University of California

Nitrogen Management Training

for Certified Crop Advisers

Competency Area 3

Integration of N Cycling with Cultural Management

How to reduce leaching, increase efficiency and reduce costs

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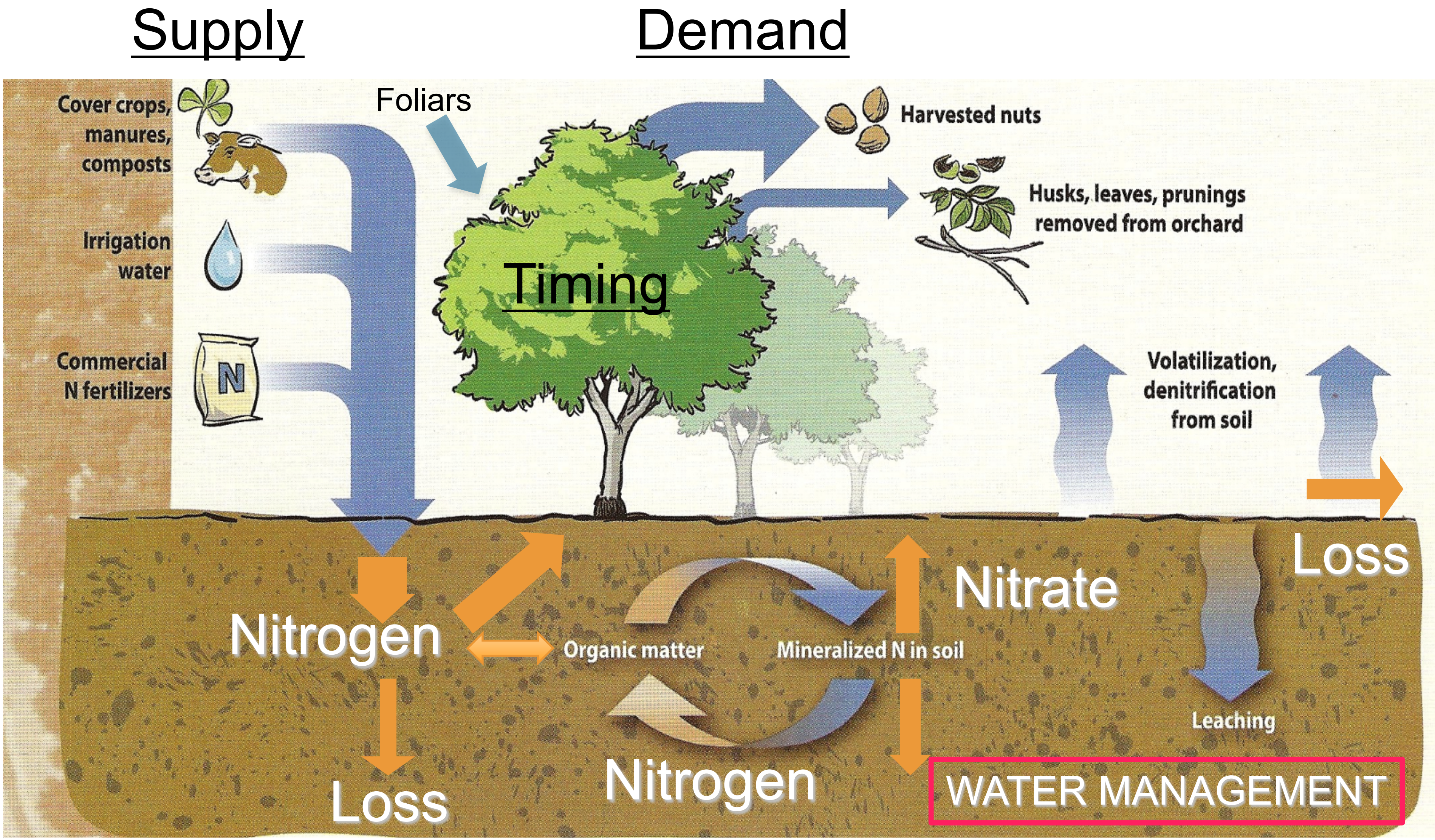
The Nitrogen Cycle: A balancing act.



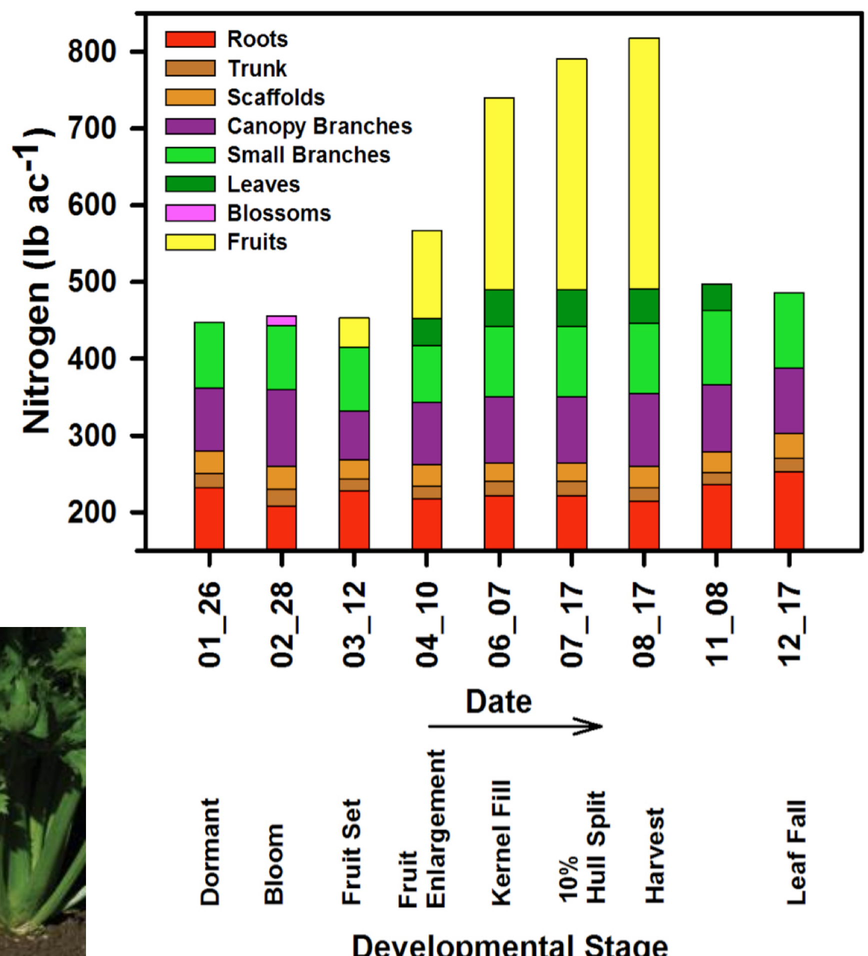
Kathy Kelley-Anderson et al: ANR Pub # 21623

Efficient Nitrogen Management:
The 4 R's (http://www.ipni.net/4r)

- Apply the Right Rate
  - Match supply with crop demand (all inputs- fertilizer, organic N, water, soil).
- Apply at the Right Time
  - Apply coincident with crop demand and root uptake.
- Apply In the Right Place
  - Ensure delivery to the active roots.
  - Minimize movement below root zone
- Use the Right Source

