Fertilizer Management for Plant Health and Environmental Water Quality Protection

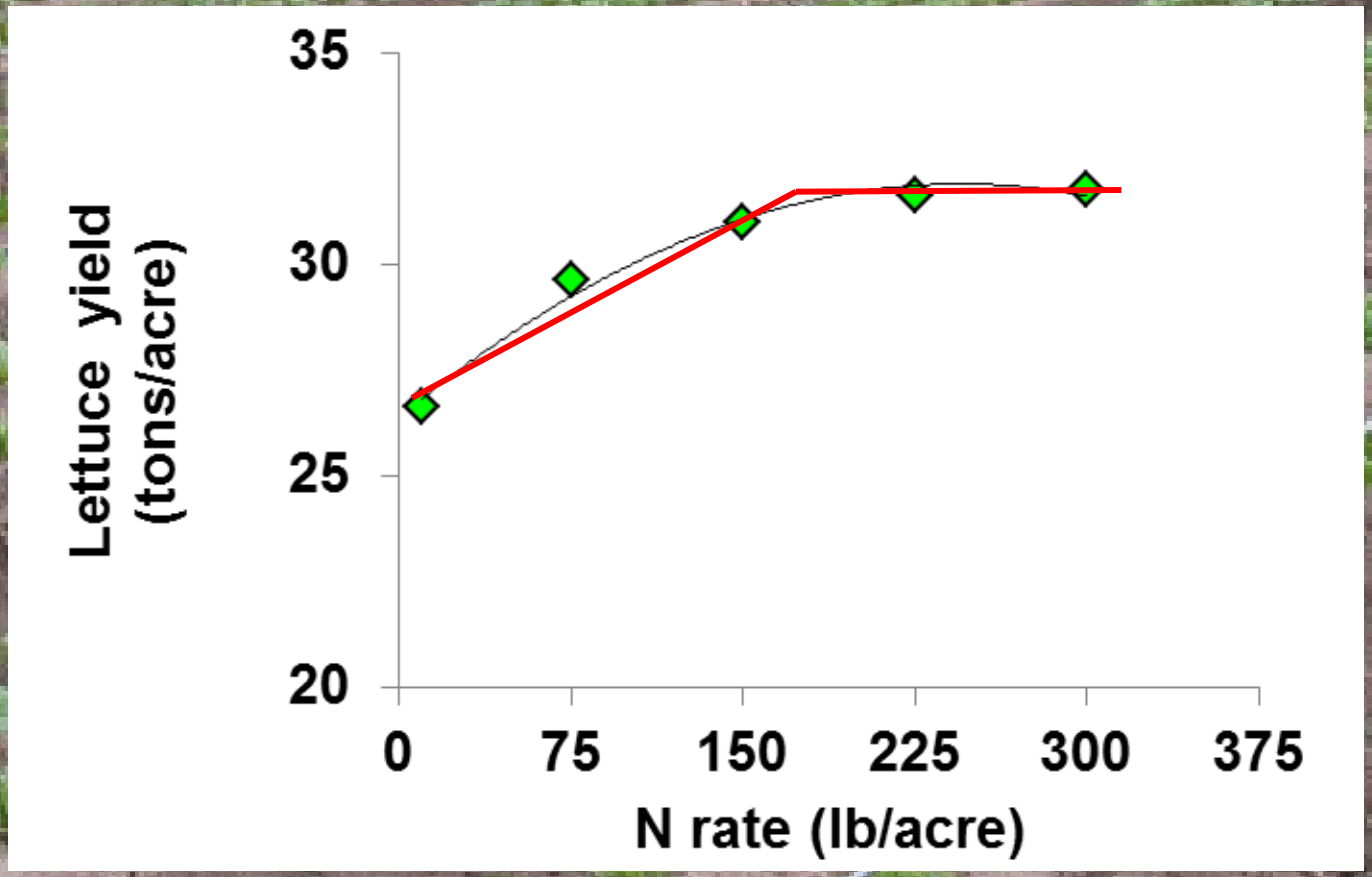
Florida and California are different …

… but we share some problems, and solutions

Nitrogen and phosphorus management for horticultural crop production can be tricky :

- **Effects on crop yield**
- **Effects on product quality**
- **Effects on environmental water quality**

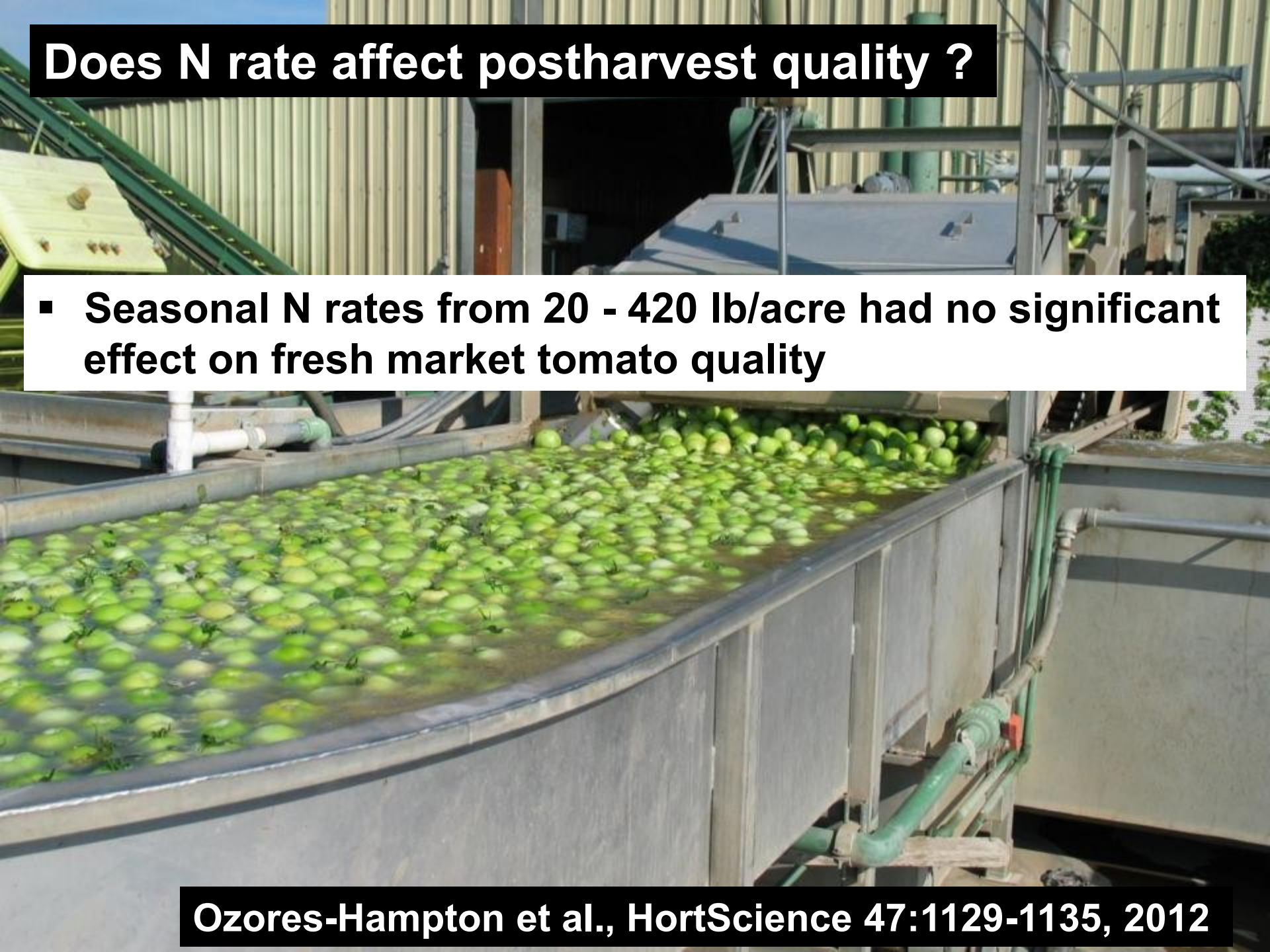
N rate affects crop yield



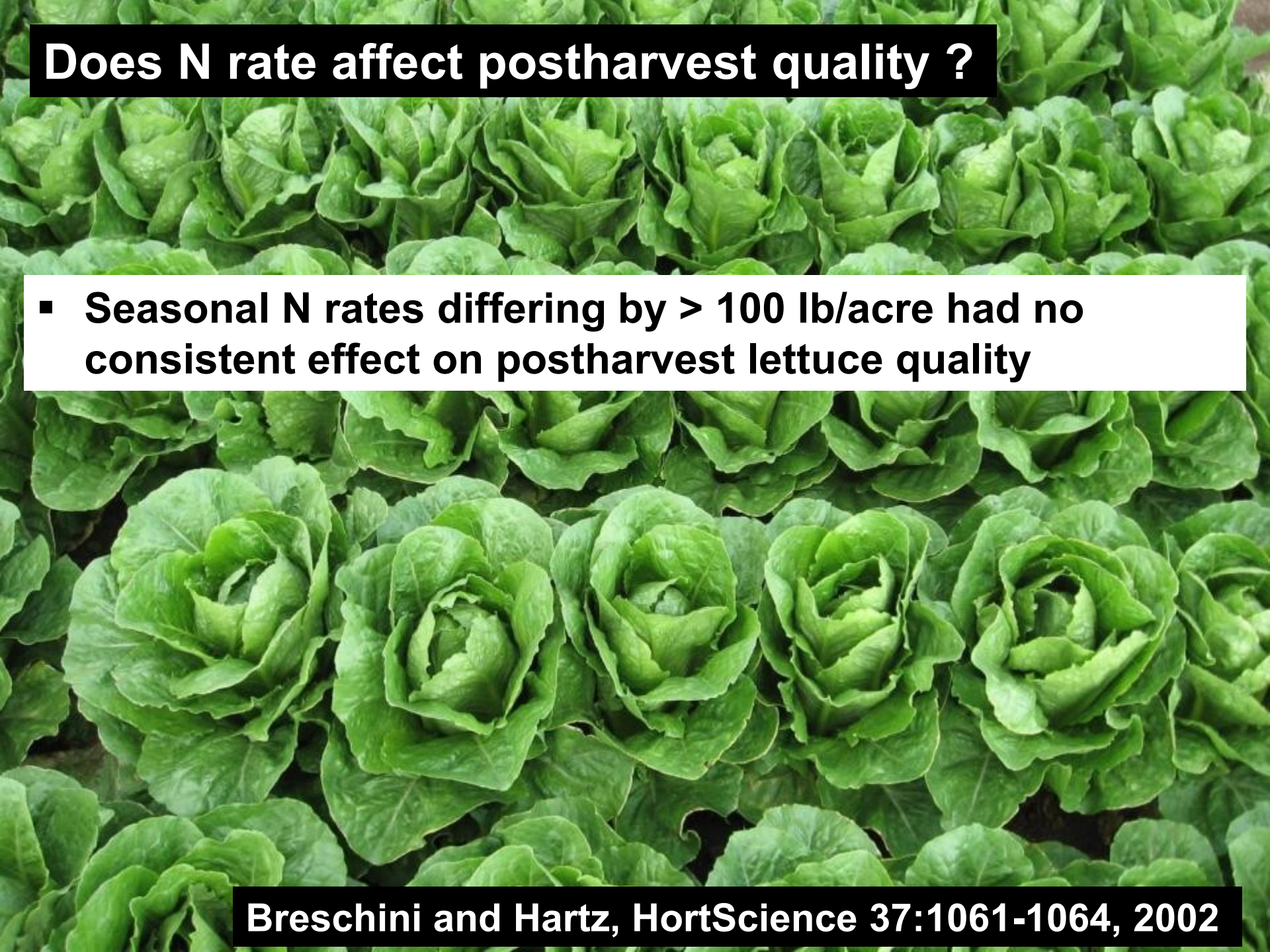
Bottoms et al., HortScience 47:1768-1774, 2012

Does N rate affect postharvest quality ?

