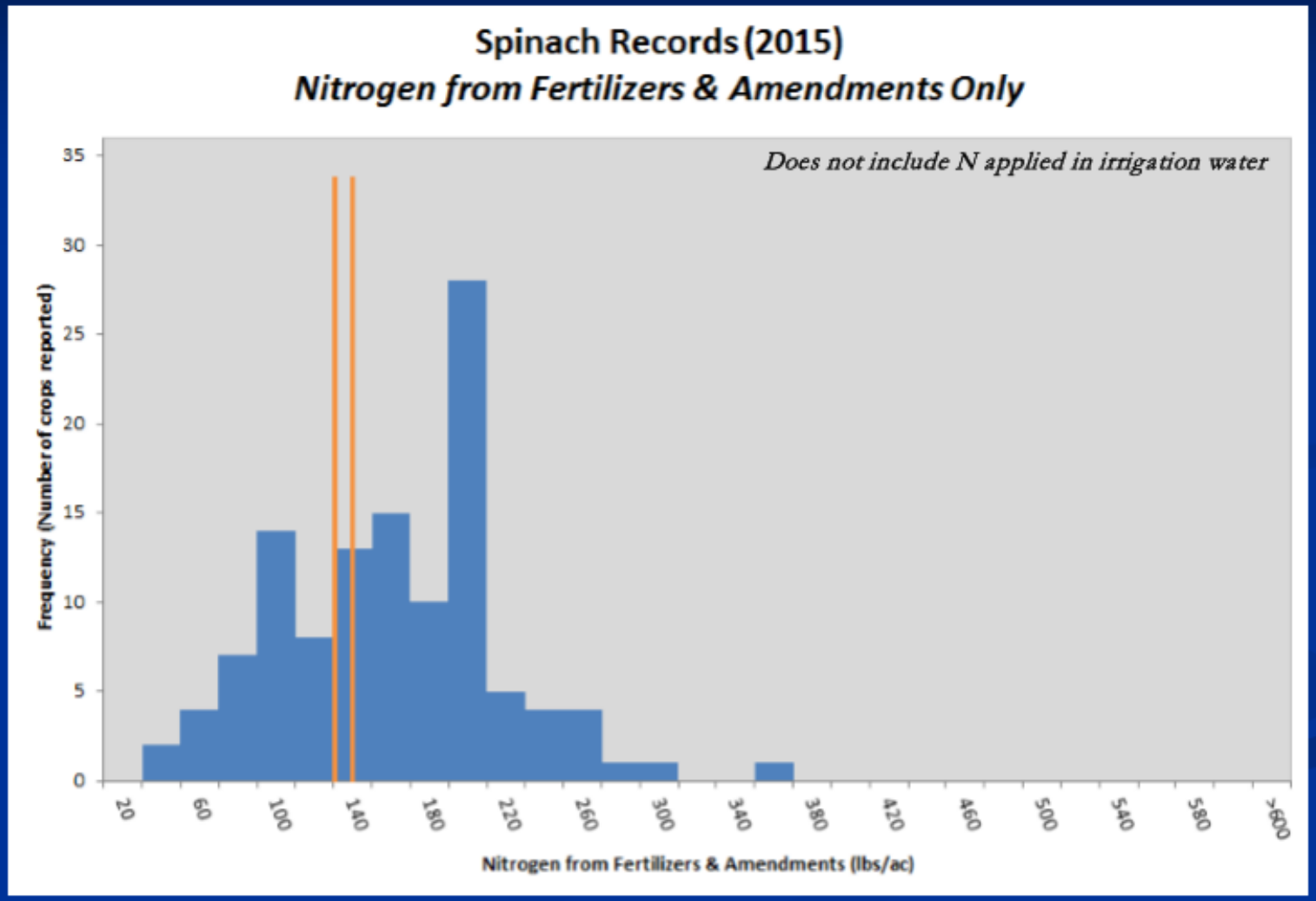
Grower Reported N from Fertilizers

(117 Crop Records) Compared to Specific Crop Nitrogen Uptake



Challenges to improving NUE in Leafy Green Vegetables

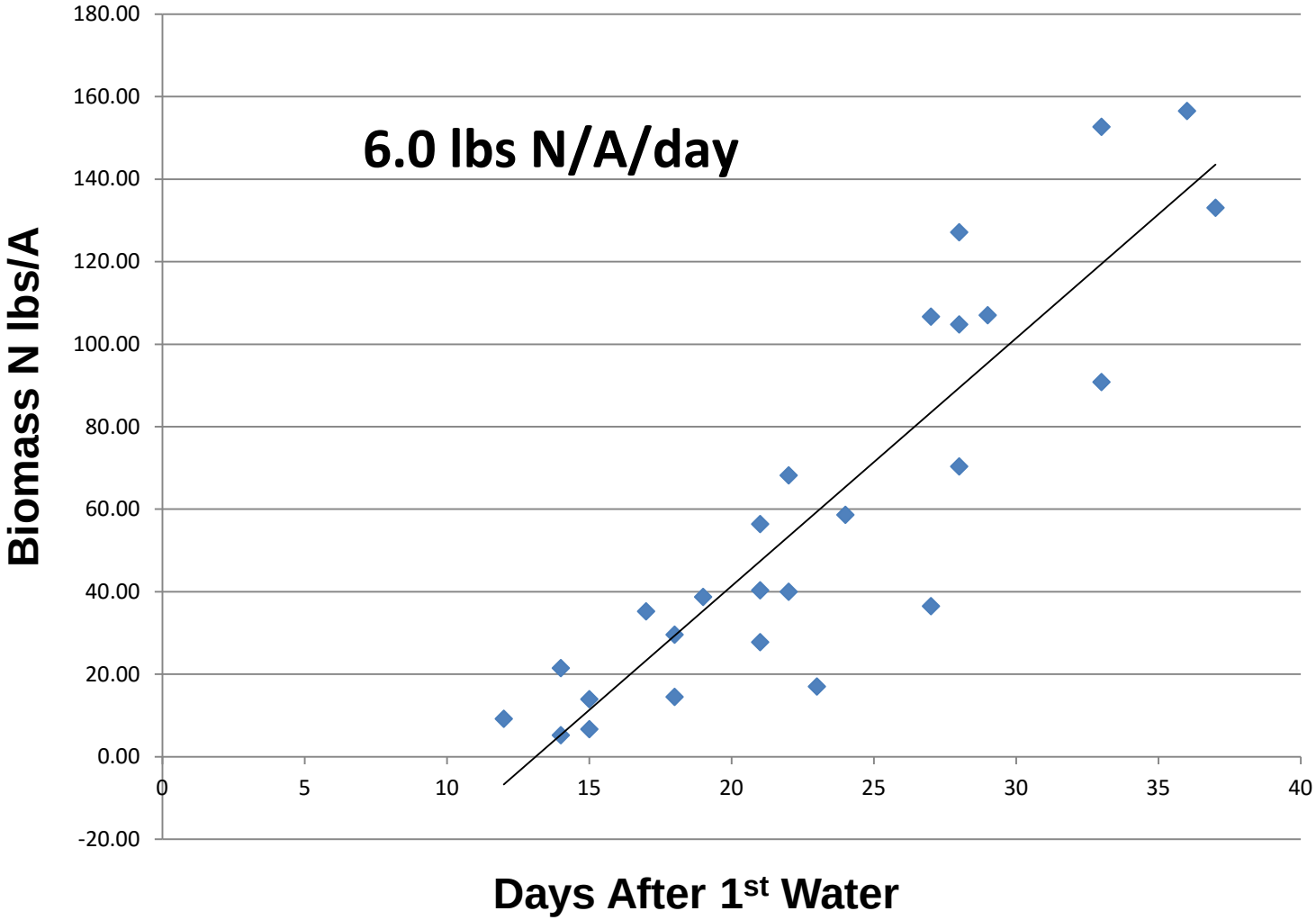
- Rapid growth cycle and high rate of N is taken up in the last half of the cycle
- Double cropping
- Shallow rooted
- Irrigation management is key to keeping nitrate-N in the rootzone
- Spinach grown on high-density beds which are exclusively sprinkler irrigated
- High quality demands for final product