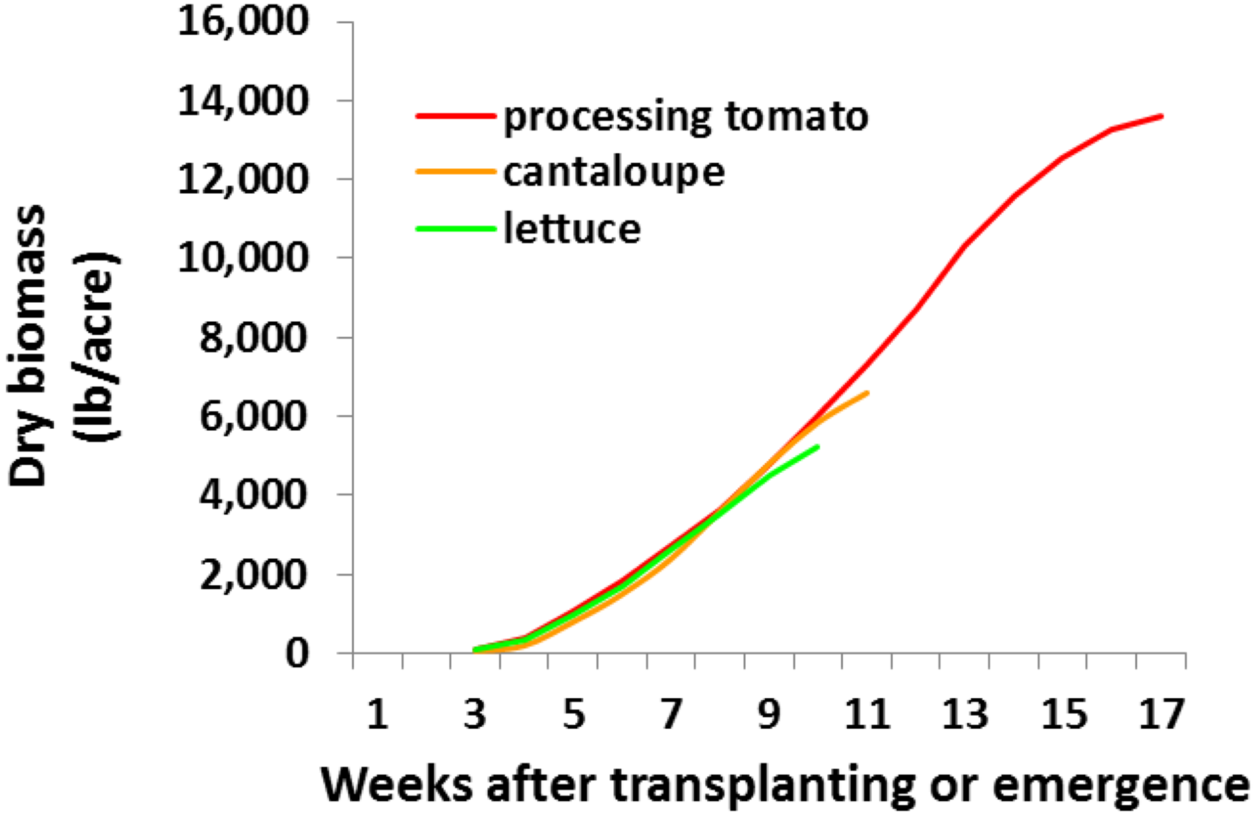
The 4 R's are specific to ever individual crop/field and every year.

Right Rate and Timing:
Plant Nutrient Demand



Muhammad, PhD Dissertation. 2013

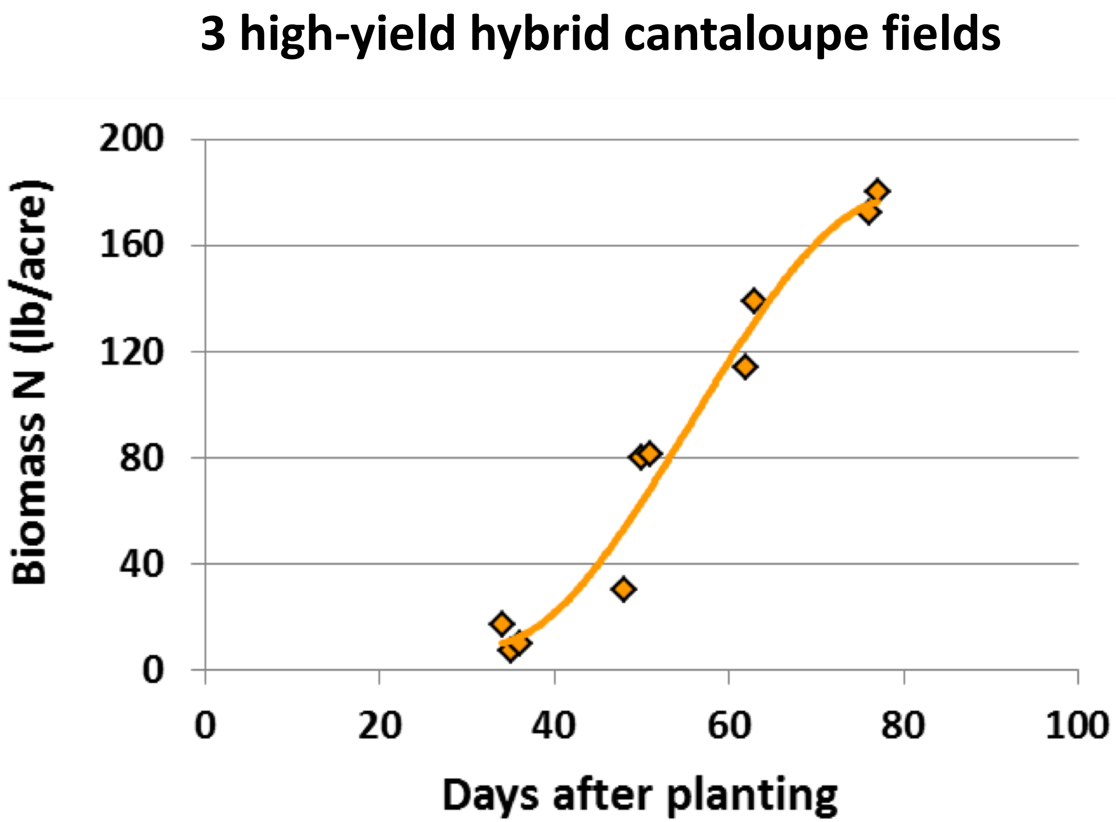
Annual vegetable crops show a characteristic growth pattern