- Seasonal N rates from 20 - 420 lb/acre had no significant effect on fresh market tomato quality



Ozores-Hampton et al., HortScience 47:1129-1135, 2012

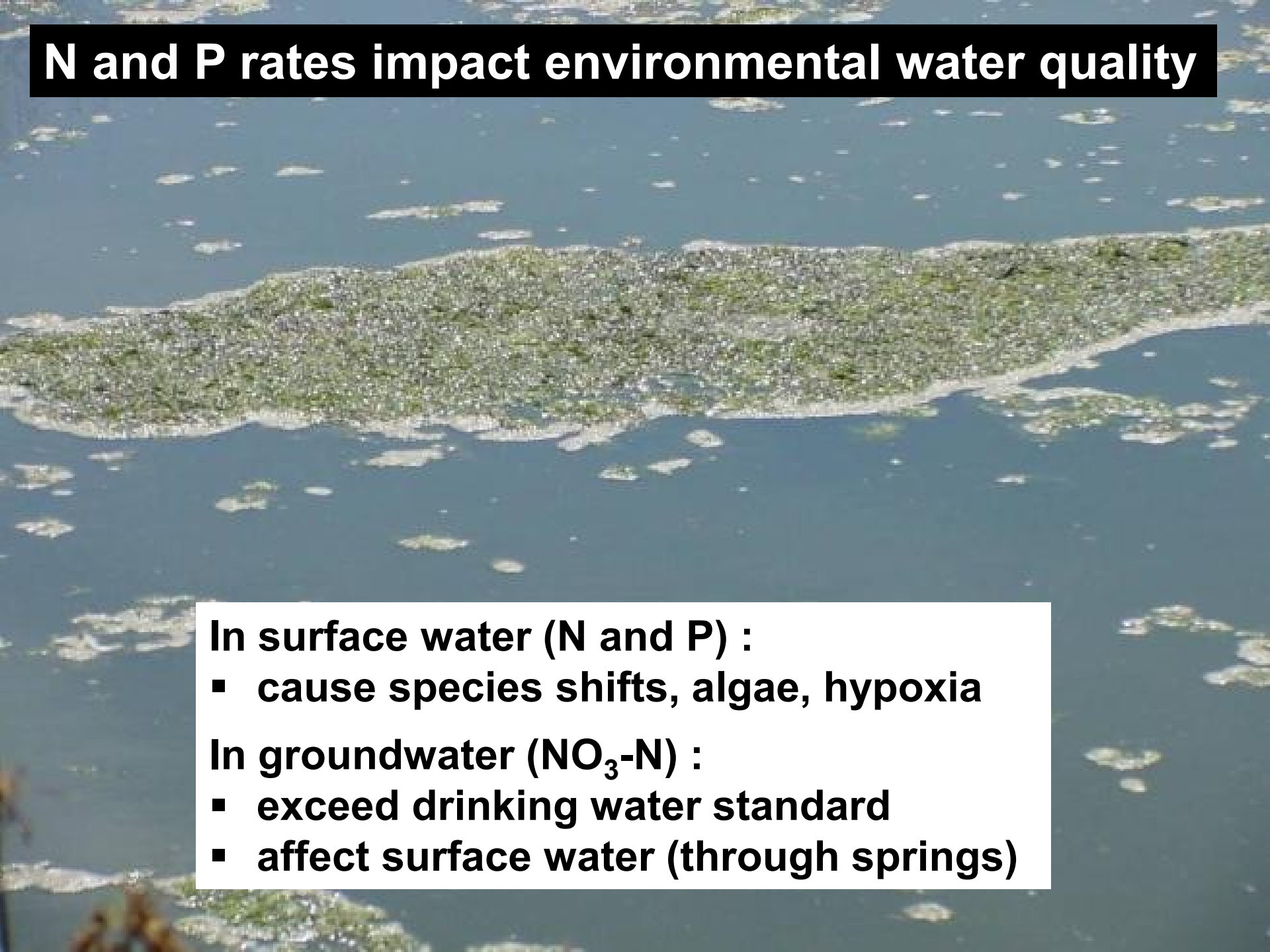


Does N rate affect postharvest quality ?

- Seasonal N rates differing by > 100 lb/acre had no consistent effect on postharvest lettuce quality

Breschini and Hartz, HortScience 37:1061-1064, 2002

N and P rates impact environmental water quality



In surface water (N and P) :

- **cause species shifts, algae, hypoxia**

In groundwater (NO_3-N) :

- **exceed drinking water standard**
- **affect surface water (through springs)**

What are the environmental nutrient concentration targets ?

- Federal drinking water standard is 10 PPM NO_3-N

- Environmental standards vary by area, can be as low at 1 - 2 PPM NO_3-N, and 0.06 PPM PO_4-P

Where are we now ?

In coastal California :

- **groundwater often 10 - 30 PPM NO_3-N**
- **surface water is often**

  20 - 40 PPM NO_3-N

  0.1 - 0.4 PPM PO_4-P

- **Nutrient impairments are widespread in Florida**

So what are regulators going to do ?

In coastal California, new rules have been proposed :

- **'N balance ratio' of 1.0 (vegetables) or 1.2 (strawberry)**
  ratio = fertilizer N applied vs. crop N uptake
- **Intent is to move toward a ratio based on N removal from the field in harvested product**

Nutrient loading to the environment

Basic principle :

Fertilizer N and P applied but not removed from the field in harvested products are at risk of *eventually* being lost to the environment

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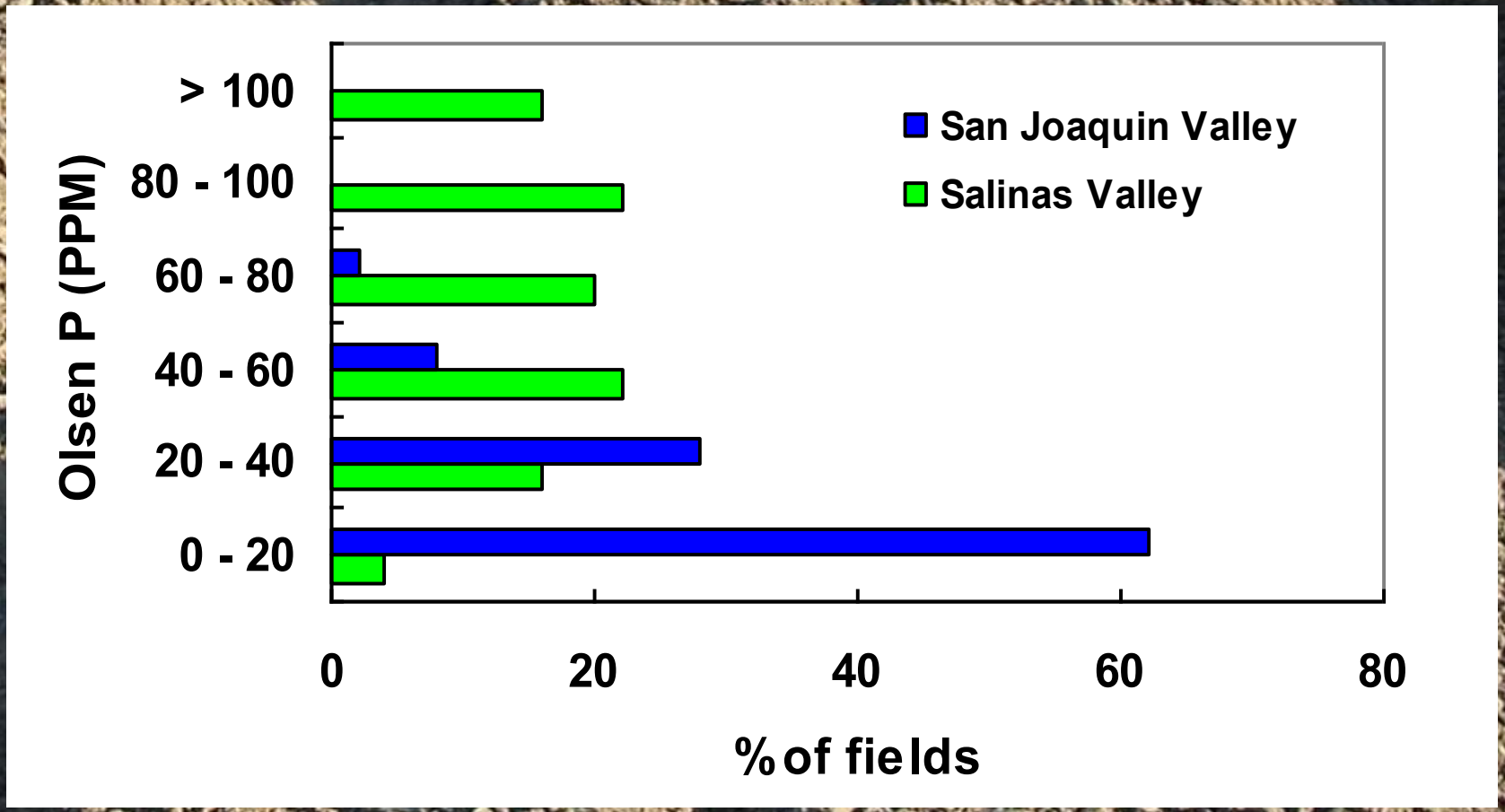
Therefore, water quality protection requires :

- **preventing excessive P buildup in soil**
- **maintaining reasonable proportionality between N application and harvest removal**

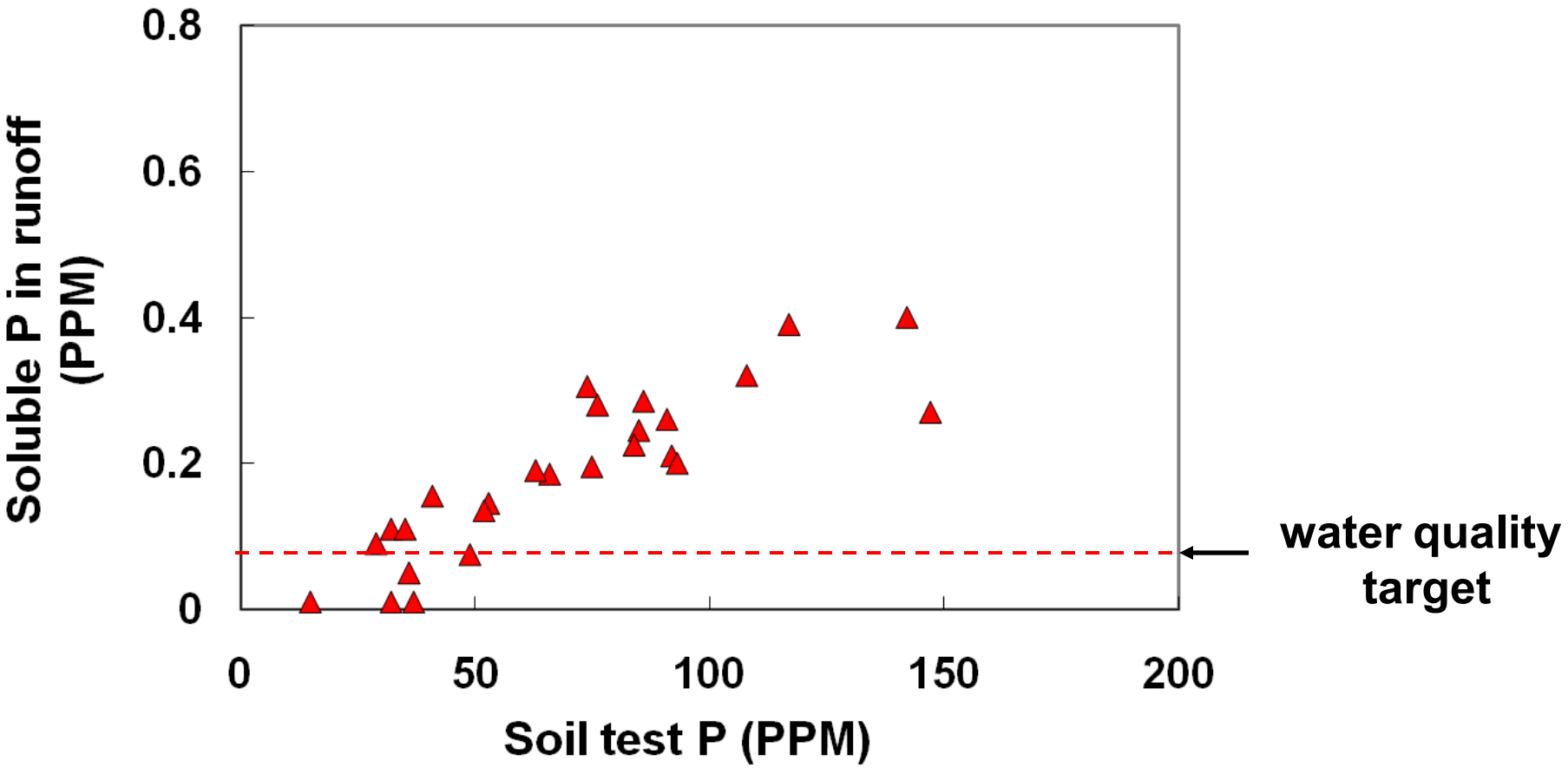
Fertilization practices have long-term consequences :

- San Joaquin Valley - one crop per year, vegetables and row crops
- Salinas Valley - two crops per year, all vegetables



Soil P status directly affects the degree of environmental hazard :

In a simulated runoff study using 25 California vegetable soils :



Is P fertilization always necessary ?

