

# Nutrient Uptake by Spinach

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# **Central Coast Regional Water Quality Control Board Proposed Regulations**

- Certified Irrigation and Nutrient Management Plan (INMP) to document N applied vs. N removed by crops**
- N balance ratio 1.0 for annual rotations that are double cropped**
- For example, if double cropped lettuce annually removes 240 lbs of N/A (120 lbs N/A/crop), could only apply 240 lbs N/A/year**

# Challenges meeting regulations

- High Nitrogen use efficiency required
- Shallow root system
- High quality demands
- Short crop cycle
- Uncertainty about nutrient uptake





**Yellowing along  
sprinkler line**

# Research objectives

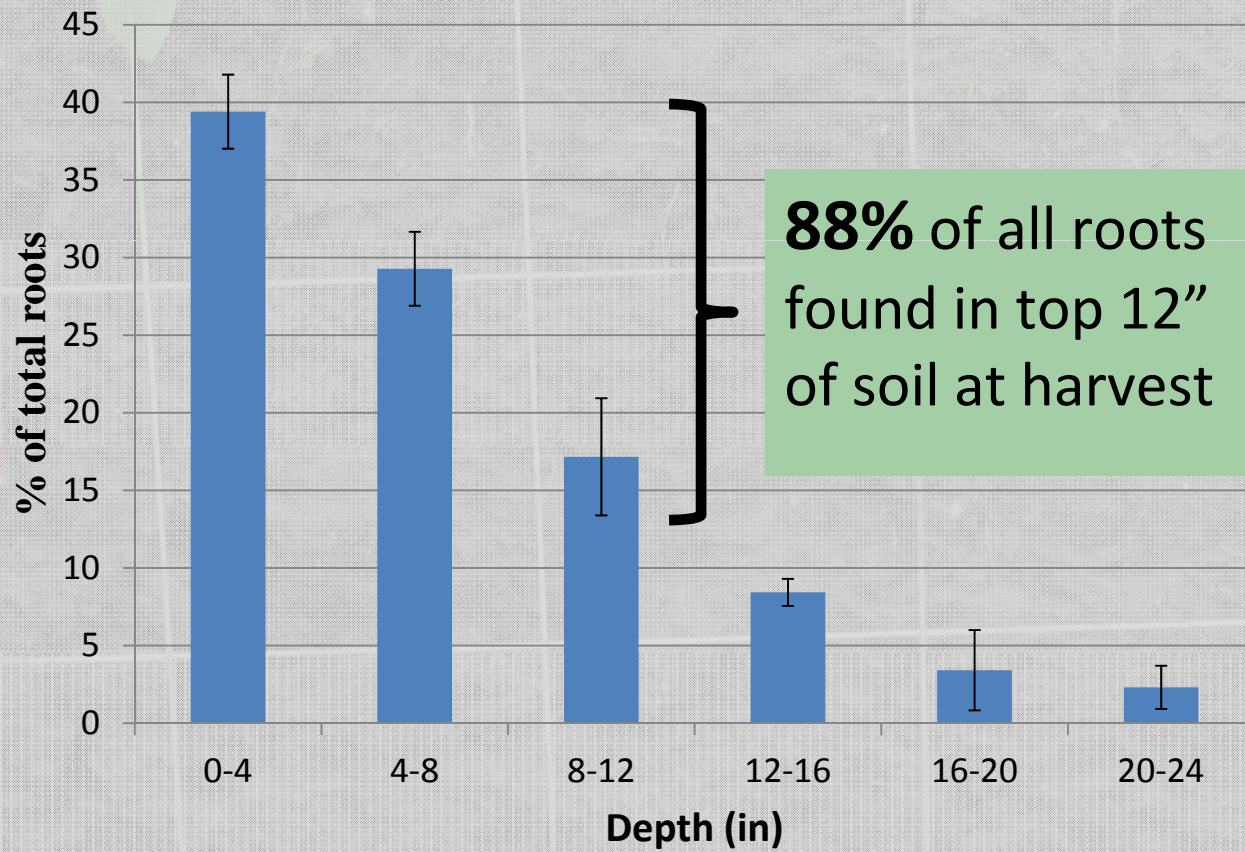
Better understand the nutrient uptake characteristics and root physiology of spinach