Courtesy of Tim Hartz

N uptake follows the same pattern

- **N uptake by cantaloupe:**

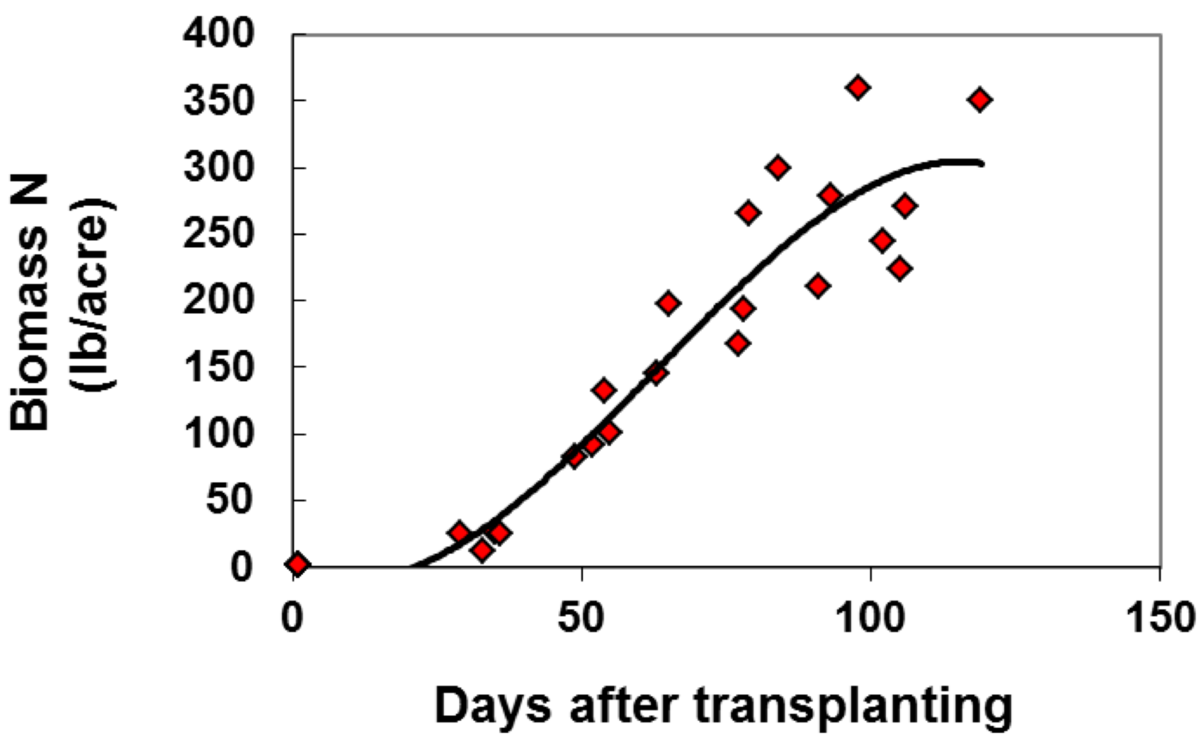


Courtesy of Tim Hartz

N uptake follows the same pattern

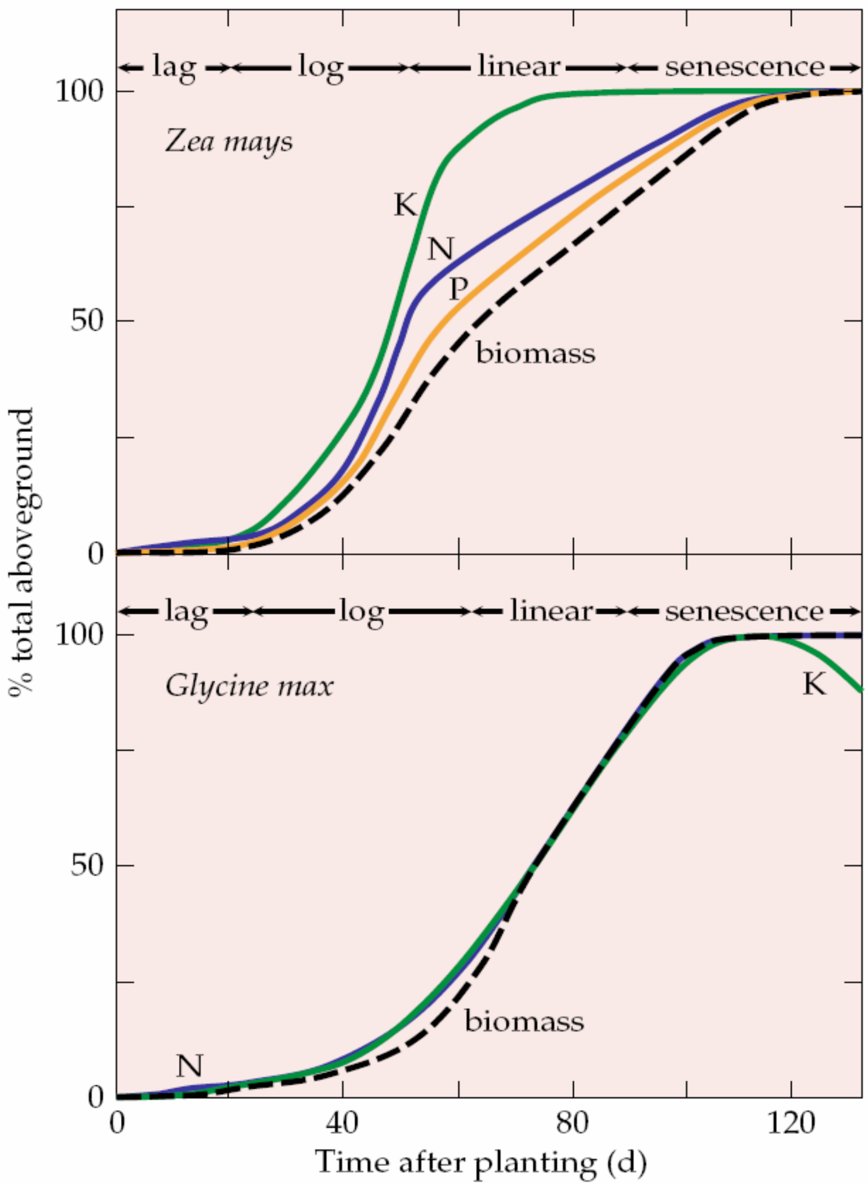
- **N uptake by processing tomato:**

Data from four high-yield fields



Courtesy of Tim Hartz

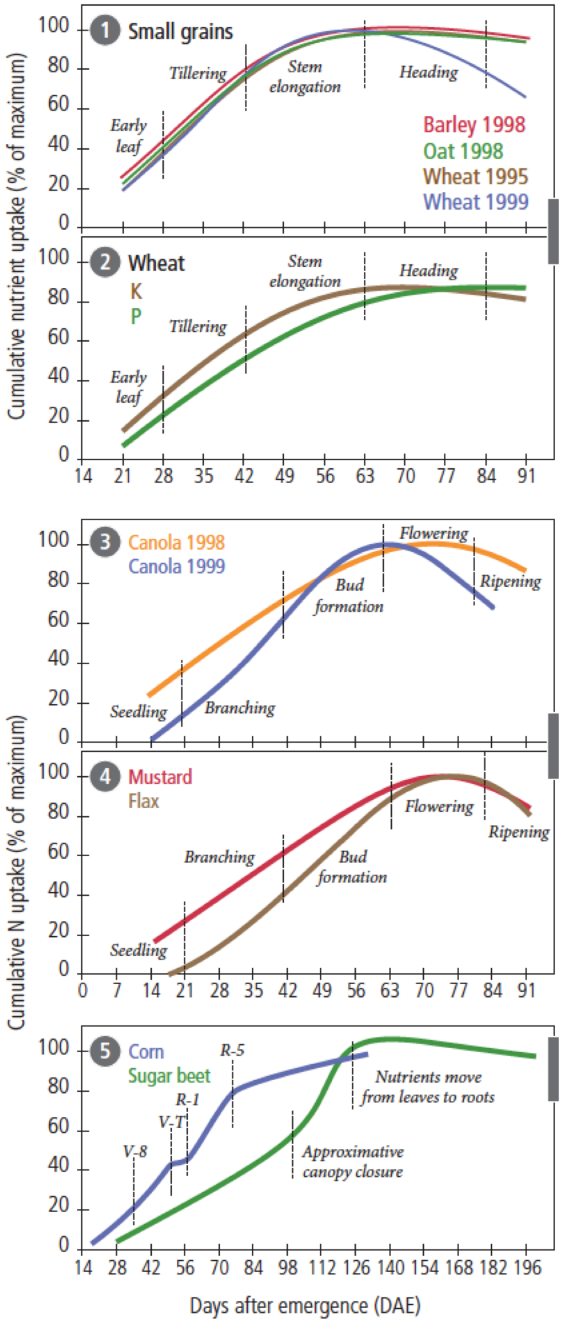
Right Timing: Plant Nutrient Demand



Demand for N is Largely Driven by Biomass accumulation

Nutrient demand per time is related to growth rate; fast growth requires a high rate of N uptake and assimilation

Fernandez et al., Foliar Fertilization, Scientific Principles and Field Practices, 2013



Cumulative nutrient uptake as a percent of maximum accumulation by dryland spring grains over time in Saskatchewan; ❶ wheat, oat, and barley N in 1998, and wheat N in 1999, ❷ wheat P and K in 1998.

Cumulative N uptake as a percent of maximum accumulation by ❸ canola in 1998 and 1999, ❹ mustard and flax in 1998 in Saskatchewan.

Cumulative N uptake as a percent of maximum accumulation by corn in Manitoba (V-8 = 8 leaf, V-T = tassel emergence, R-1 = silking, R-5 = dent) and sugar beet in France.

Knowledge of Nutrient Accumulation Patterns

Consideration of all Nitrogen Sources

- irrigation
- residual N
- manures

Realistic yield estimation and in-season adjustments for seasonal conditions.