Strategies to Improve NUE in Leafy Green Vegetable Production

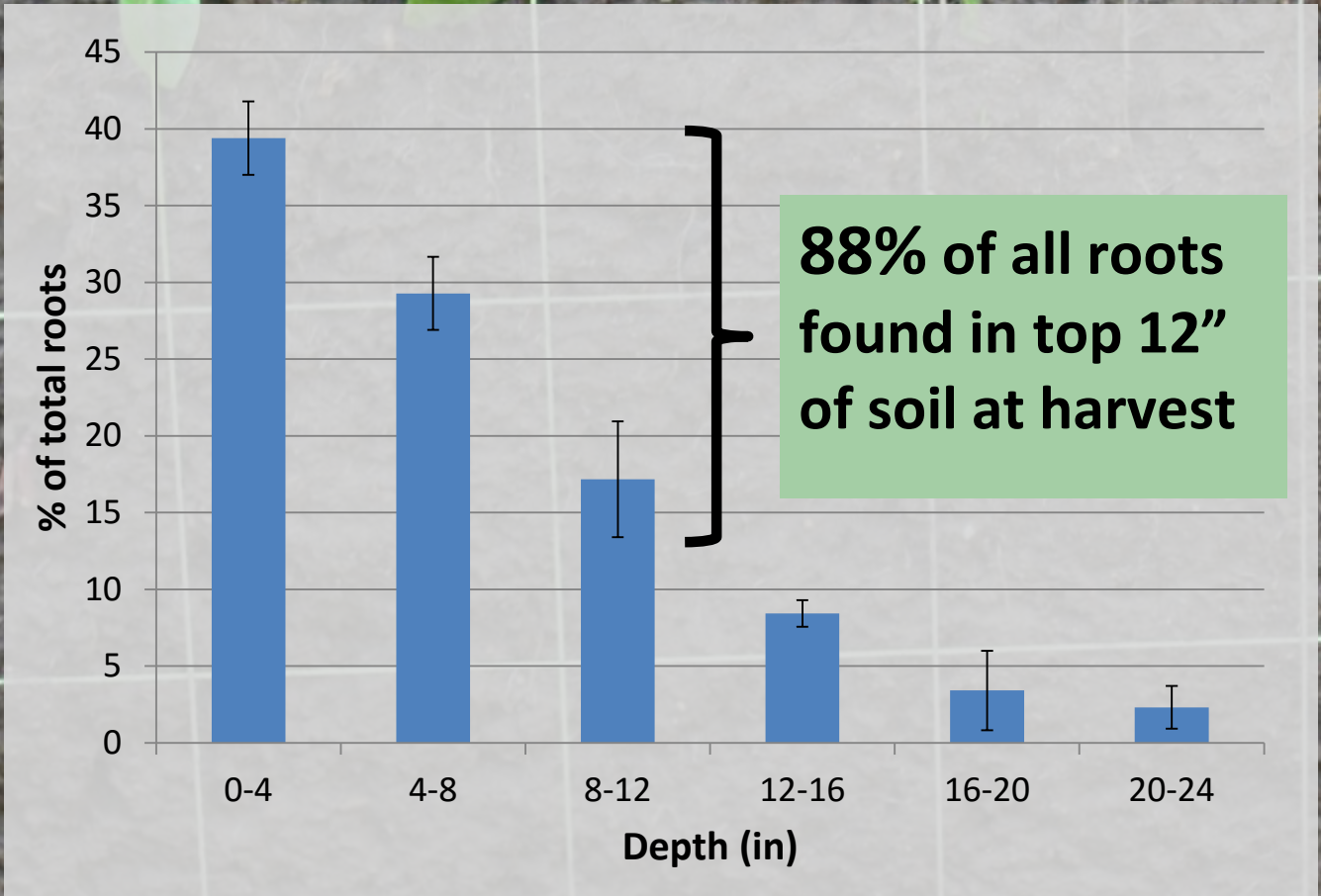
- Careful irrigation management
- Accounting for residual soil nitrate and adjusting fertilizer applications accordingly
  - Crop by crop diagnostic approach (not a program approach)
- These two strategies will provide the majority of the benefits that we can realistically achieve in this cropping system
- Use of deep rooted cover crops or rotational crops to take up residual soil nitrogen