# Nitrate and root distribution



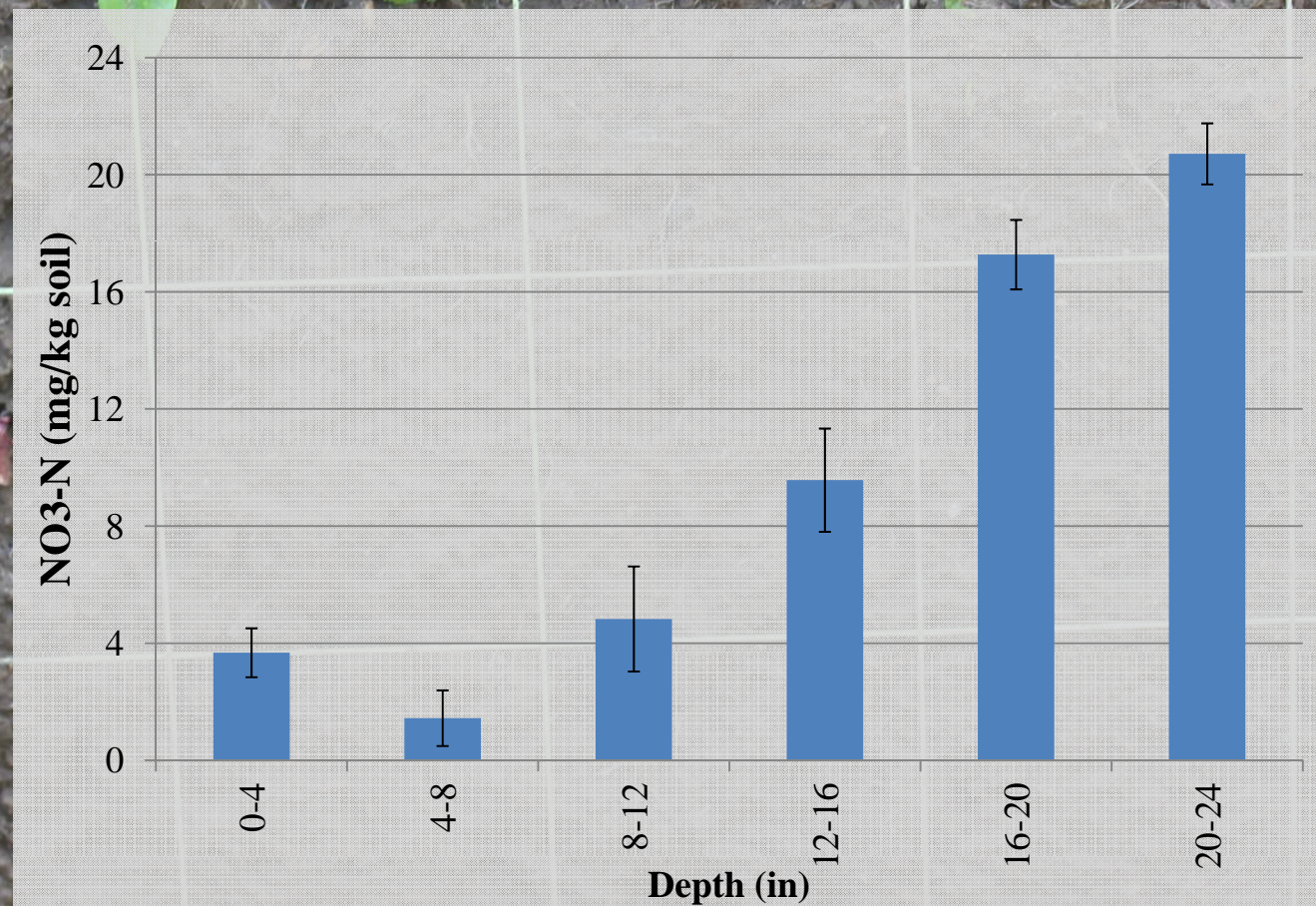
- At harvest pits dug to 2 feet (4 sites)
- Roots exposed with pressurized sprayer
- Roots counted in each grid
- Nitrate measured in each grid