Fernandez et al., Foliar Fertilization, Scientific Principles and Field Practices, 2013

Current N fertilization rates often exceed N demand:

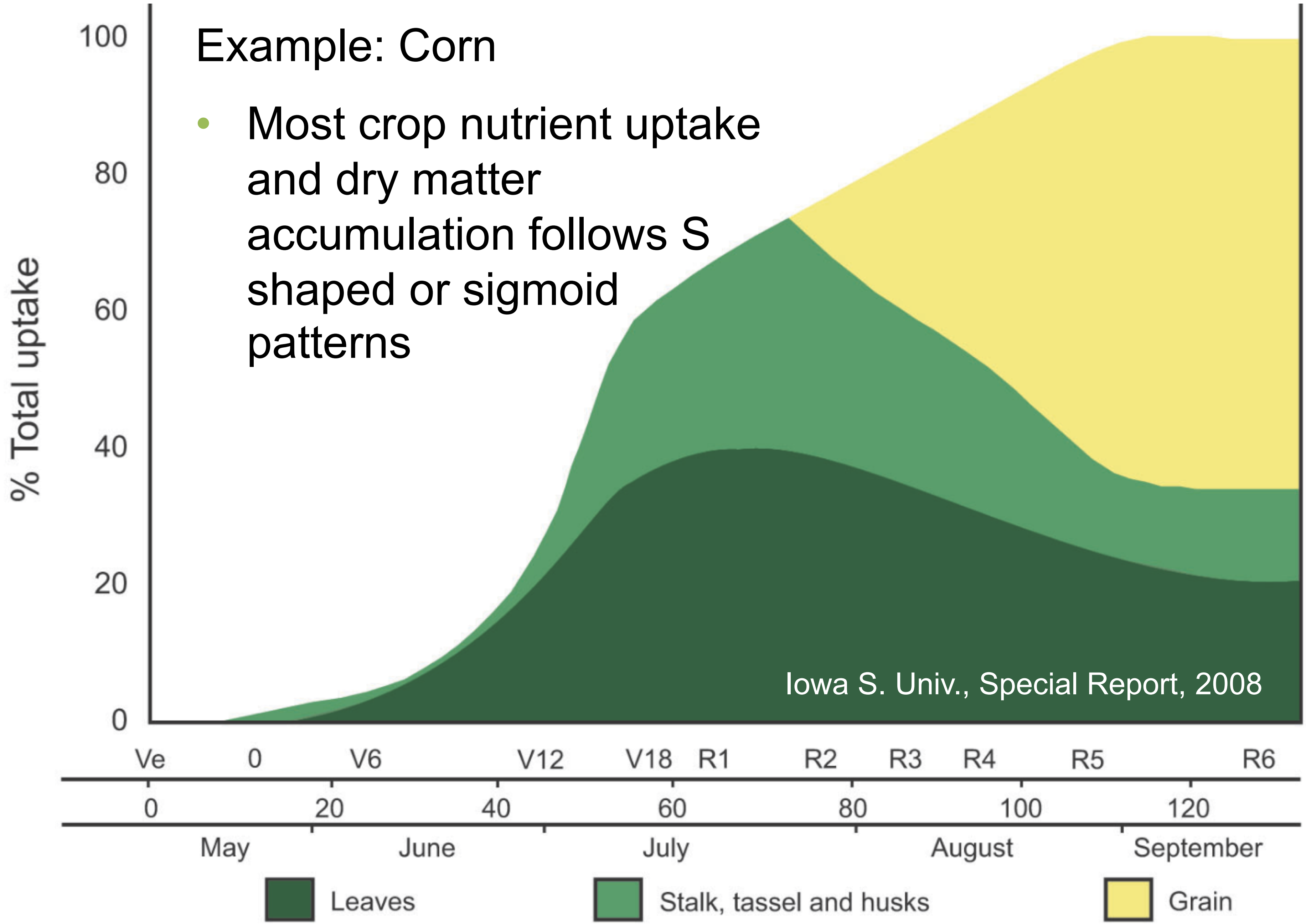
	Typical range (lb N / acre)		
	seasonal N application	Total crop N uptake	N removal in harvest
Lettuce	120-200	110-140	60-80
Broccoli	150-250	200-300	60-90
Celery	200-300	180-240	120-160
Spinach	120-180	80-110	60-80
Strawberry	160-260	180-200	70-100

Courtesy of Tim Hartz

Crop uptake dynamics and fertilizer timing

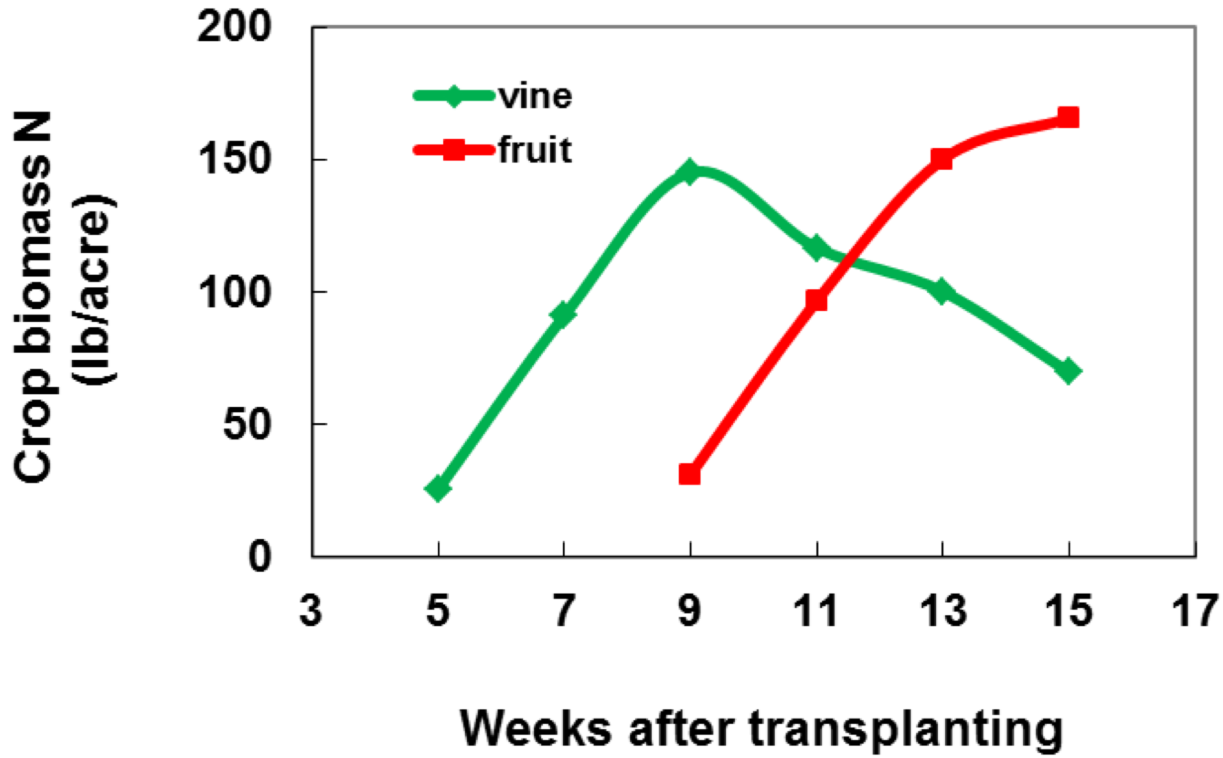
Example: Corn

- Most crop nutrient uptake and dry matter accumulation follows S shaped or sigmoid patterns