Spinach Nitrogen Uptake

N uptake range 80-130 lbs N/A



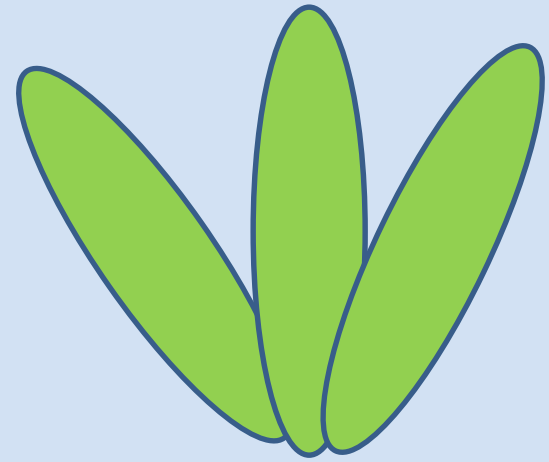
Rooting Depth of Spinach

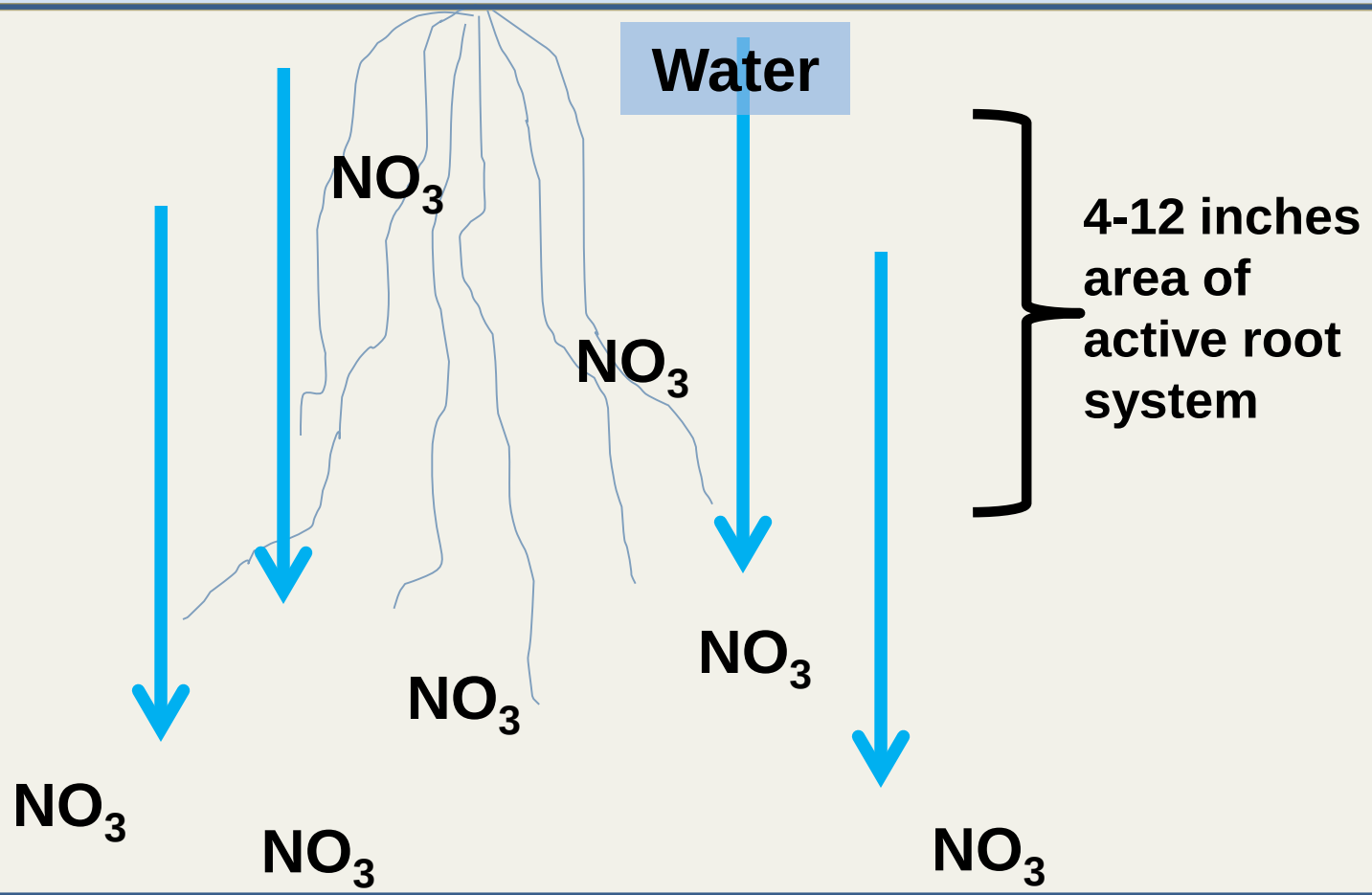


Nitrogen Fertilizer Technologies

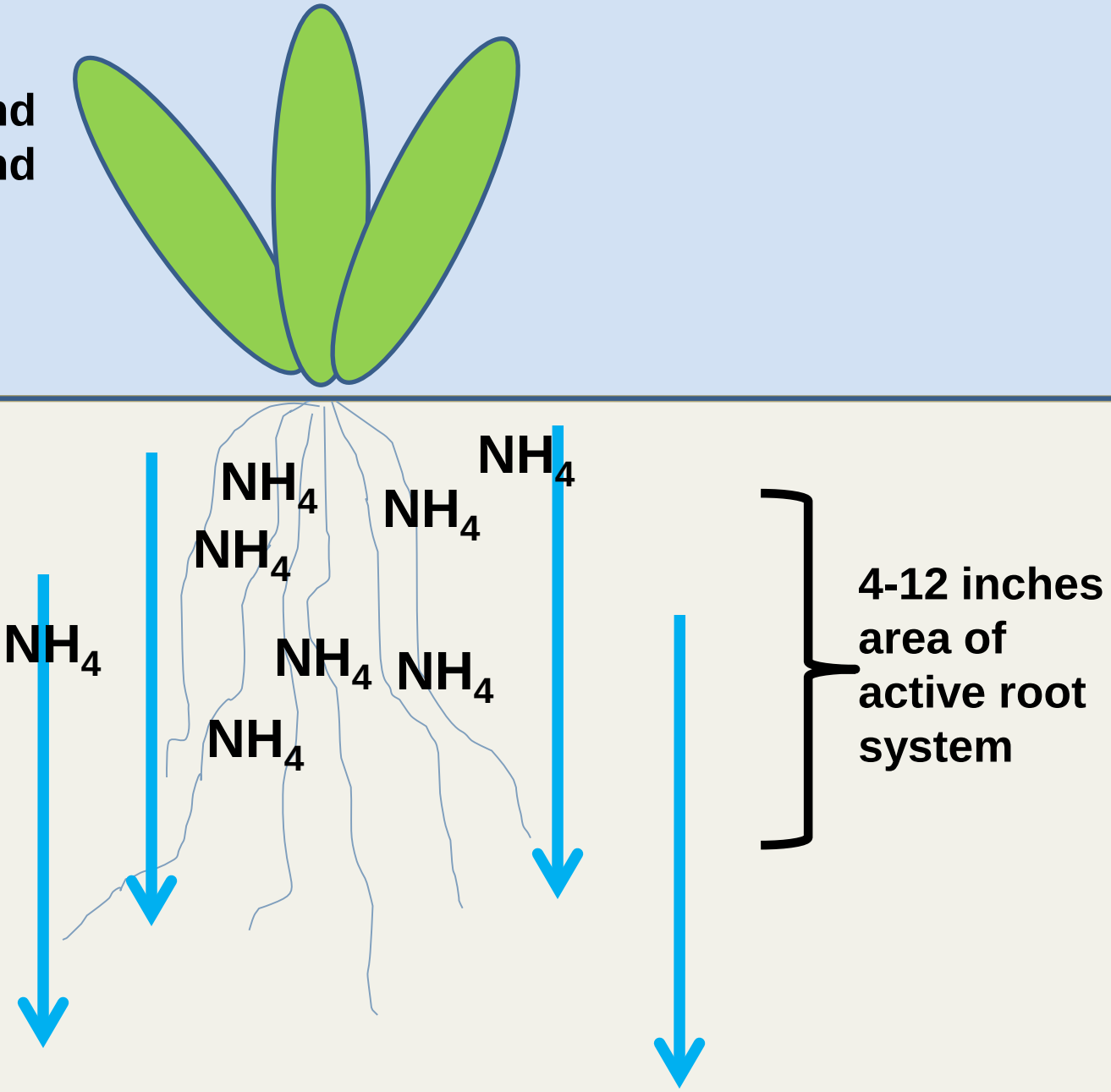
- **Most mineral nitrogen during the summer production season (warm soils) rapidly converts to nitrate and is leachable**
- **Are there ways to manage mineralization to nitrate and gain some increase in NUE?**