P fertilizer trials in coastal lettuce :

- 15 lettuce fields chosen, representing the typical range of soil test P values for the Salinas Valley
- P treatment comparison:
  - grower's preplant P (averaged 80 lb P_2O_5/acre)
  - no applied P

Is P fertilization always necessary ?

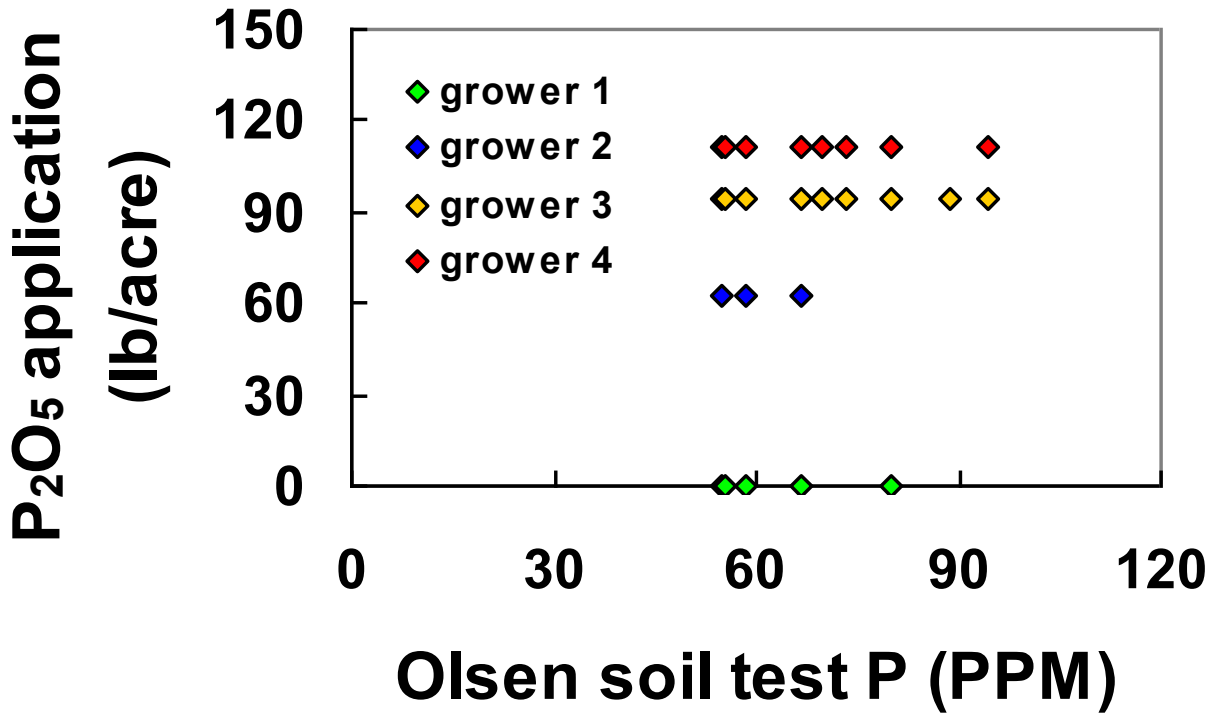
Field	Soil bicarbonate P test (PPM)	Did P fertilization improve yield?
1	35	yes
2	40	yes
3	53	no
4	54	yes
5	55	no
6	57	no
7	57	no
8	62	no
9	62	no
0	72	no
11	78	no
12	81	no
13	82	no
14	98	no
15	124	no

How efficiently was the applied P taken up ?

Average of non-responsive fields:

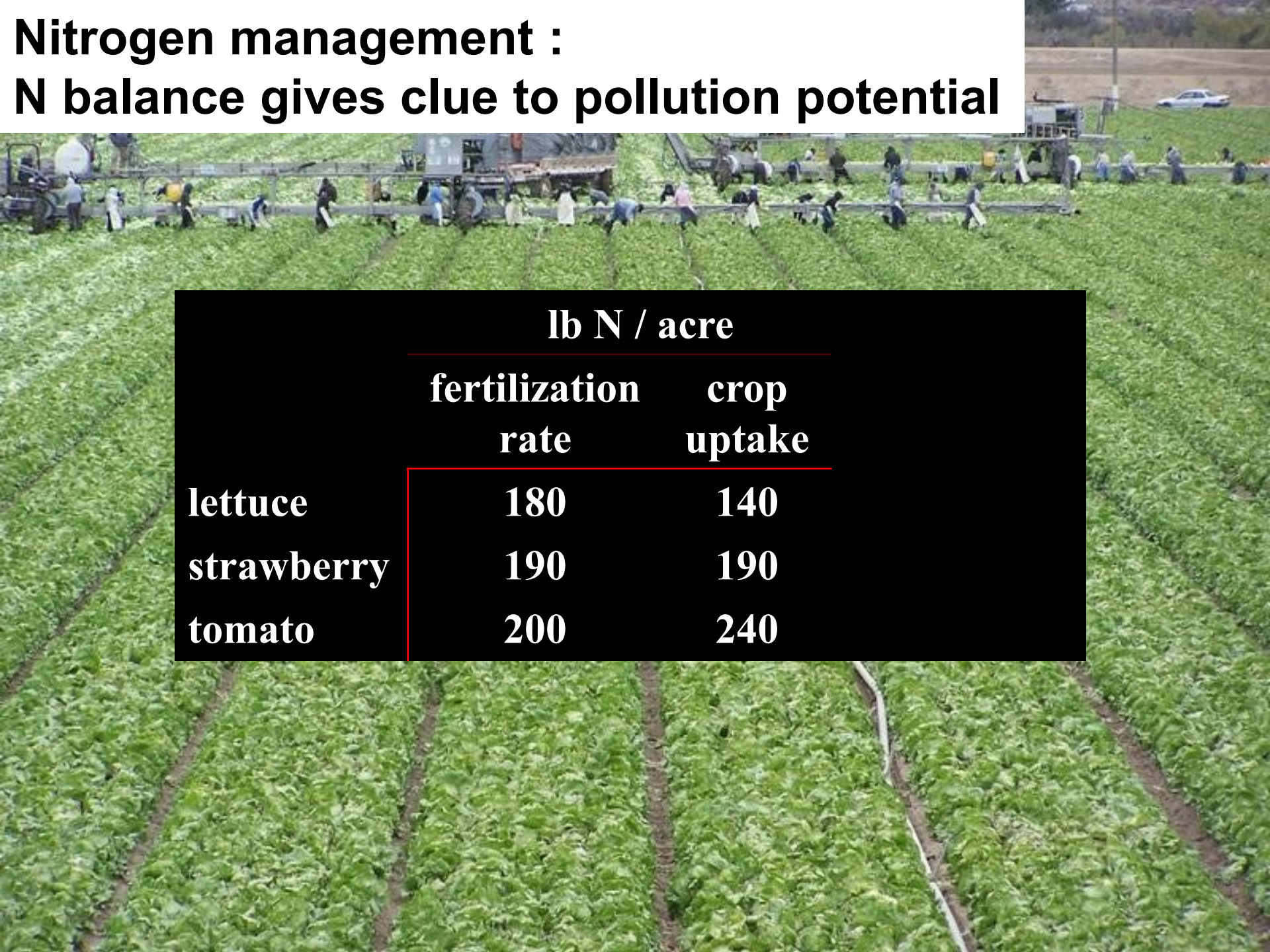
P treatment	lb P_2O_5 / acre		
	P applied	Total crop P uptake	Removal with harvest
Grower P	80	31	20
No P	0	30	20

P fertilization by ‘recipe’ wastes money, increases pollution potential :



2004-05 lettuce field survey

Nitrogen management :
N balance gives clue to pollution potential



	lb N / acre	
	fertilization rate	crop uptake
lettuce	180	140
strawberry	190	190
tomato	200	240

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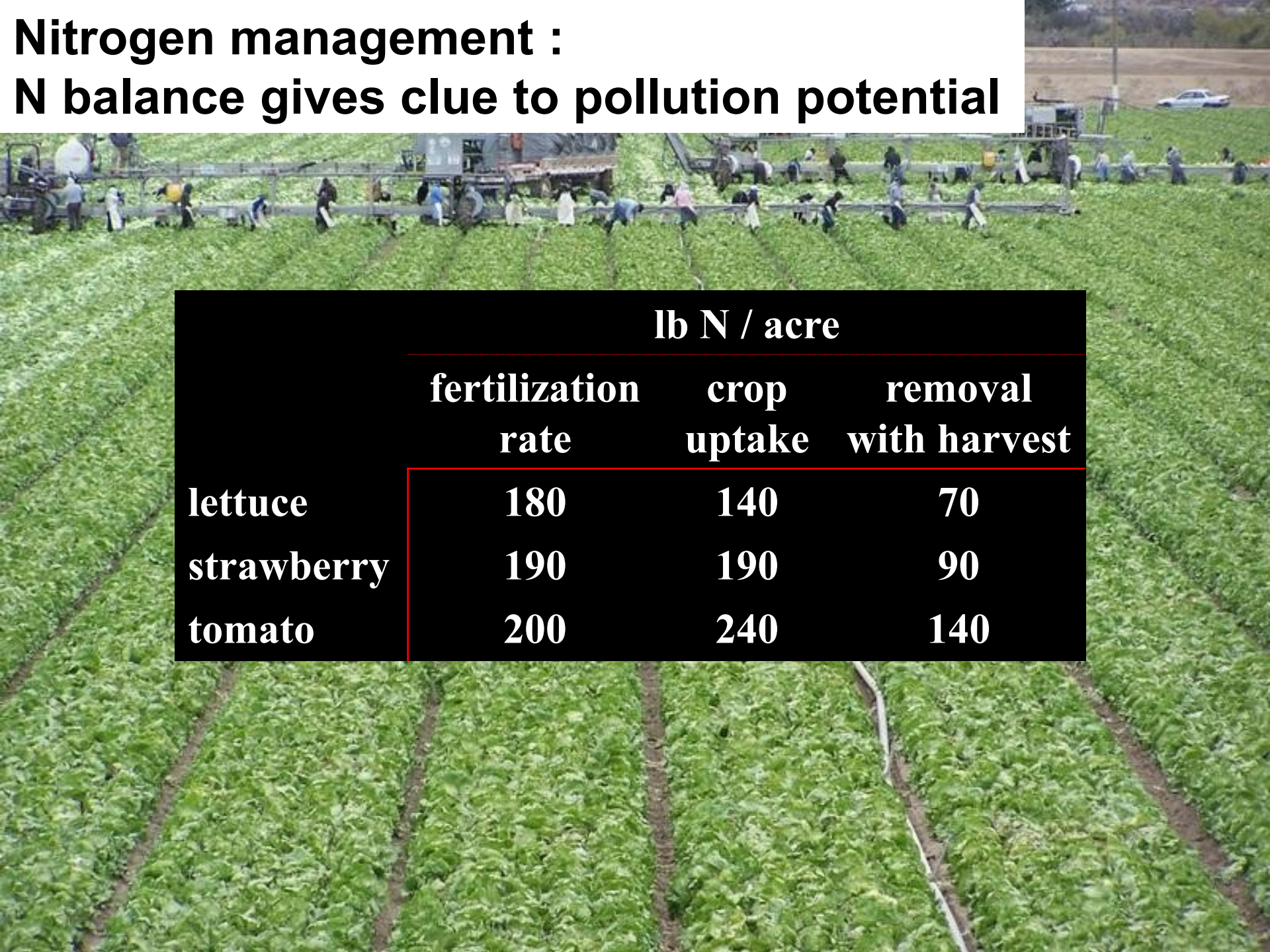


	lb N / acre		
	fertilization rate	crop uptake	removal with harvest
lettuce	180	140	70
strawberry	190	190	90
tomato	200	240	140