Fruiting crops have a characteristic pattern of N partitioning

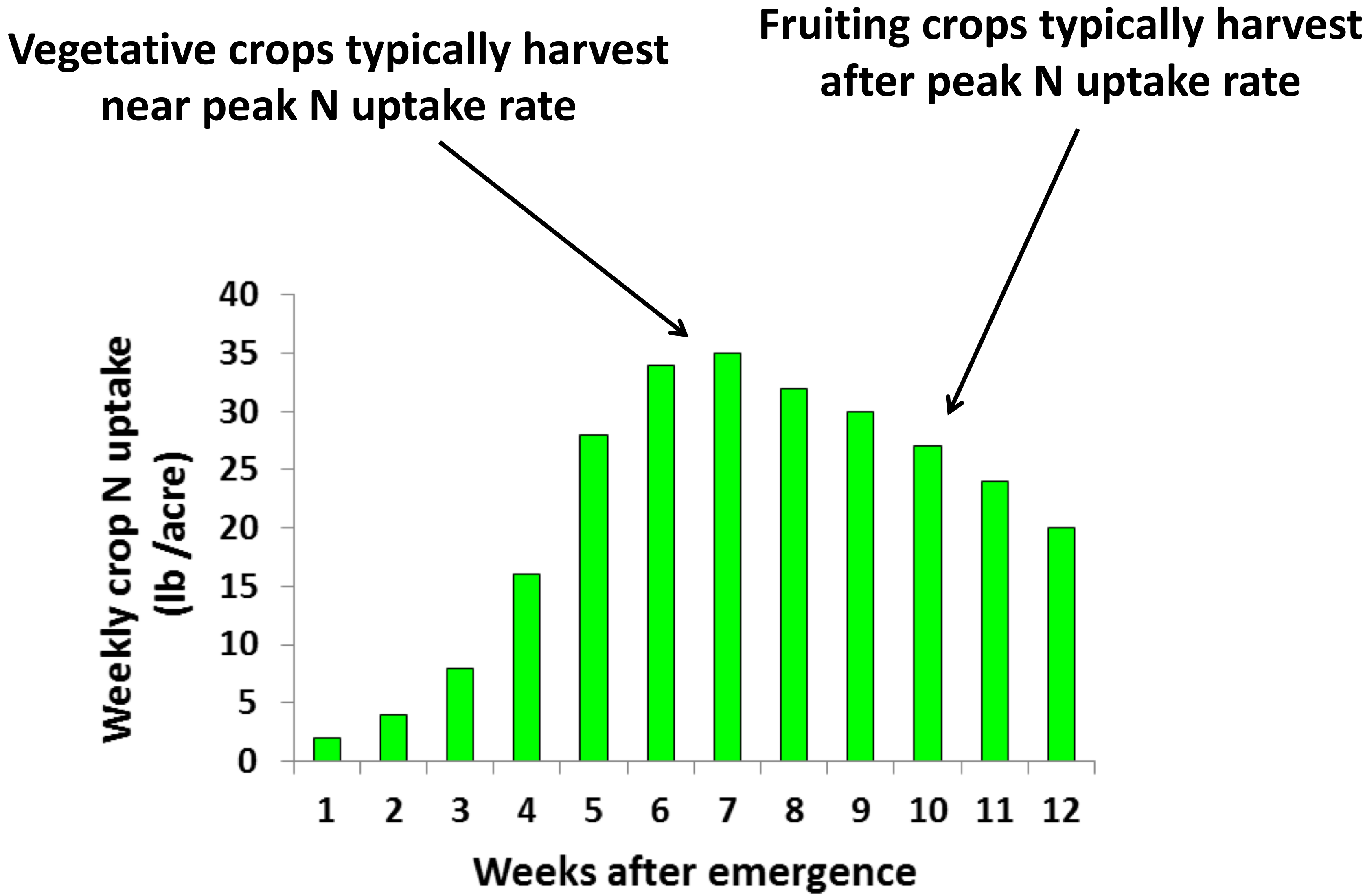
- **N partitioning by processing tomato:**



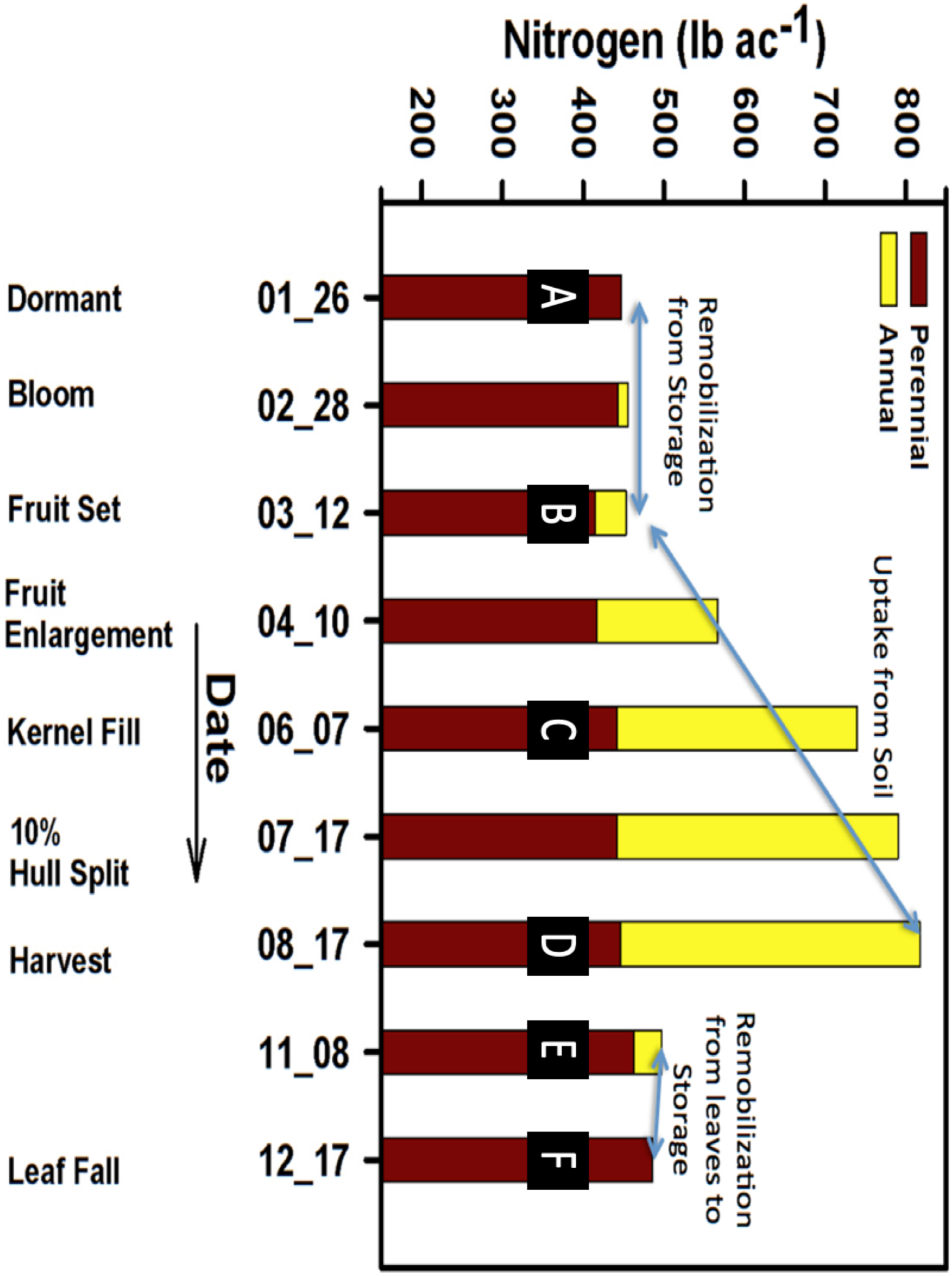
General rule:

- **Fruit typically represents 50-70% of total crop N uptake**

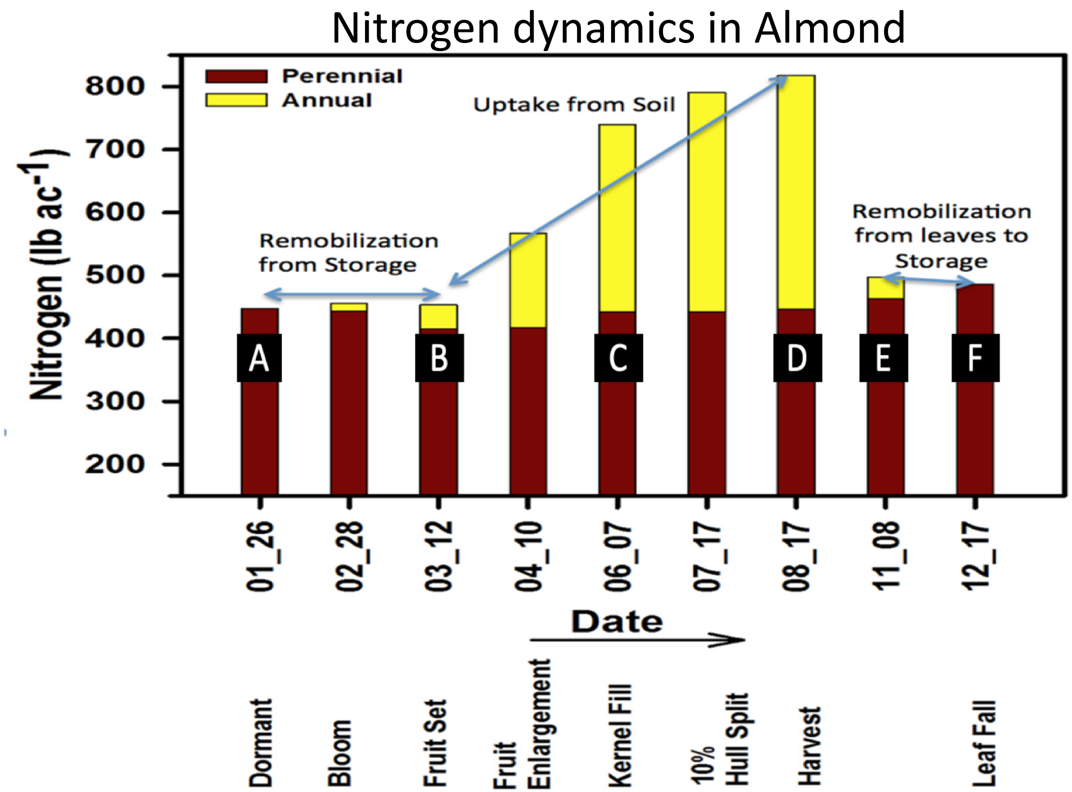
Courtesy of Tim Hartz



Courtesy of Tim Hartz



Nitrogen (lb ac-1)
200
300
400
500
600
700
800
Perennial
Annual
Dormant
01_26
A
Bloom
02_28
Fruit Set
03_12
B
Remobilization from Storage
Fruit Enlargement
04_10
Kernel Fill
06_07
C
10% Hull Split
07_17
Uptake from Soil
Harvest
08_17
D
11_08
E
Leaf Fall
12_17
F
Remobilization from leaves to Storage
Date



A to B: In the period from [A] dormancy through 70% leaf out [B], the tree depends entirely upon N that is remobilized from perennial organs (red bars) and essentially no N uptake occurs from the soil. In mature trees about 40 lbs. of stored N is available as storage N [B minus A]. The total N in the entire acre of trees in Jan [A] was 450 lbs. N acre. This N was accumulated over the prior 12 years of growth.

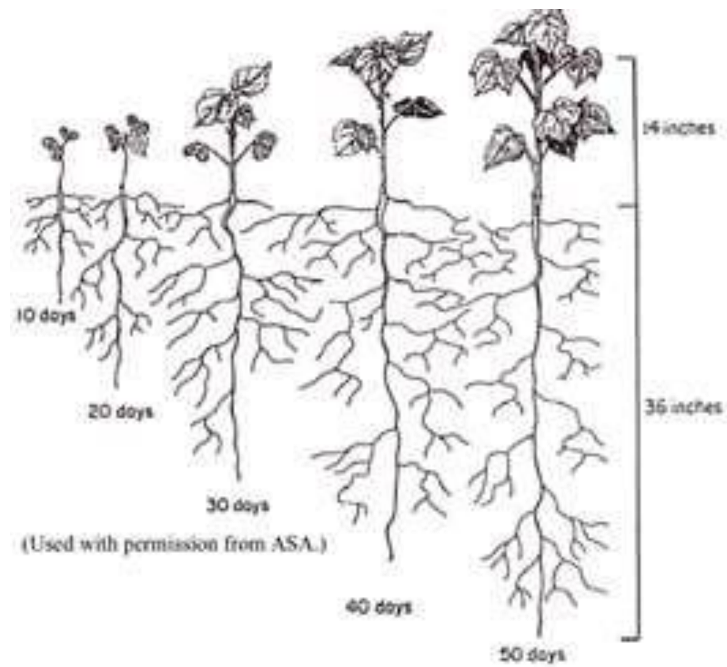
B to E: During the period from full leaf expansion until early post-harvest [E], tree N demand is satisfied entirely by soil N uptake with the vast majority of the N being utilized by fruit (yellow bars), illustrating the importance of yield estimation to determine N application.

C to E: Tree storage N (red bars) that will be used for the subsequent years' flowering and early fruit set [A to B] begins to accumulate once kernel fill is complete [C]. From kernel fill [C] until just prior to early leaf senescence [E] N is taken from the soil, once leaf senescence commences [E] N from leaves is used to fill the tree N storage [E to F] and soil uptake ceases.

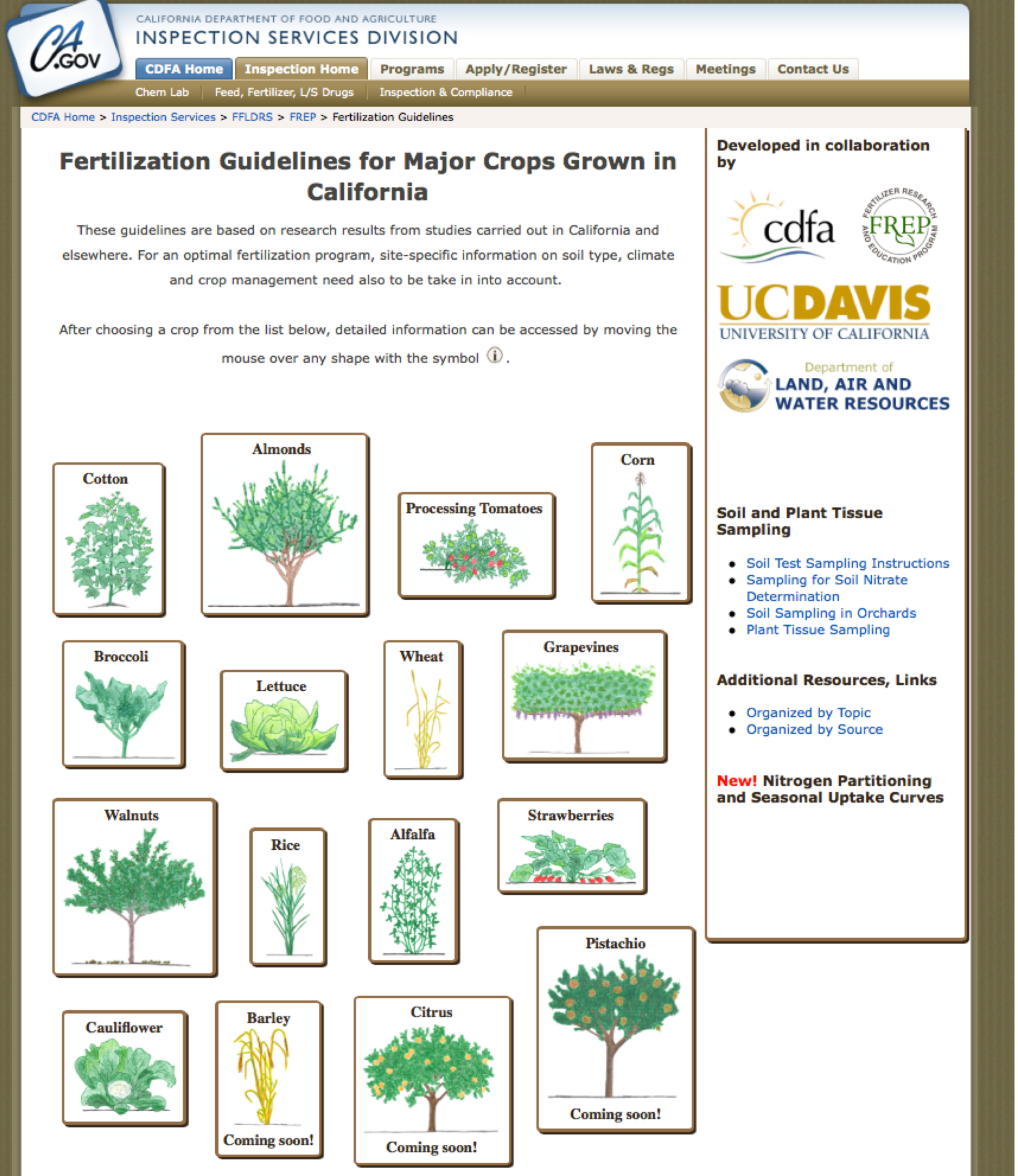
A to F: The total increment in tree N content in permanent tissues (trunk, branches, roots) is about 40 lbs. of N [F minus A].