# Root distribution



**88%** of all roots found in top 12" of soil at harvest

# Nitrate distribution



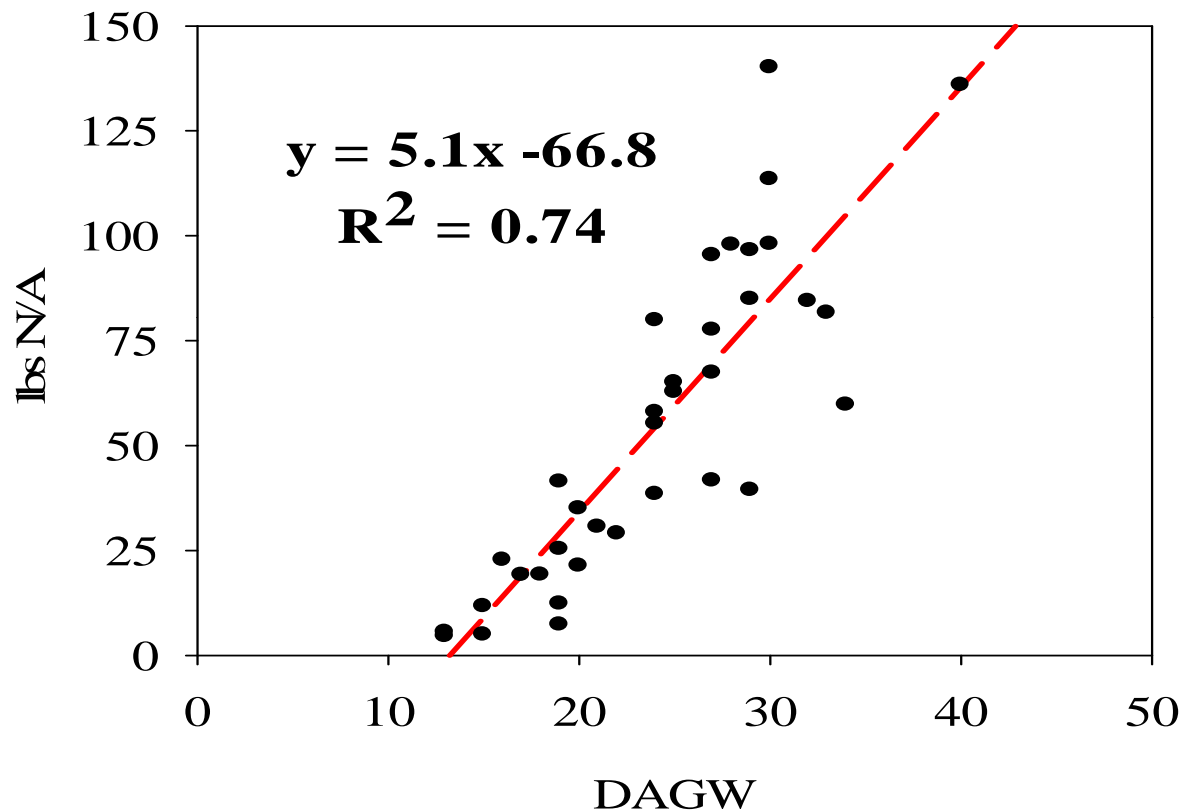
# Biomass sampling



- 80" beds only
- 3' by bedtop (3-4 reps)
- Crown and ~ ¼ in of root
- Washed to remove soil