Fate of applied N not removed in harvested products :

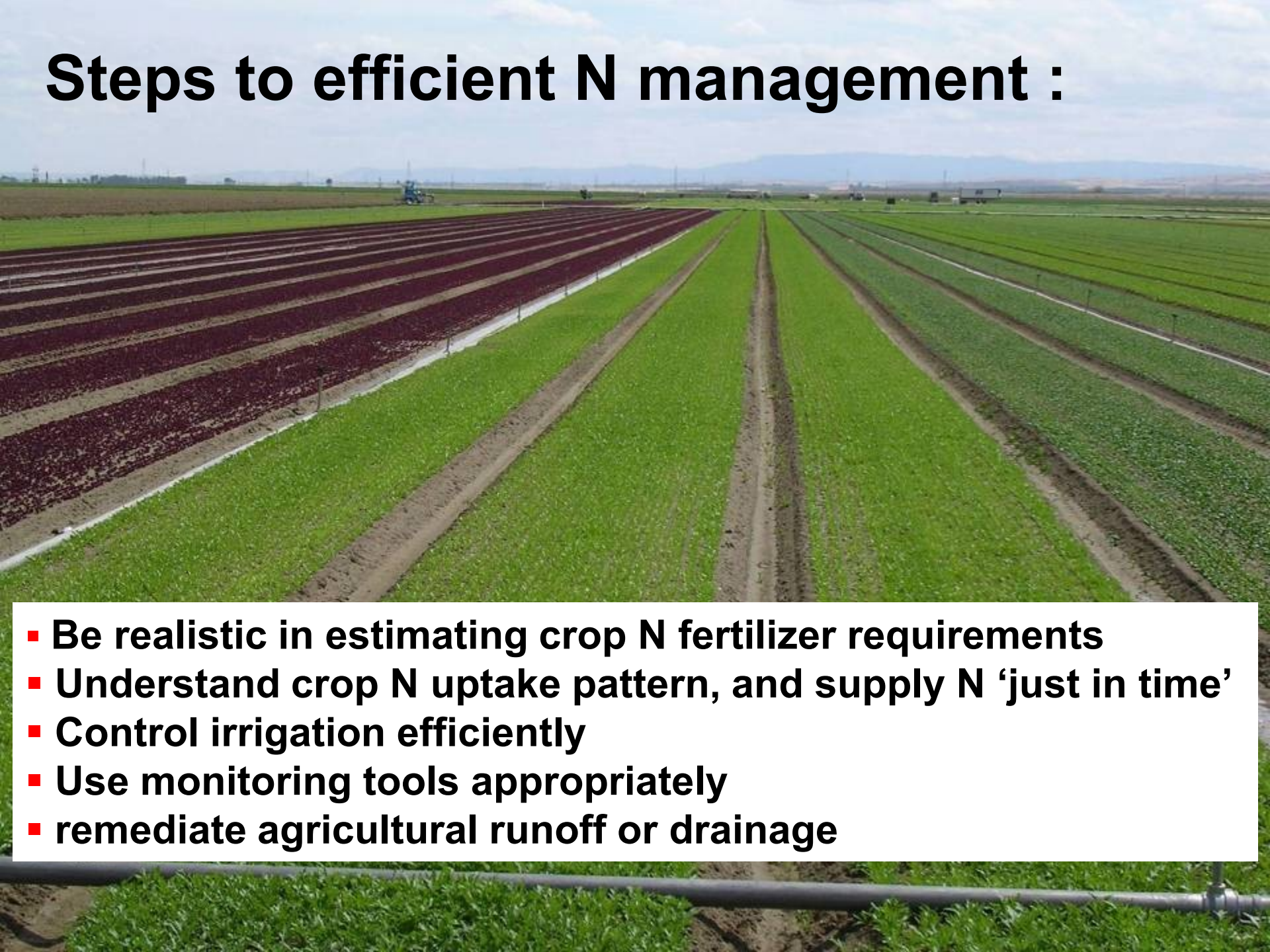
Remain in organic form

Lost through denitrification

Remain as residual soil nitrate

Lost as nitrate in water

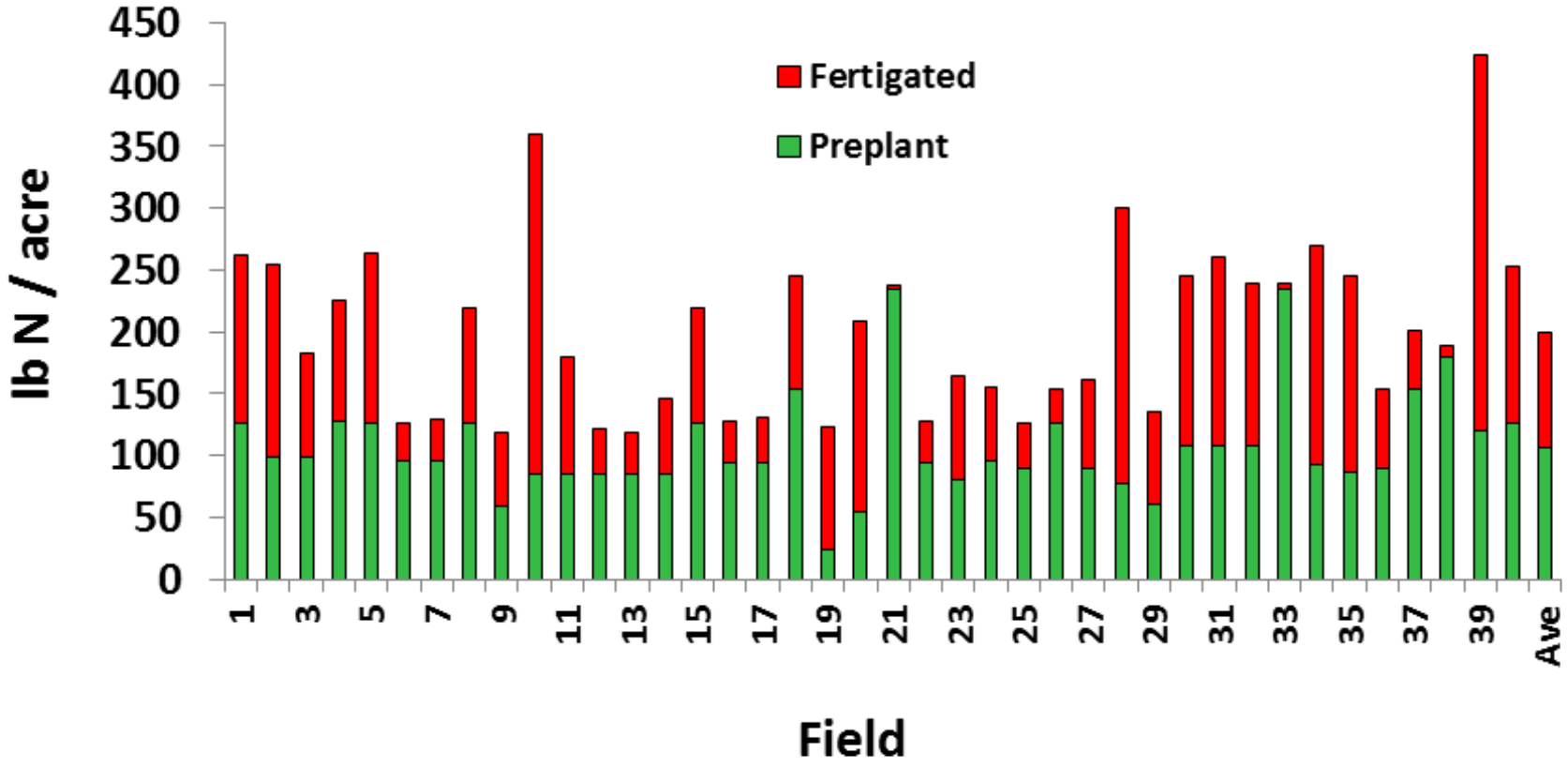
Steps to efficient N management :



- Be realistic in estimating crop N fertilizer requirements
- Understand crop N uptake pattern, and supply N ‘just in time’
- Control irrigation efficiently
- Use monitoring tools appropriately
- remediate agricultural runoff or drainage

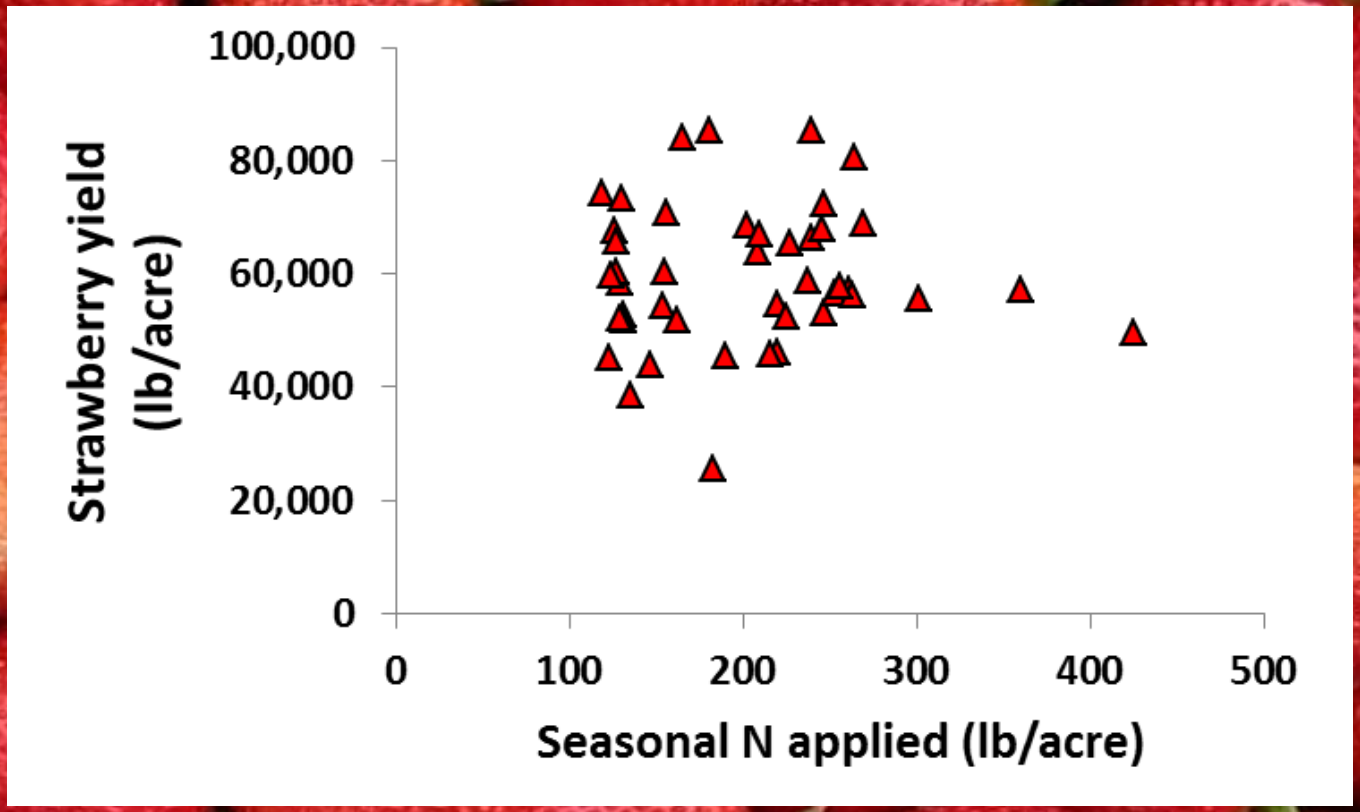
Be realistic in estimating crop N requirements :