What about nitrogen content of roots ?

- **Root growth somewhat front-loaded, but generally comprises no more than**
  10 % of total plant N uptake



Courtesy of Tim Hartz



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CDFA Home > Inspection Services > FFLDRS > FREP > Fertilization Guidelines

Fertilization Guidelines for Major Crops Grown in California

These guidelines are based on research results from studies carried out in California and elsewhere. For an optimal fertilization program, site-specific information on soil type, climate and crop management need also to be take in into account.

After choosing a crop from the list below, detailed information can be accessed by moving the mouse over any shape with the symbol ⓘ.

Developed in collaboration by

cdfa | FREP FERTILIZER RESEARCH AND EDUCATION PROGRAM | UCDAVIS UNIVERSITY OF CALIFORNIA | Department of LAND, AIR AND WATER RESOURCES

Soil and Plant Tissue Sampling

- Soil Test Sampling Instructions
- Sampling for Soil Nitrate Determination
- Soil Sampling in Orchards
- Plant Tissue Sampling

Additional Resources, Links

- Organized by Topic
- Organized by Source

New! Nitrogen Partitioning and Seasonal Uptake Curves

Google: CDFA FREP CROPS

http://apps.cdfa.ca.gov/frep/docs/Guidelines.html

Right Rate: Nitrogen in the Soil

- Specially important for annual crops.
- Soil Nitrate Testing at planting/pre-side dress is a valuable tool.
- The specifics of this is discussed in other modules in this series.

Factors Controlling Rates of Decomposition and Mineralization

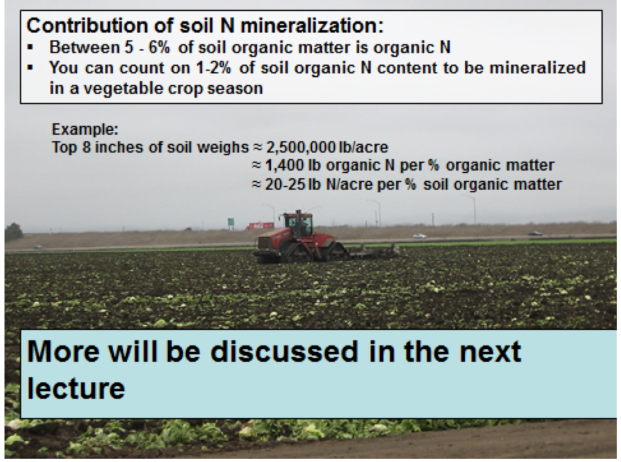
Table 11.2
TYPICAL CARBON AND NITROGEN CONTENTS AND C/N RATIOS OF SOME ORGANIC MATERIALS

Organic material	% C	% N	C/N
Spruce sawdust	50	0.05	600
Newspaper	39	0.3	120
Wheat straw	38	0.5	80
Corn stover	40	0.7	57
Maple leaf litter	48	1.4	34
Rotted barnyard manure	41	2.1	20
Bluegrass from fertilized lawn	42	2.2	20
Broccoli residues	35	1.9	18
Young alfalfa hay	40	3.0	13
Hairy vetch cover crop	40	3.5	11
Digested municipal sewage sludge	31	4.5	7
Soil microorganisms			
Bacteria	50	10.0	5
Fungi	50	5.0	10
Soil organic matter			
Average forest O horizons	50	1.3	45
Average forest A horizons	50	2.8	20
Mollisol Ap horizon	56	4.9	11
Average B horizon	46	5.1	9

As a rule of thumb:

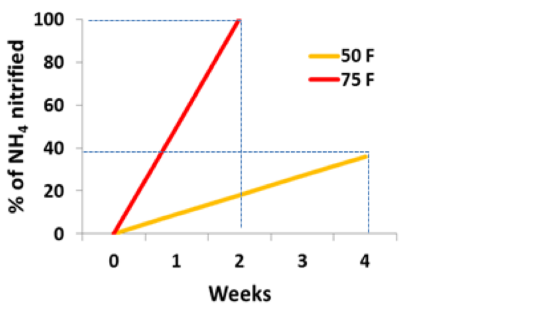
- A C:N ratio of 20:1 is the dividing line between immobilization and mineralization
- Generally, N mineralization occurs with residue N >2% under aerobic conditions
- Anaerobic = no mineralization

Elements of the Nature and Properties of Soils, 3/e by N. Brady and R. Weil



How quickly does nitrification occur?

- Nitrification rate governed mostly by temperature



Source: Adapted from Western Fertilizer Handbook

Right Rate is Field Specific:

Twenty neighboring Almond Orchards

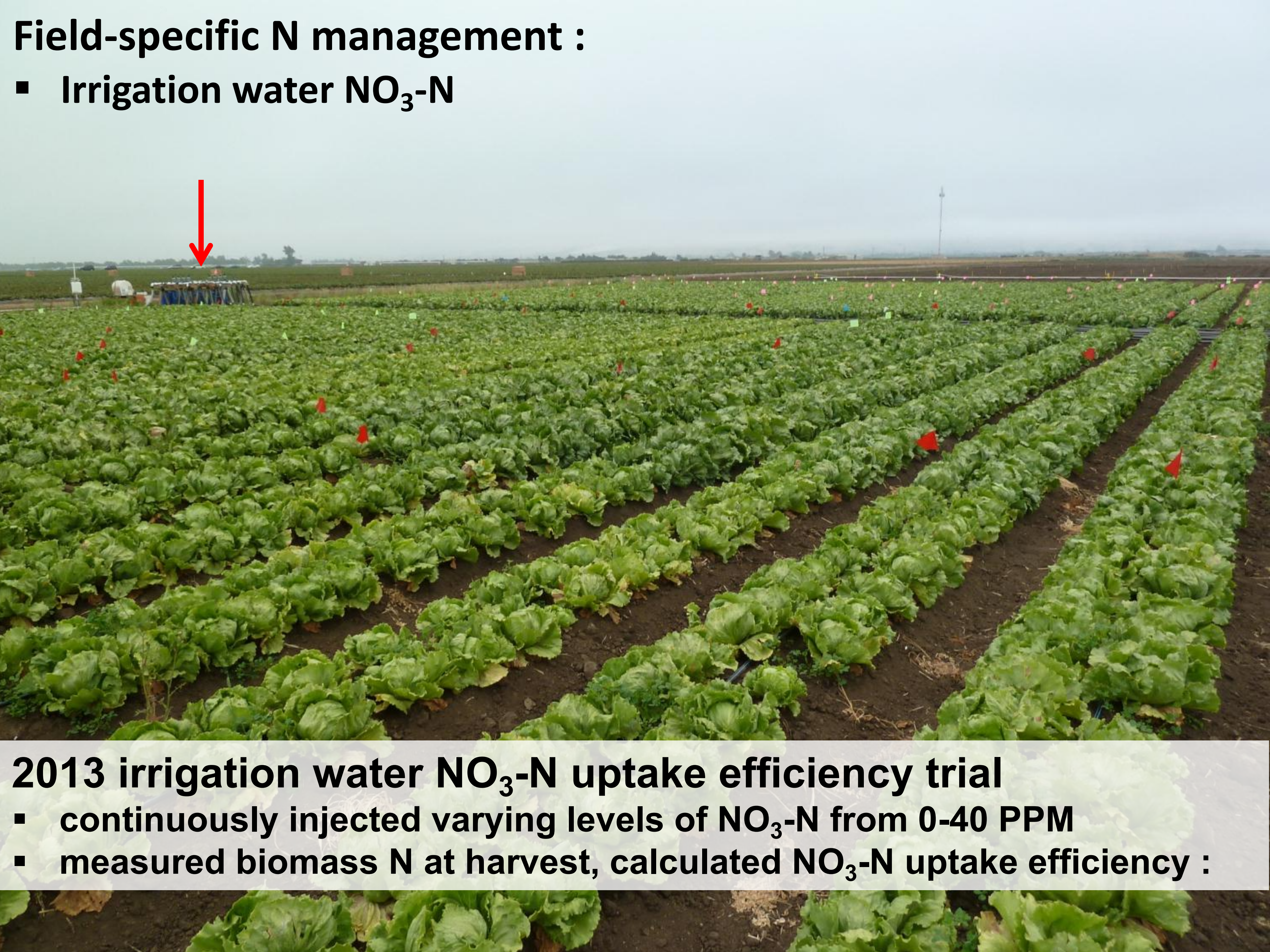
Yield varies dramatically and hence N demand varies dramatically.