Shallow root system and high water use makes it difficult to keep a high percent of soil nitrate in the area of active roots





Ammonium has a positive charge and absorbs to clay and organic matter (both rich in negative charges)



Nitrogen Fertilizer Technologies

- In the corn belt of the US and in Europe “nitrogen stabilizers” are commonly used to reduce nitrogen losses via volatilization of urea and ammonical fertilizers, as well as nitrate leaching.
- Two categories fertilizer technologies:
  - Nitrification inhibitors
  - Controlled release fertilizers

Nitrogen Fertilizer Technologies

- Initial studies on nitrapyrin in the 1980's with nitrapyrin on cool season vegetables looked promising
- Since then production practices have changed:
  - advent of drip irrigation and movement away from furrow irrigation
  - Use of high-density beds for spinach and other crops

Nitrification Inhibitors

$$NH_4^+ \not\longrightarrow NO_3^-$$

- These chemicals disrupt the activity of *Nitrosomonas* and *Nitrobacter* bacteria which are responsible for nitrification of ammonium to nitrate
- The goal is to keep more of the applied nitrogen as ammonium which is less susceptible to leaching

- Dicyandiamide (DCD)
  - Agrotain
  - Agrotain Plus
    - Contains a urease inhibitor
- Dimethlpyrazolphosphate (DMPP)
  - Entec (Europe)
  - NovaTec
- Nitrapyrin
  - N-Serve
  - Instinct,
  - Vindicate
- Others

AGROTAIN PLUS

DCD Dry Concentrate

SUPER U

DCD

Dow AgroSciences

Instinct™

Registered in CA on corn/wheat in the registration process for tree fruit and vegetables

COMPO

DMPP

Controlled Release Fertilizer

one example

- **The diffusion of nitrate out of the prill is controlled by the thickness of the coating and environmental conditions (temperature)**
- **The coating meters the released nitrate rather than allowing the release of a large quantity that would build up a nitrate pool**

Urea **Polyurethane coated Urea**

Controlled Release Fertilizers

GREENFEED™

Coated urea prills (polyurethane and other coatings)

Chains or rings of urea molecules (can be foliar applied)

Nitrogen Technology Evaluations

2012-2016

Material	Trade name	Comment
Nitrification inhibitors		
Nitrapyrin	Instinct	Inhibitor or Nitrosomonas and Nitrobacter, commonly used in the cornbelt
DMPP	Novatec	Inhibitor or Nitrosomonas and Nitrobacter. The active ingredient is commonly used in Europe
DCD + urease inhibitor fertilizer additive	Agrotain Plus	DCD is the nitrification inhibitor and is mixed with a urease inhibitor; used as a fertilizer addative
DCD + urease inhibitor impregnated urea prill	Super U	DCD is the nitrification inhibitor and is mixed with a urease inhibitor; formulated as a dry prill
Controlled release		
Polymer coated urea prill	Duration 45	Polyurethane coated urea prill
Urea triazone	N-Sure	Ring of urea molecules; liquid formulation

Fertilizer Technology Trials

- All trials included an untreated control and with a standard fertilizer rate, as well as a moderate rate: 25-35% less than standard (produce less yield)
- All fertilizer technology treatments were applied at the moderate rate to be able to observe any boost in yield that they might provide
- We interpreted any boost in yield as a possible improvement in NUE