- Seasonal N fertilization of 40 commercial strawberry fields



	Ave	Min	Max
Preplant	106	24	234
Fertigated	93	3	304
Total	200	118	424

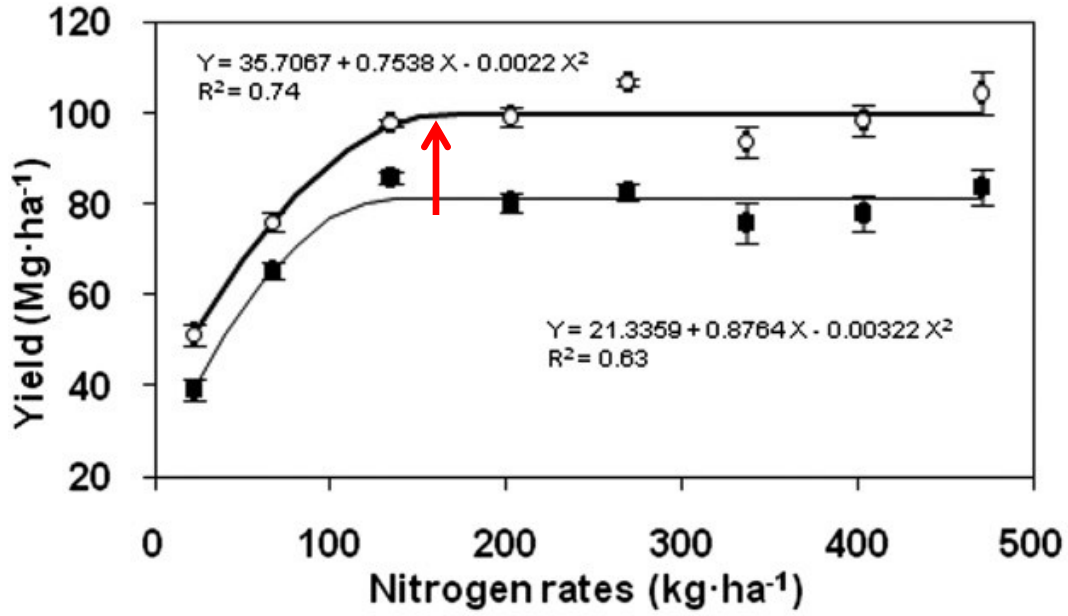
In the real world, N application rate seldom drives yield :



Florida tomato :

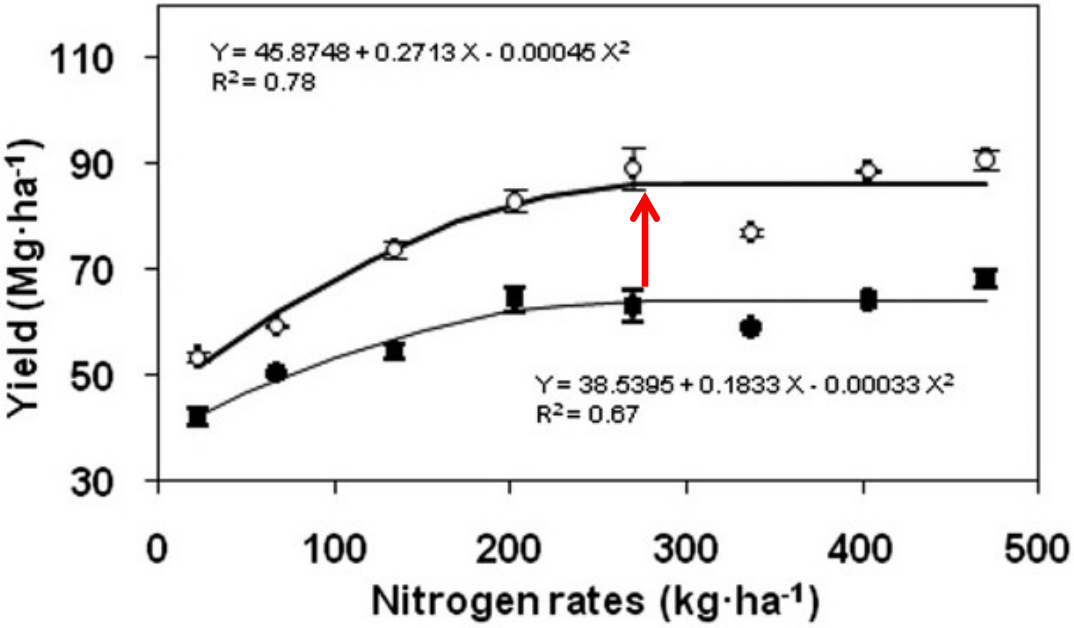
2007:

- Higher yield
- Less N required



2008:

- Lower yield
- More N required



Ozores-Hampton et al., HortScience 47:1129-1135, 2012

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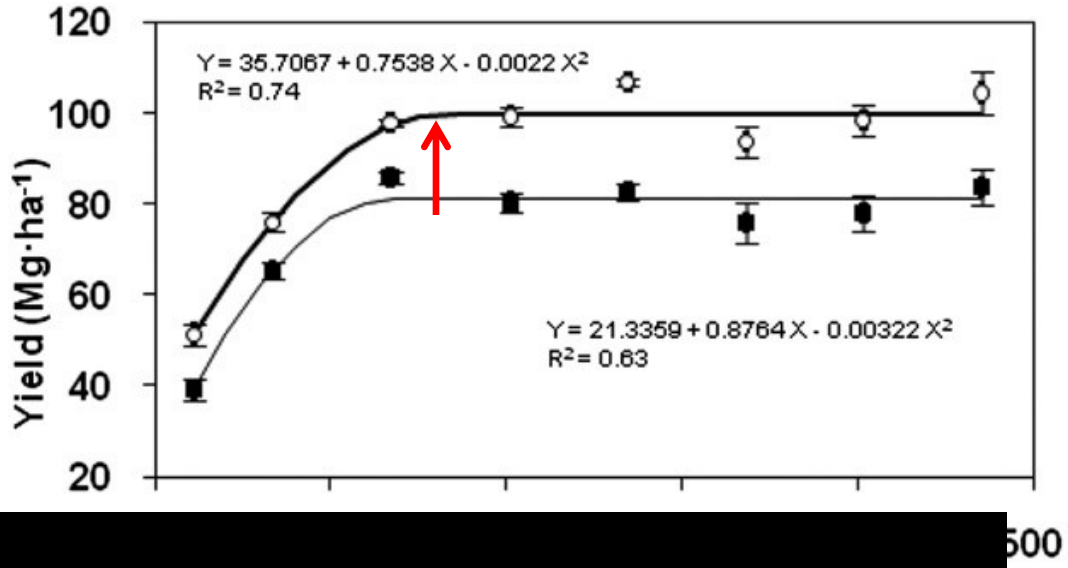
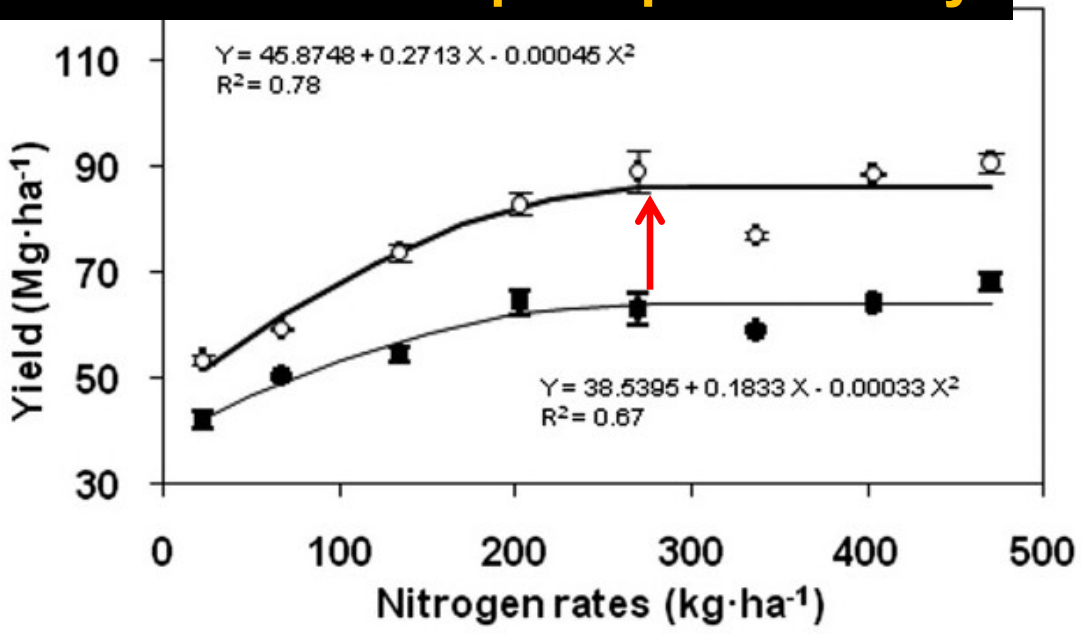


Conclusion:

- It takes at least 250 lb N/acre to ensure peak productivity

2008:

- Lower yield
- More N required



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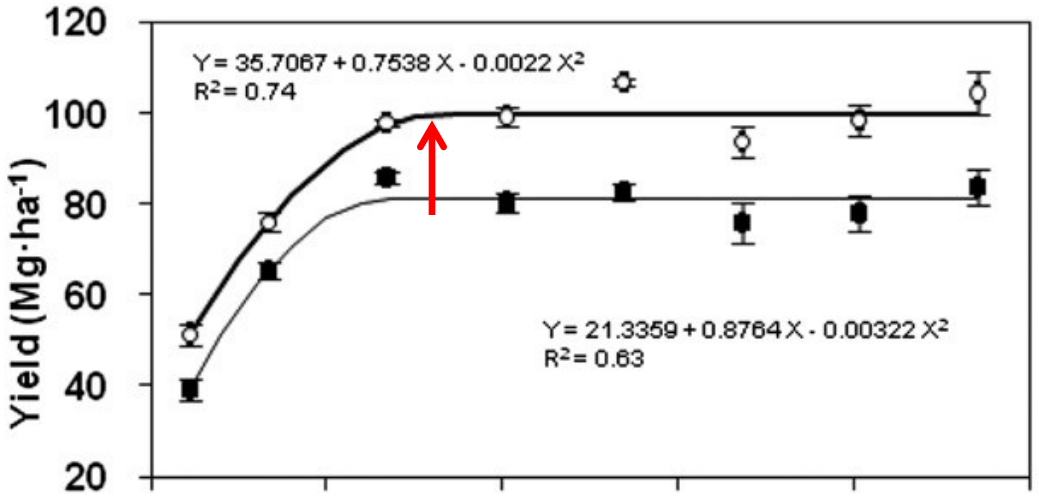
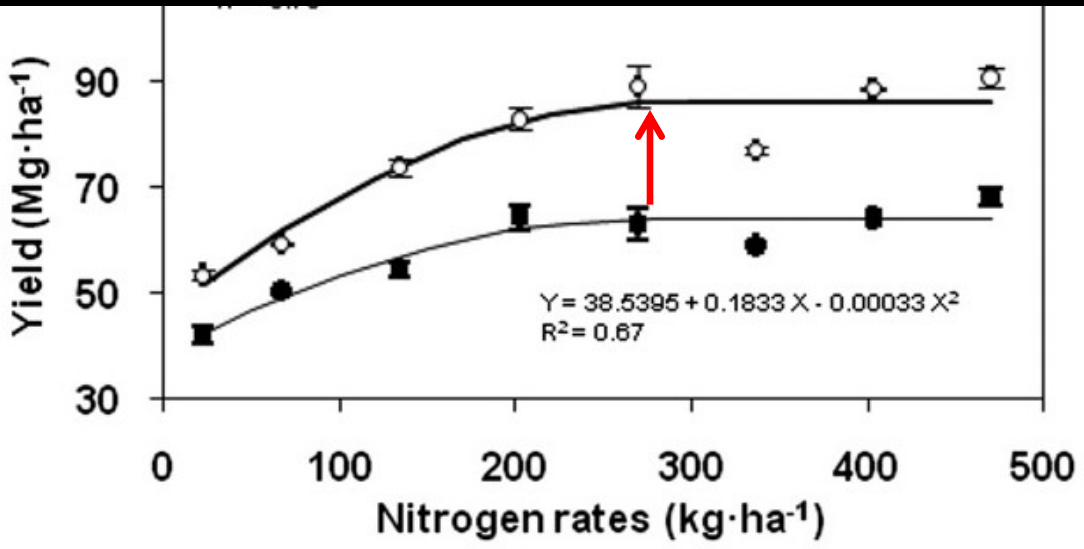


Alternative conclusion:

- Field-specific factors govern N requirement, and N efficiency requires adjusting for those factors

2008:

- Lower yield
- More N required

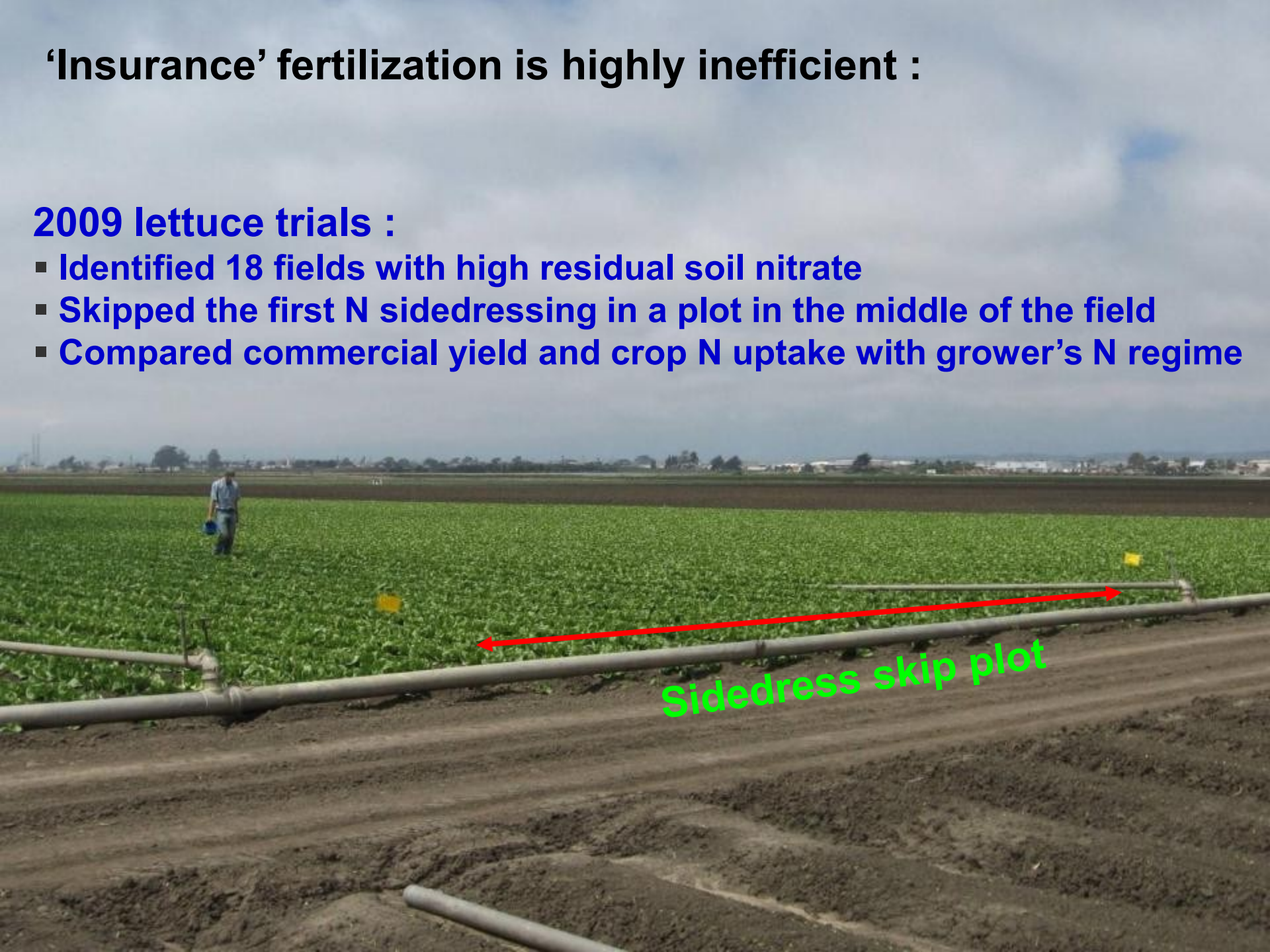


Ozores-Hampton et al., HortScience 47:1129-1135, 2012

‘Insurance’ fertilization is highly inefficient :

2009 lettuce trials :

- Identified 18 fields with high residual soil nitrate
- Skipped the first N sidedressing in a plot in the middle of the field
- Compared commercial yield and crop N uptake with grower’s N regime

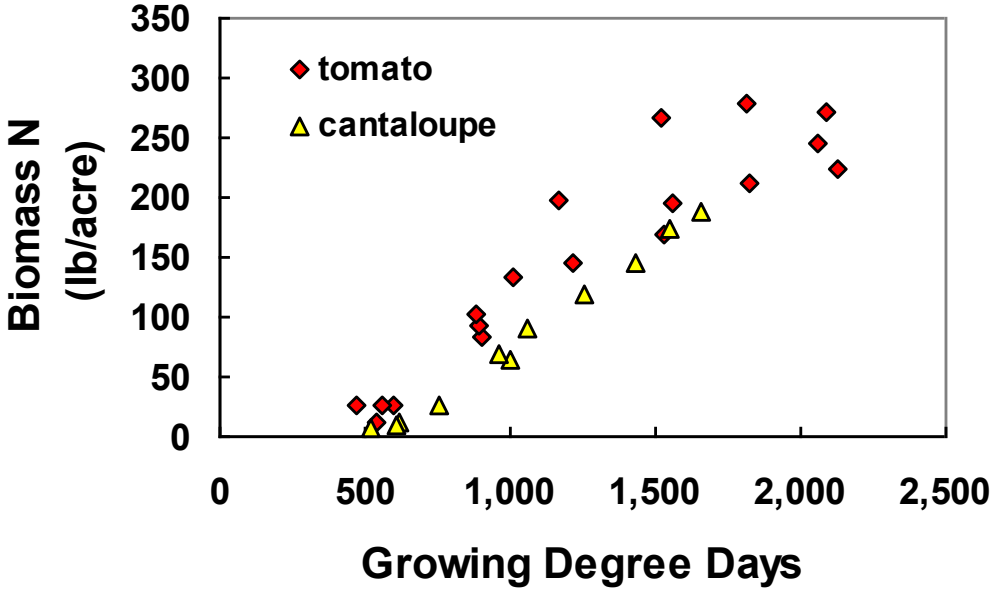


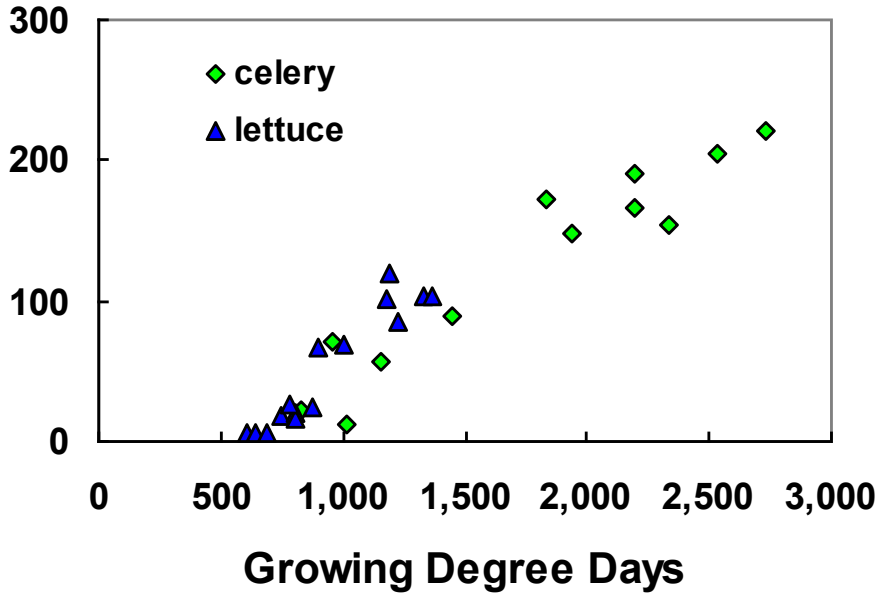
Averaged across fields :

	lb /acre		
	Total N applied	Commercial harvest weight	Total crop N uptake
Grower N	134	37,300	139
Reduced N	61	37,400	132

Only 10% of the extra N applied was taken up by the crop

Understand crop N uptake pattern, and supply N 'just in time' :



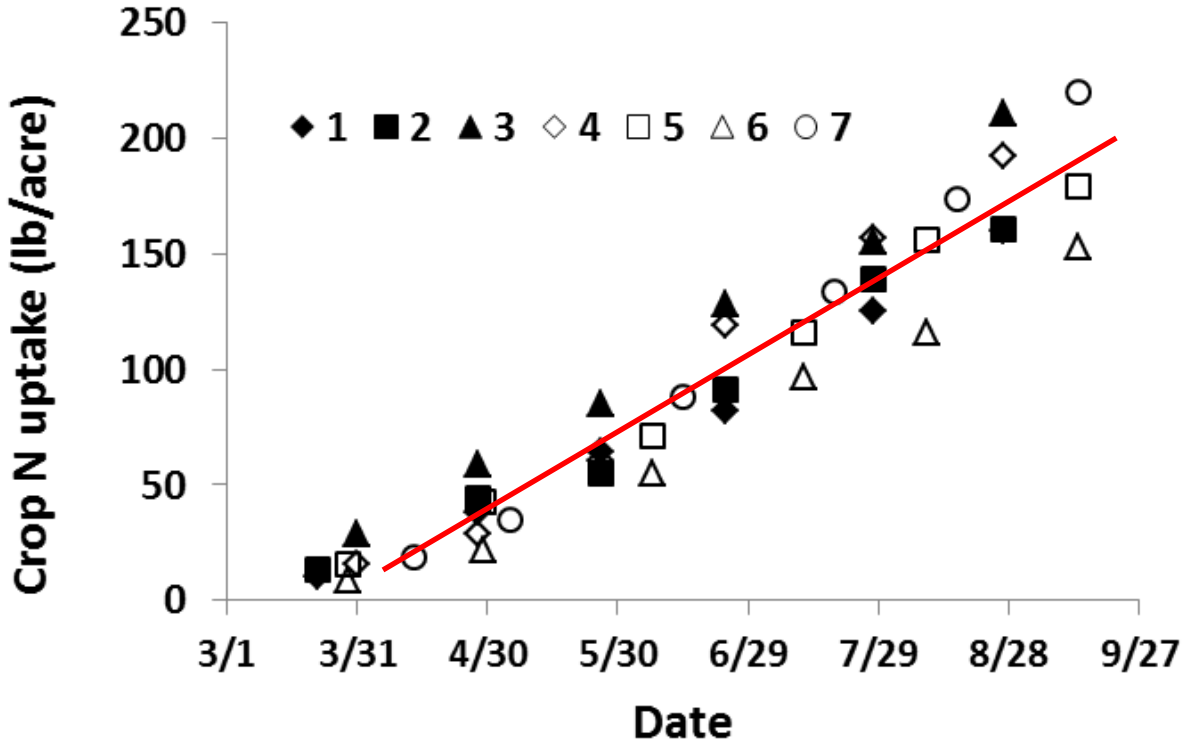


Most vegetable crops have a similar N uptake pattern :

- Slow early N uptake
- Peak uptake of 3 - 6 lb N/acre/day

Nutrient uptake by strawberry :





- N uptake averaged about 1 lb / acre / day from March through August

IFAS recommendations for drip fertigation reflect crop N uptake pattern :

Tomato

Production system	Nutrient	Total (lbs/A)	Preplant[y] (lbs/A)	Injected[x] (lbs/A/day) Weeks after transplanting[w] 1-2	3-4	5-11	11	13
Drip irrigation, raised beds, and polyethylene	N	200	0-70	1.5	2.0	2.5	2.0	1.5