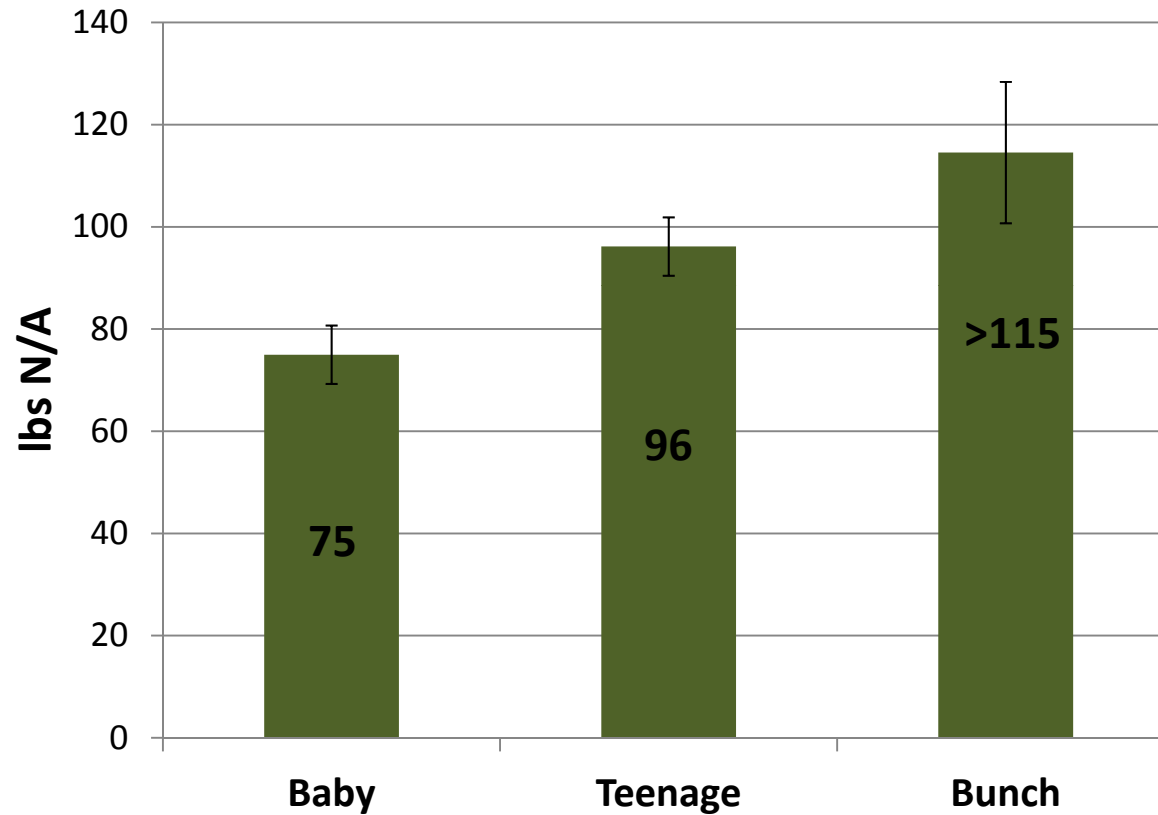


# Spinach Nitrogen Uptake from 14 fields



- **11 lbs N/A** in first 2 wks
- **5.1 lbs N/A/d** from 13 d to harvest
- **7.3 lbs N/A/d** in the week prior to harvest

# Spinach Nitrogen Uptake by product



# Residue N remaining after harvest



Clipped:

- 44% of N taken up by crop remains in field

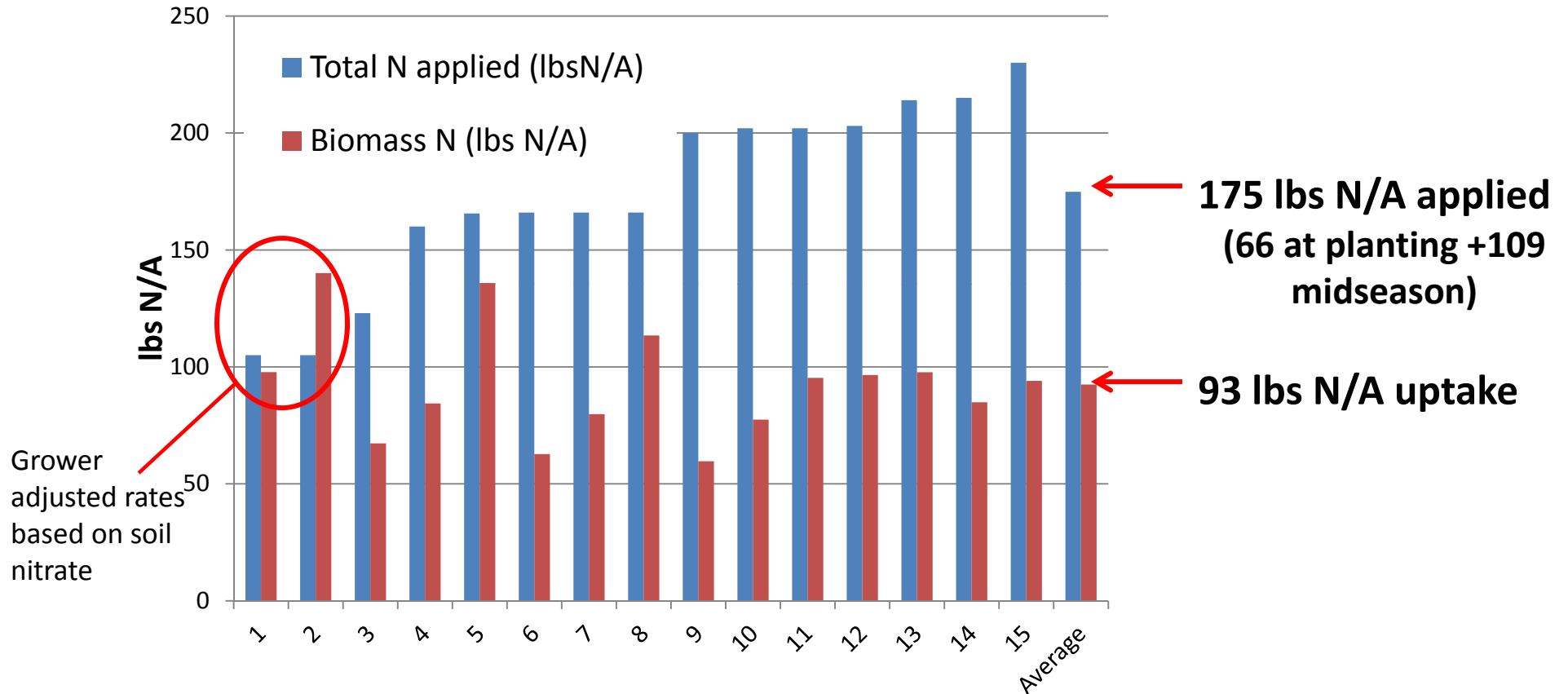
Bunch:

- 35% of N taken up by crop remains in field



Residue ~5% N

# N fertilizer and plant uptake



**88%** more N applied than taken up in the crop

# Nitrogen fertilizer applications

	Preplant/ planting	Midseason	Total
	----- lbs N/A -----		
1st crop	73	118	191
2nd crop	59	105	164
All	66	109	175

# Nitrogen management for Spinach



- Soil testing
  - Pre-planting
  - Before midseason fertilizer application
- 1<sup>st</sup> vs. 2<sup>nd</sup> Crop
- Irrigation to match ET
- Certified Crop Adviser (CCA)