Lettuce trial: Drip irrigation manifold

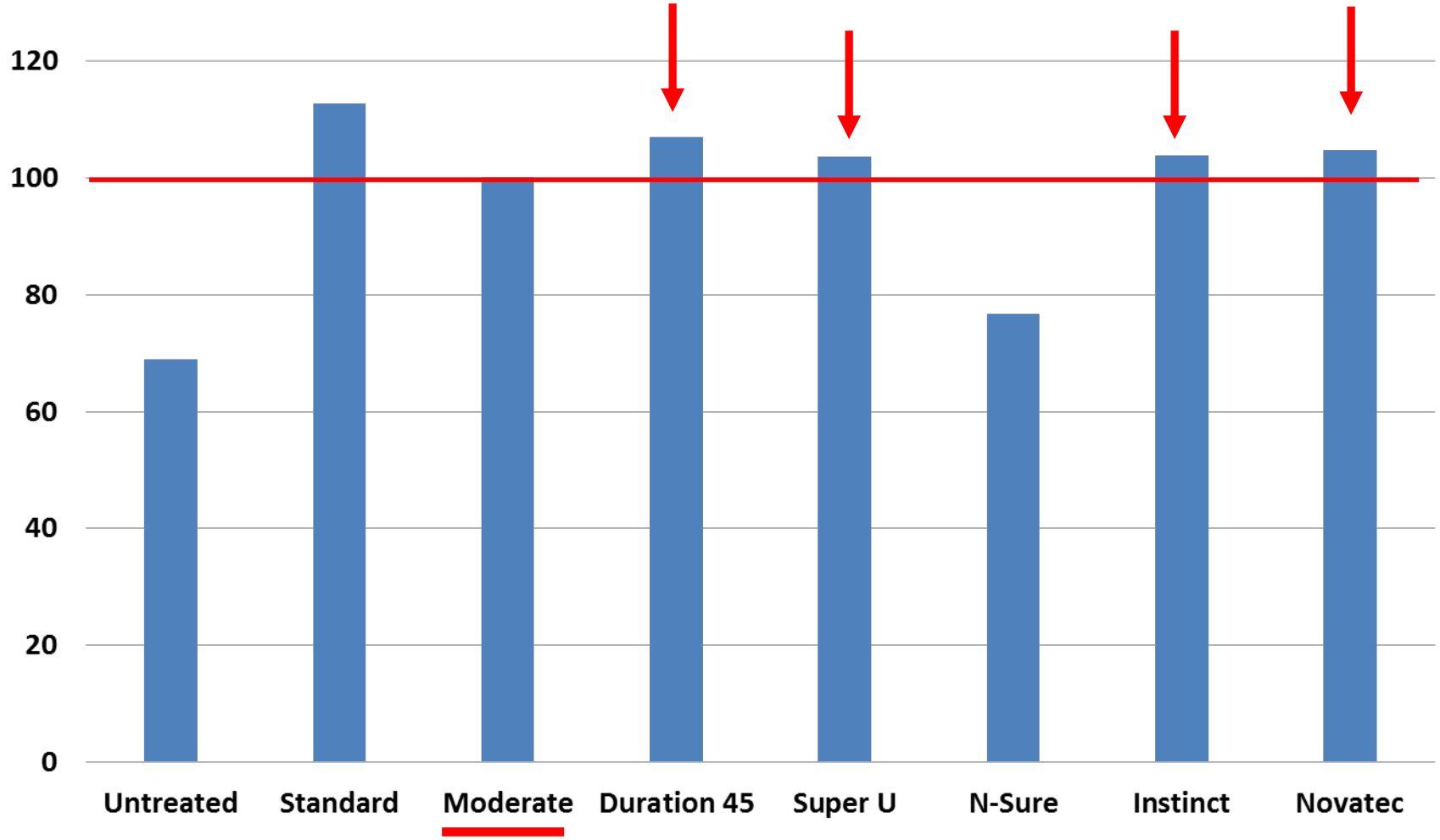
Lettuce trials conducted at USDA research station.

Spinach trials conducted on grower's fields.