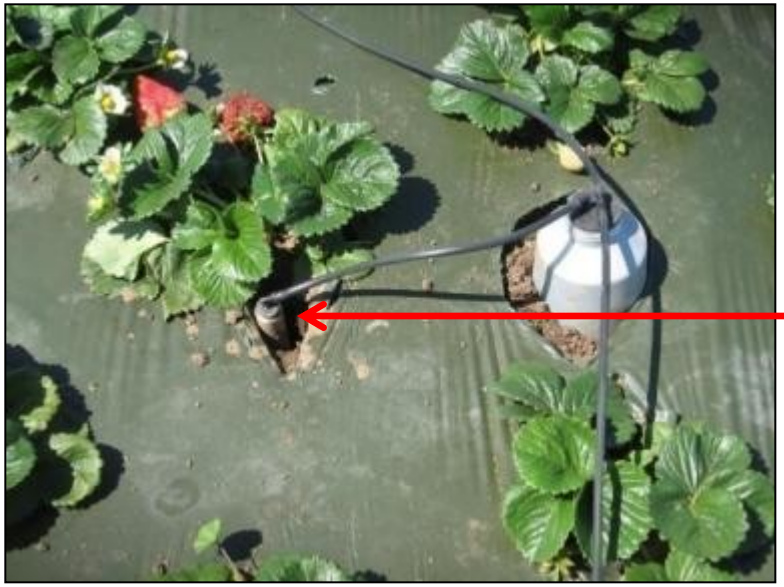
Strawberry

Production system	Nutrient	Total (lbs/A)	Preplant[y] (lbs/A)	Injected[x] (lbs/A/day) Growth period[w] First 2 weeks	Sept. to Jan.	Feb. and Mar.	April
Drip irrigation,	N	150	0-40	0.3	0.6	0.75	0.6

Control irrigation efficiently because …

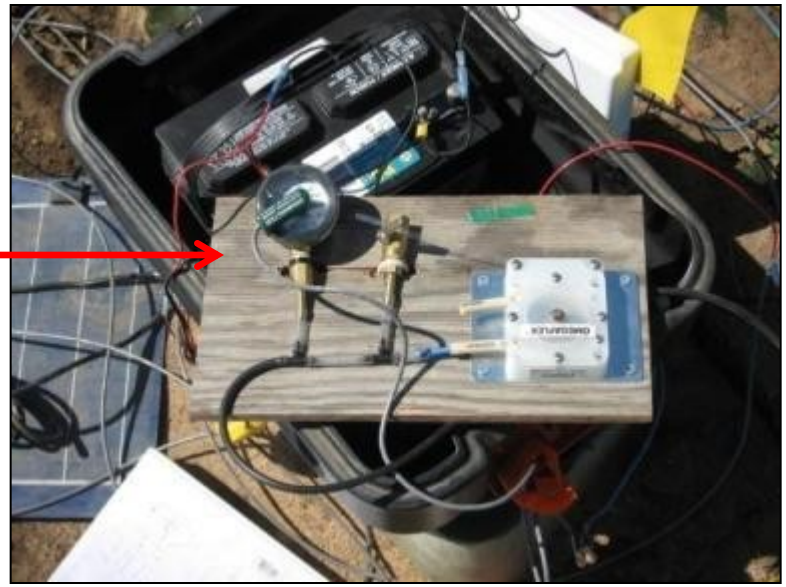
N leaching losses can be substantial

Measuring N leaching



Suction lysimeter

Controlled vacuum held throughout an irrigation cycle

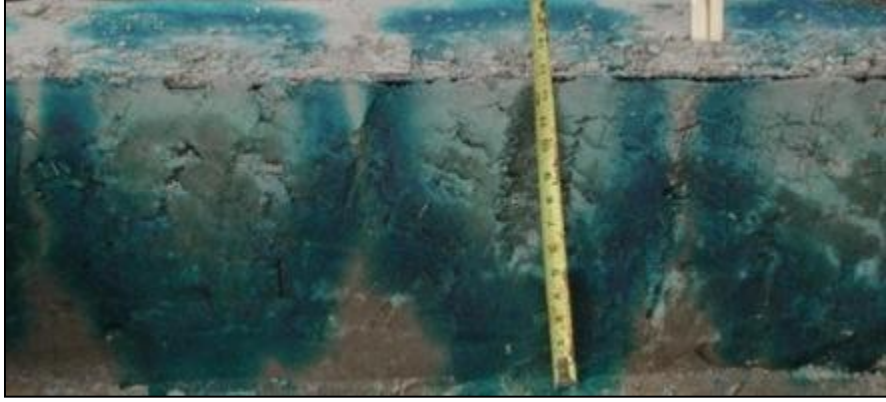


What is the typical NO_3-N concentration of water leaving fertilized root zones ?

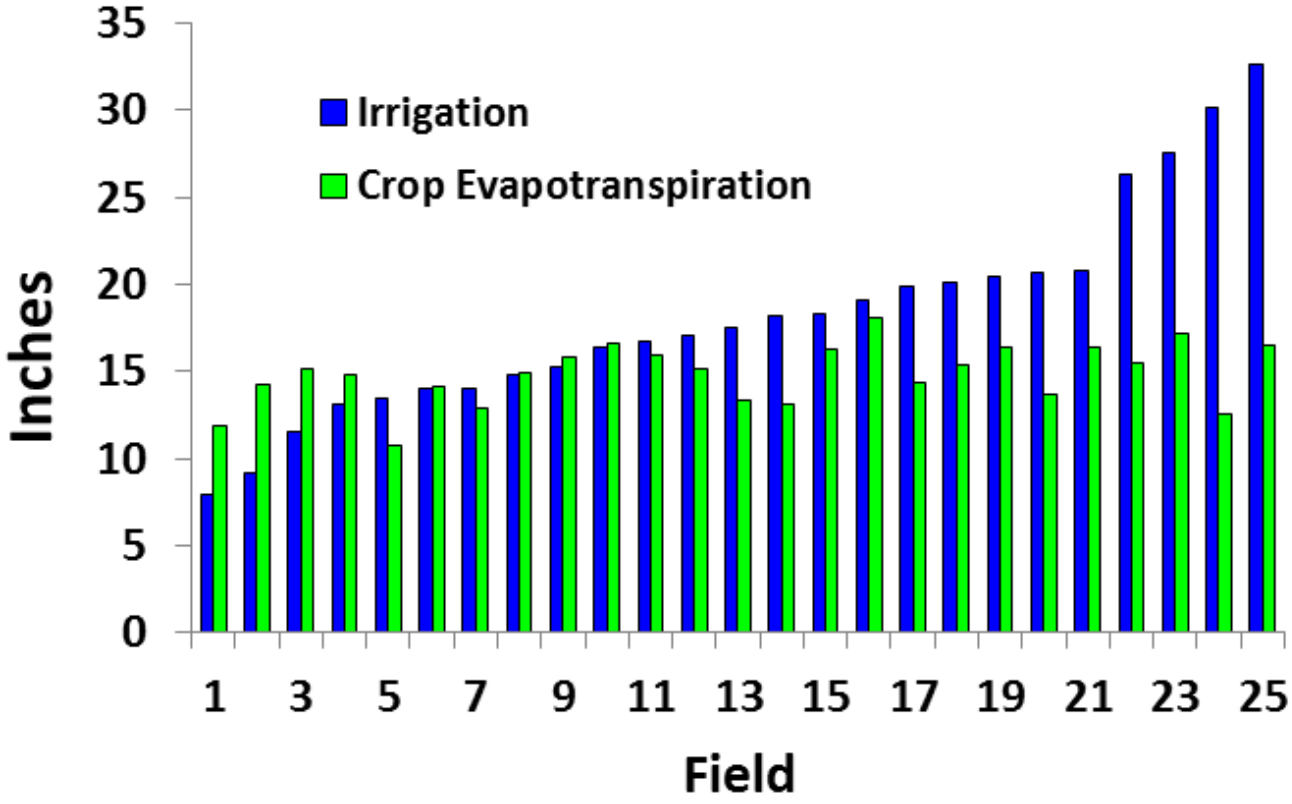
10 - 30 PPM NO_3-N common
= 2 - 7 lb N/acre · inch

40 - 120 PPM NO_3-N common
= 9 - 27 lb N / acre · inch

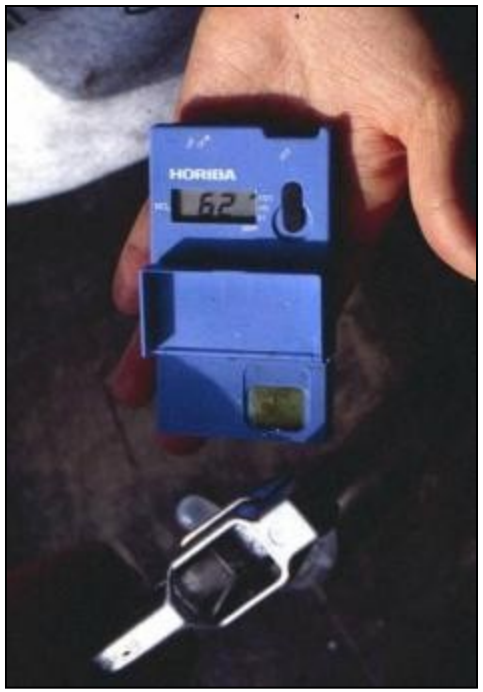
Irrigation efficiency varies :



Seasonal drip irrigation applied in 25 strawberry fields



Use monitoring tools appropriately



- **In-season soil NO_3-N testing is the most effective tool to prevent unnecessary fertilization in California vegetable production**

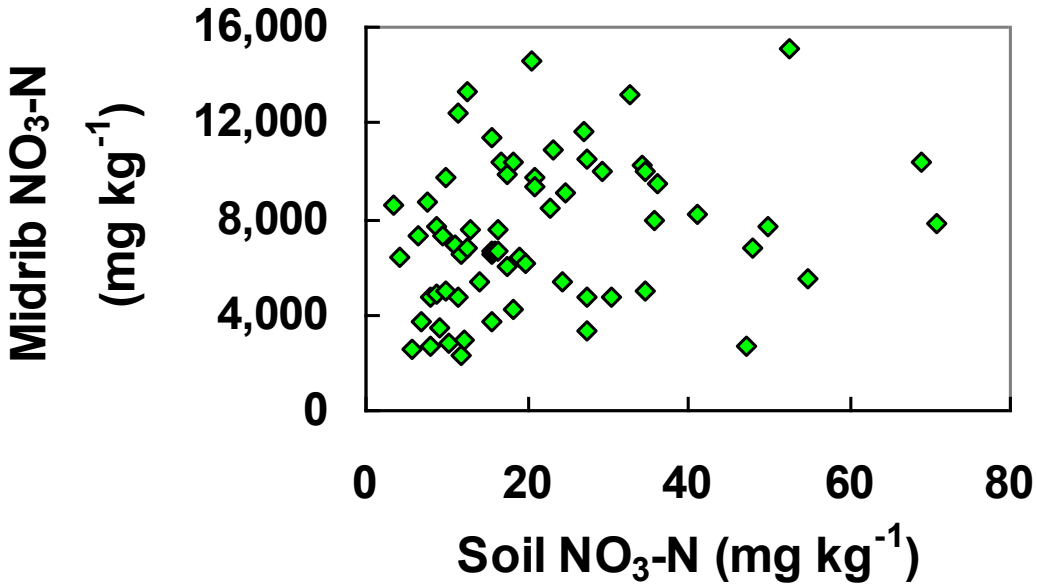
Does in-season soil NO_3-N testing have relevance in Florida ?

Which is more useful, monitoring petiole NO_3-N or leaf total N ?