# Rapid soil nitrate analysis



## Quick Test

### – Advantages

- Inexpensive
- Quick
- Easy
- Robust

### – Disadvantage

- Small sample size

# Rapid soil nitrate analysis

**SOLUM** 



## Solum “No Wait Nitrate” system

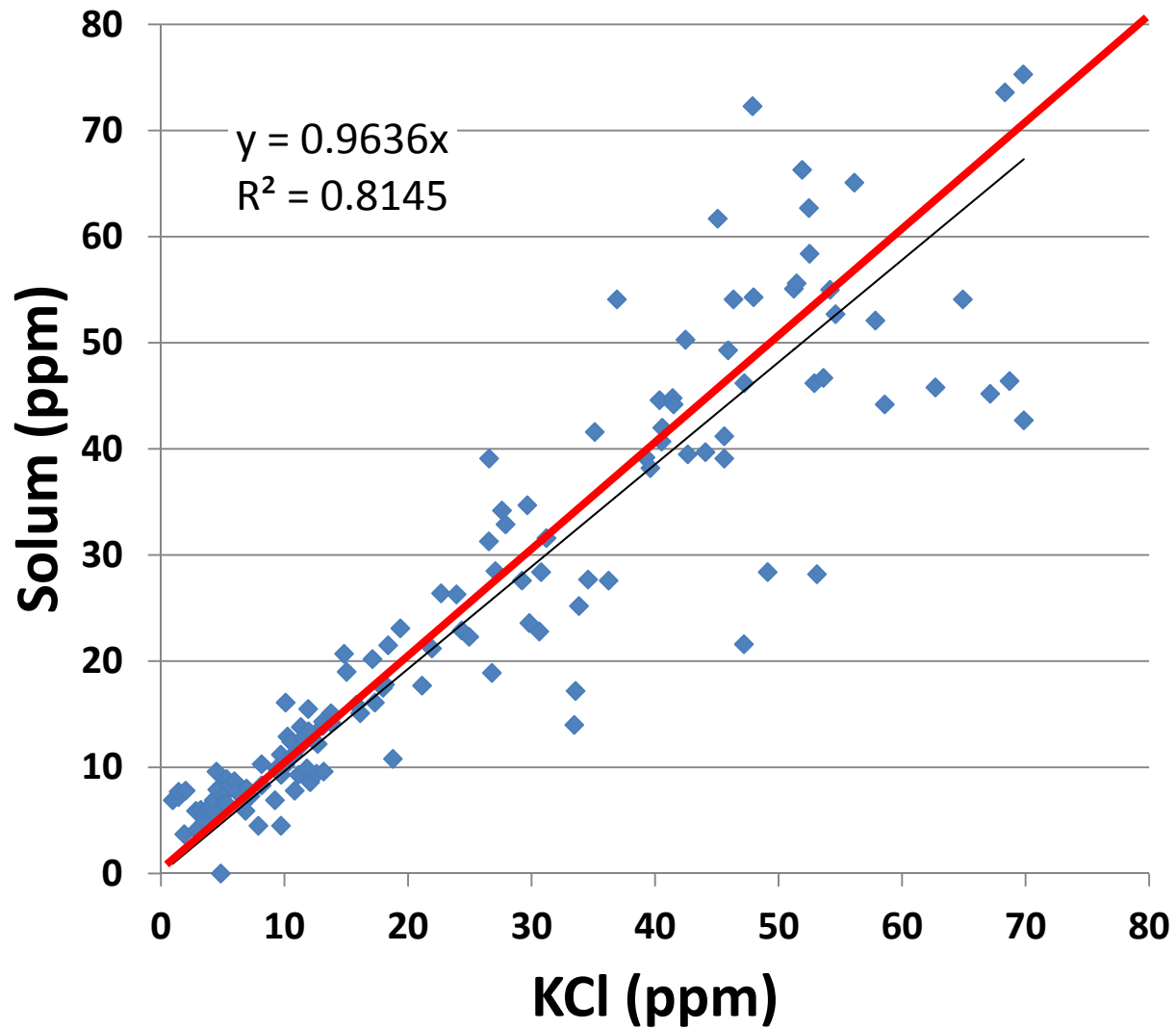
### – Advantages

- Large sample size
- More accurate than QT