Spinach trial: Dry or sprayed-on materials

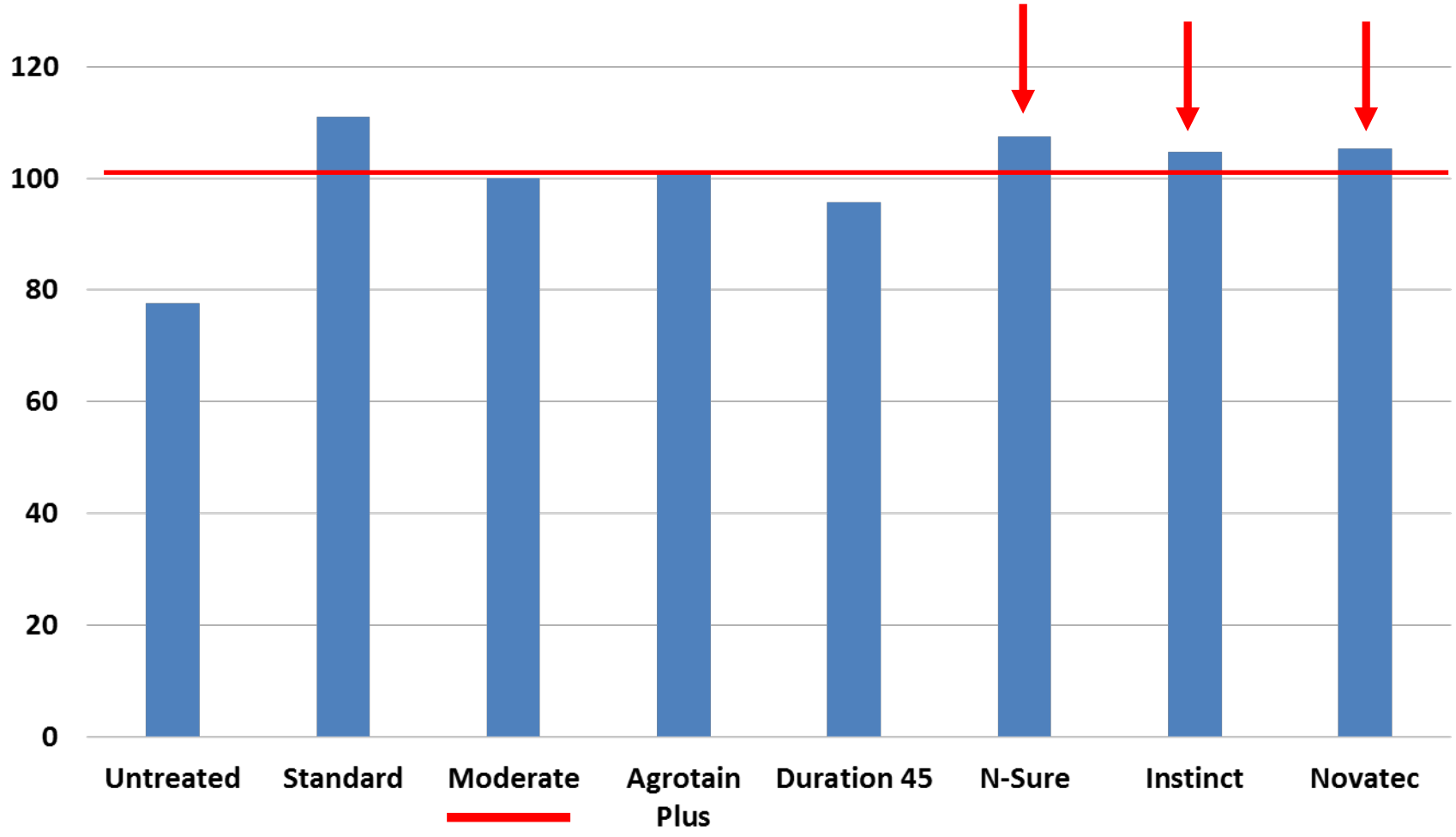
Average Relative Yield of Spinach Treated with Fertilizer Technologies

average of 7 trials



Average Relative Yield of Lettuce Treated with Fertilizer Technologies

average of 4 trials



Timing of Application
2016 Lettuce Trial

Material	Nitrapyrin application timing	Total N/A	Fresh Biomass tons/A	Head wt lbs
Standard	---	150	28.313	1.81
Moderate	---	80	23.566	1.50
Nitrapyrin 0.50 lb ai[1]	1st app.	80	23.832	1.52
Nitrapyrin 1.0 lb ai[1]	1st app.	80	24.619	1.57
Nitrapyrin 0.50 lb ai[2]	1st & 2nd app.	80	25.363	1.62
Nitrapyrin 1.0 lb ai[2]	1st & 2nd app.	80	25.727	1.64

Nitrogen Technology

- **The job of the nitrogen technologies is difficult because they are highly influenced by the soil system and are subject to biological, chemical and physical influences**
- **But, temperature, soil type, moisture, residual mineral N make prediction of efficacy on a field by field basis difficult**

Nitrogen Technology

- **Nitrogen technologies show potential for improving NUE**
  - **The effect was modest, but is real**
- **These technologies do not replace good agronomic and irrigation practices, but can enhance these basic practices**
- **The longevity of the activity of nitrification inhibitors needs more research**