- Leaf total N shows overall crop N status
- Petiole NO_3-N thought to reflect recent N uptake, or soil N availability

Petiole NO_3-N has serious flaws :

- not closely related to soil N availability

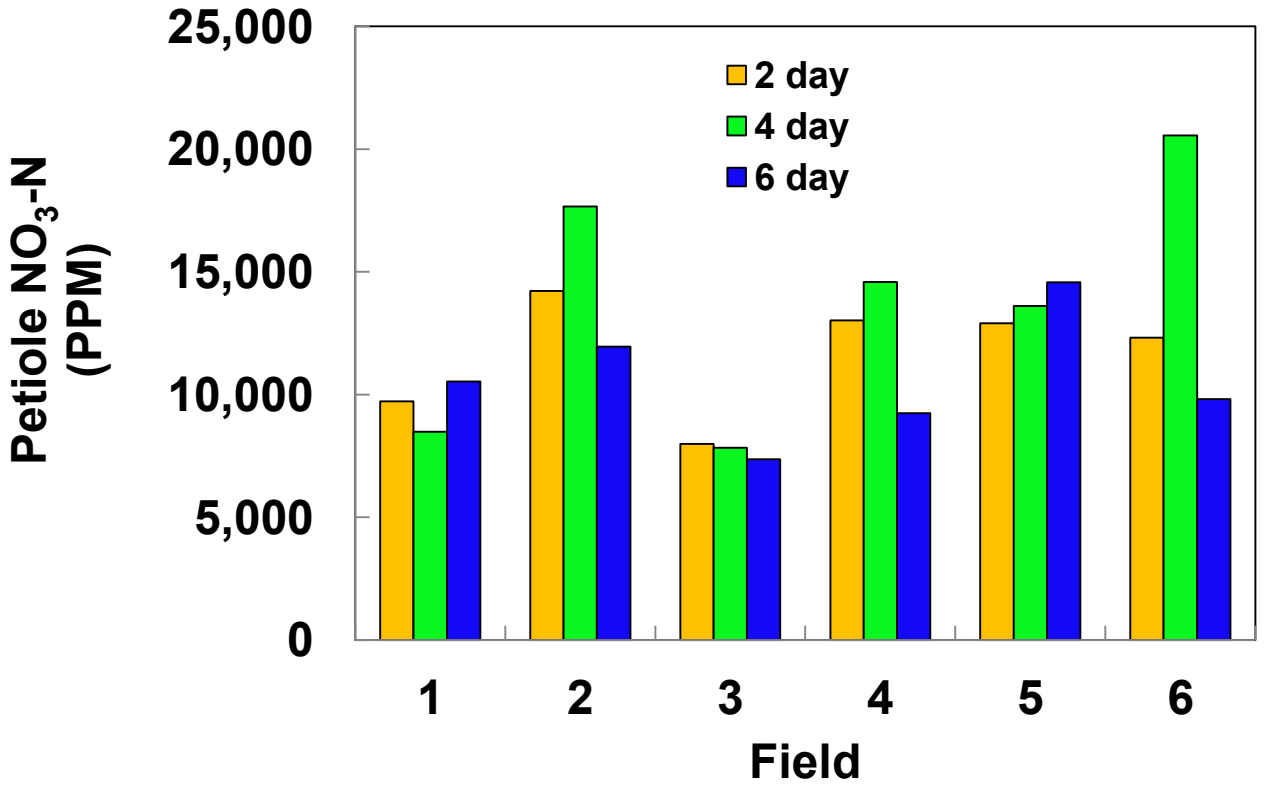


2004-05 survey of coastal lettuce fields, early heading stage

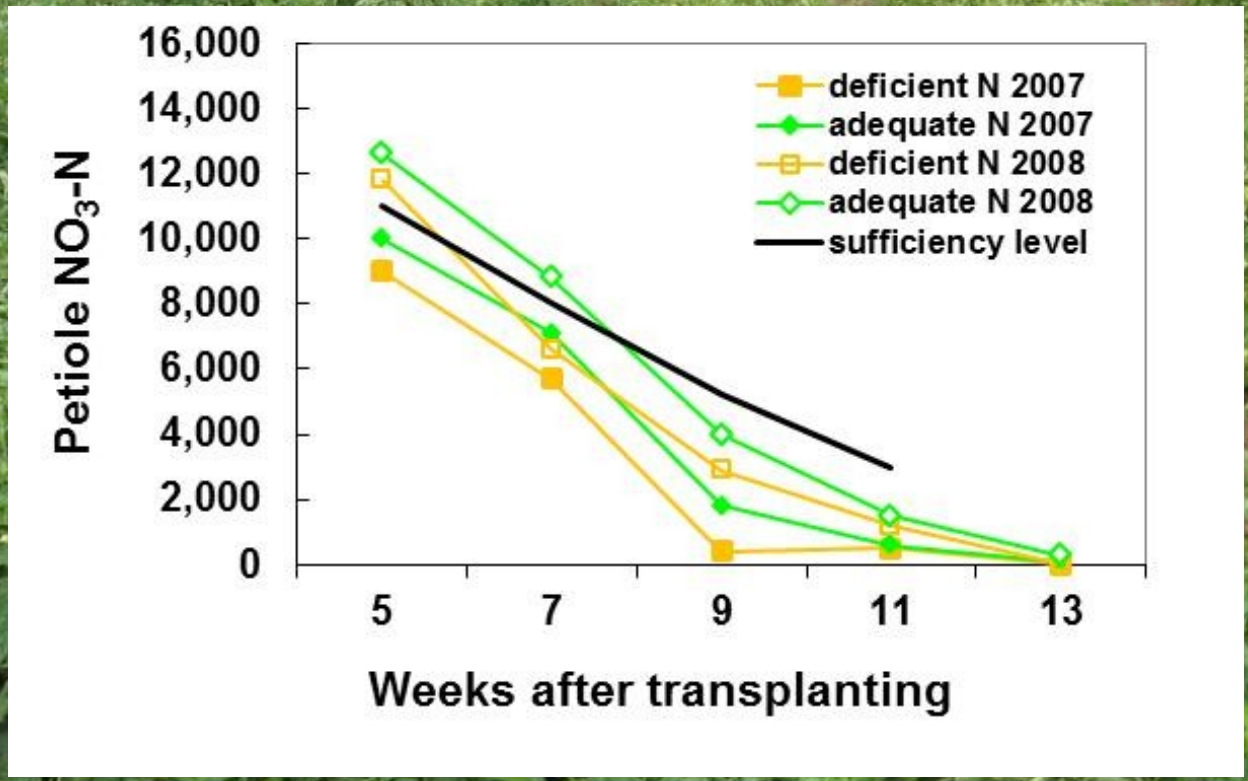
Petiole NO_3-N has serious flaws :

- strongly influenced by environmental factors

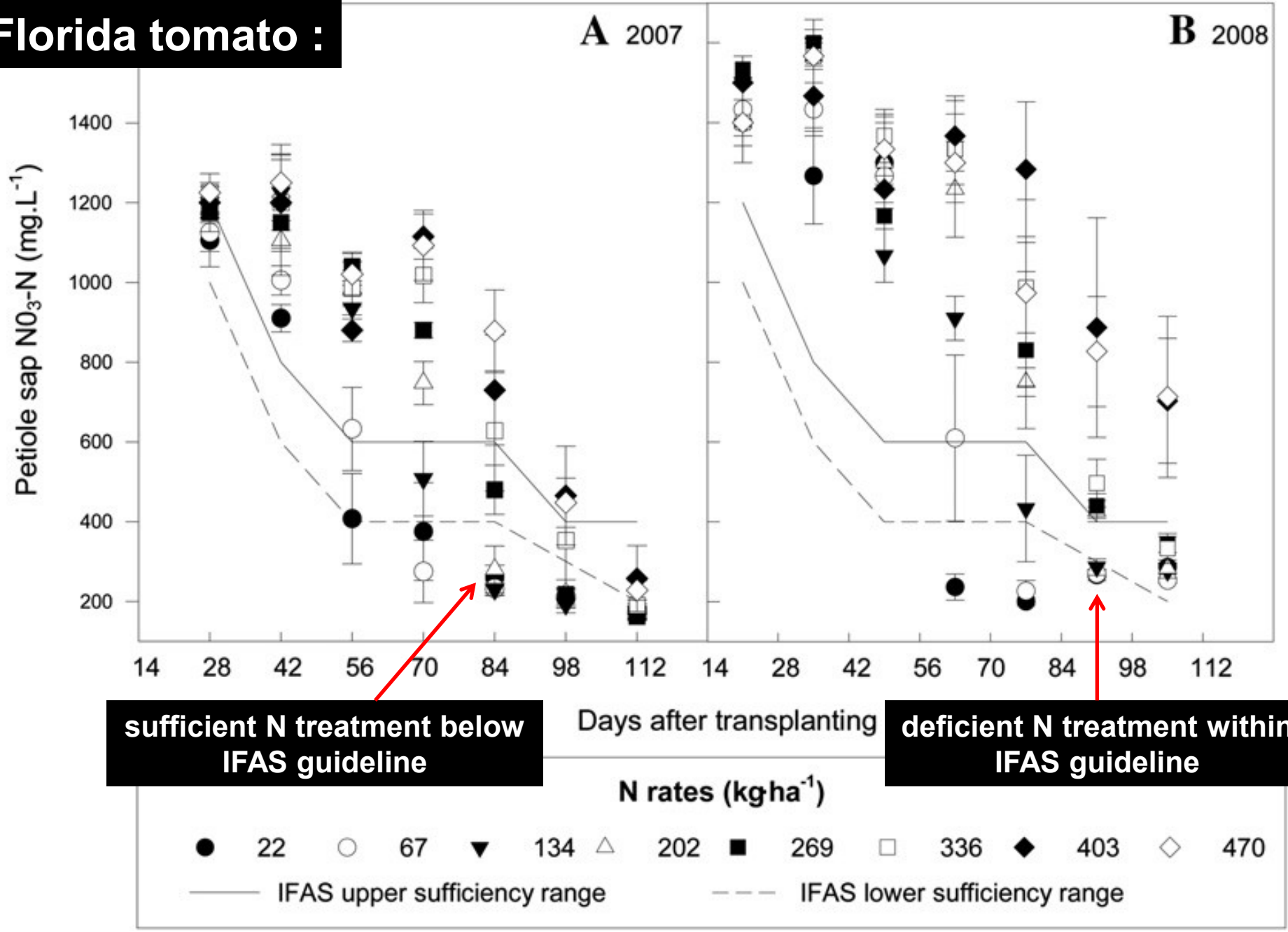
Six sprinkler-irrigated broccoli and cauliflower fields, sampled every 2 days over an irrigation cycle :



California processing tomato N fertigation trials



Florida tomato :



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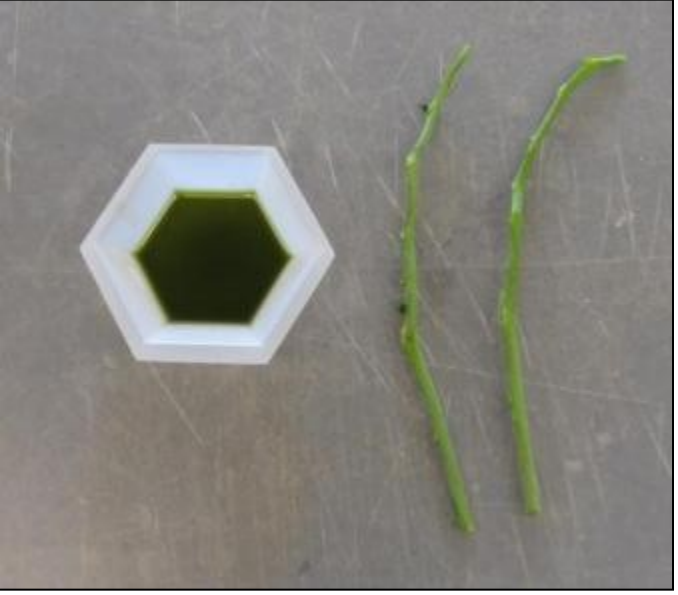

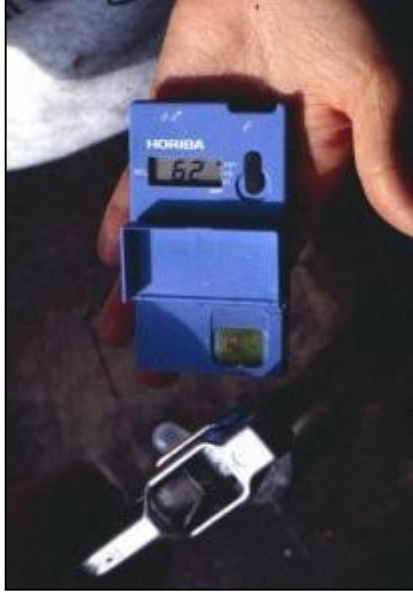

Bottom line on petiole testing :

- as an agronomic practice, maintaining high petiole NO_3-N can ensure crop nitrogen sufficiency
- as a BMP practice, maintaining high petiole NO_3-N will often lead to unnecessary N fertilization, which increases N pollution potential

Can water be treated to remove NO_3-N ?

- **Biological denitrification is promising**
  - **wetlands**
  - **denitrification bioreactors**

Wood chip bioreactors :

- 3 pilot-scale wood chip reactors are running in the Salinas Valley, treating tile drain effluent and surface runoff

- In coastal California conditions, annual denitrification potential is ≈ 3 lb N/yd^3 of bioreactor volume; in warmer Florida conditions the potential may be even greater

Can water quality and horticultural production coexist ?

It will not be easy, but progress toward improved water quality can be made while maintaining crop productivity