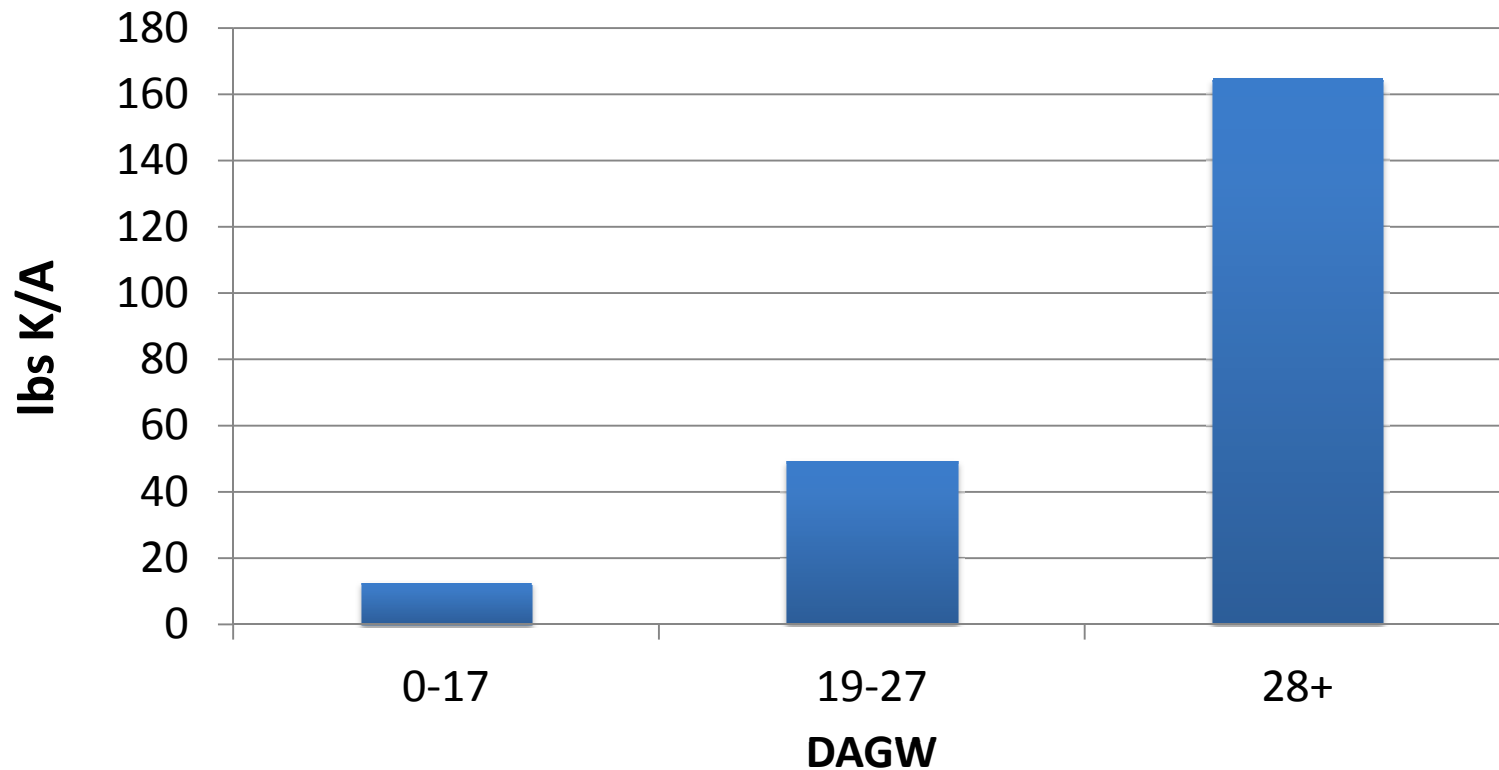
### – Disadvantages

- Expensive
- More time consuming

# Solum performance

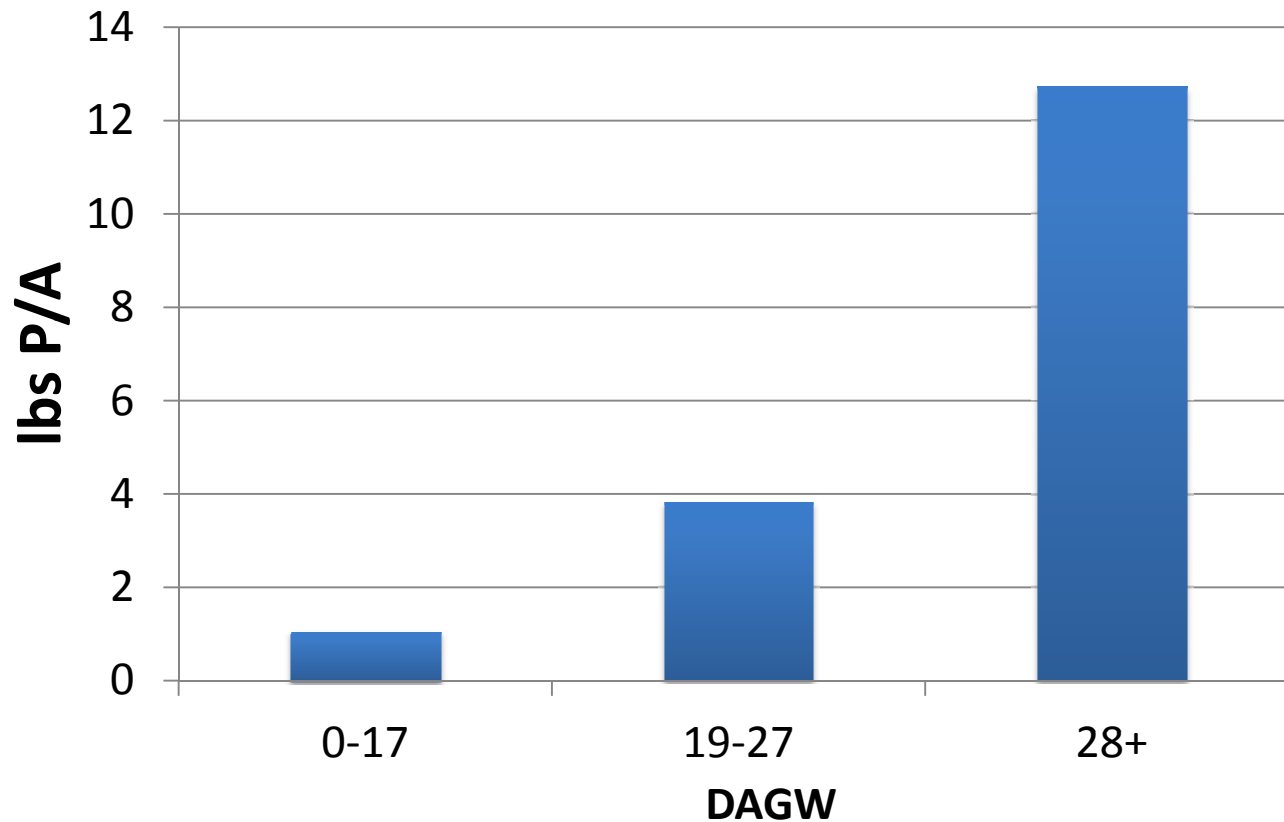


# Spinach Potassium Uptake



- 7.2 lbs K/A in first 2 wks
- 9.3 lbs K/A/d from 13 d to harvest
- ~160 lbs K/A at harvest

# Spinach Phosphorus Uptake



- 0.7 lbs P/A in first 2 wks
- 0.7 lbs P/A/d from 13 d to harvest
- ~12 lbs P/A at harvest

# Challenges



- Shallow root system
- High nitrogen demand
- Short crop cycle
- Demanding quality standards
- Experience interpreting soil test results
- 1st vs 2<sup>nd</sup> crop

# Acknowledgements



- California Leafy Greens Research Board
- Cooperating growers