Nitrogen in Irrigation Water: Free Fertilizer!

- Formula for Nitrate: Nitrate concentration (ppm) x inches crop irrigation applied x 0.052
- Formula for Nitrate-N: Nitrate-N concentration (ppm) x inches crop irrigation applied x 0.23

Field-specific N management :

- Irrigation water NO_3-N

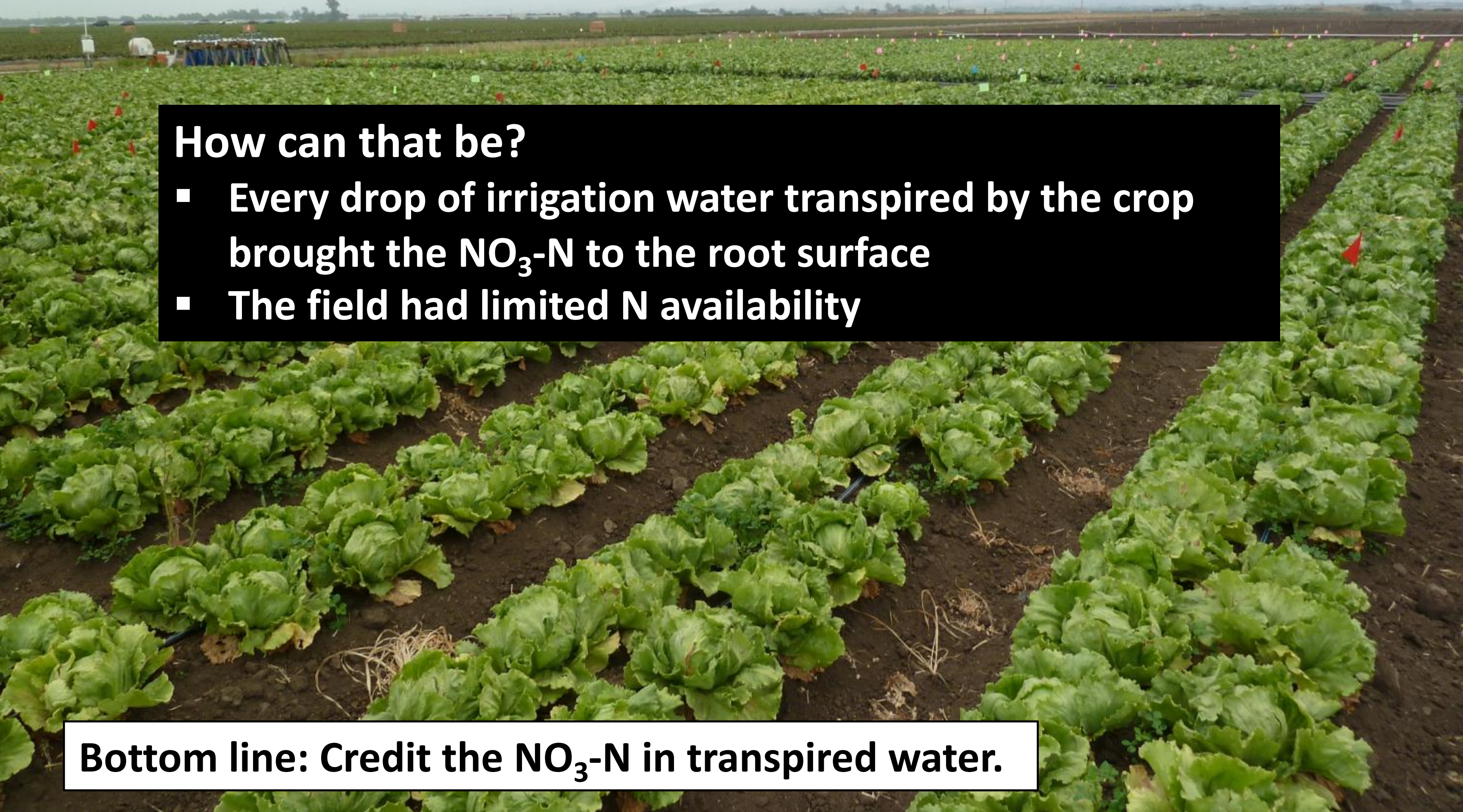


2013 irrigation water NO_3-N uptake efficiency trial

- continuously injected varying levels of NO_3-N from 0-40 PPM
- measured biomass N at harvest, calculated NO_3-N uptake efficiency :

Results:

- calculated on the basis of crop evapotranspiration (ET_c), plant uptake of irrigation water NO_3-N was nearly 100%



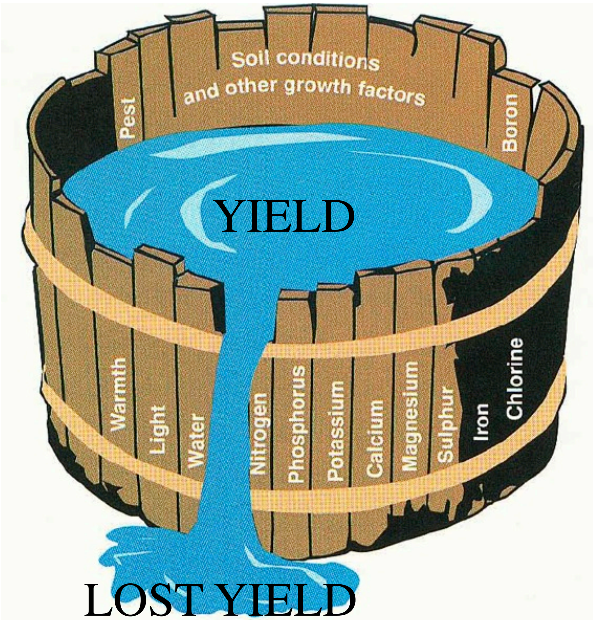
How can that be?

- Every drop of irrigation water transpired by the crop brought the NO_3-N to the root surface
- The field had limited N availability

Bottom line: Credit the NO_3-N in transpired water.

Right Source: Nutrient Balance

The efficiency of nitrogen will always depend upon the adequacy of all other essential elements and growth conditions.

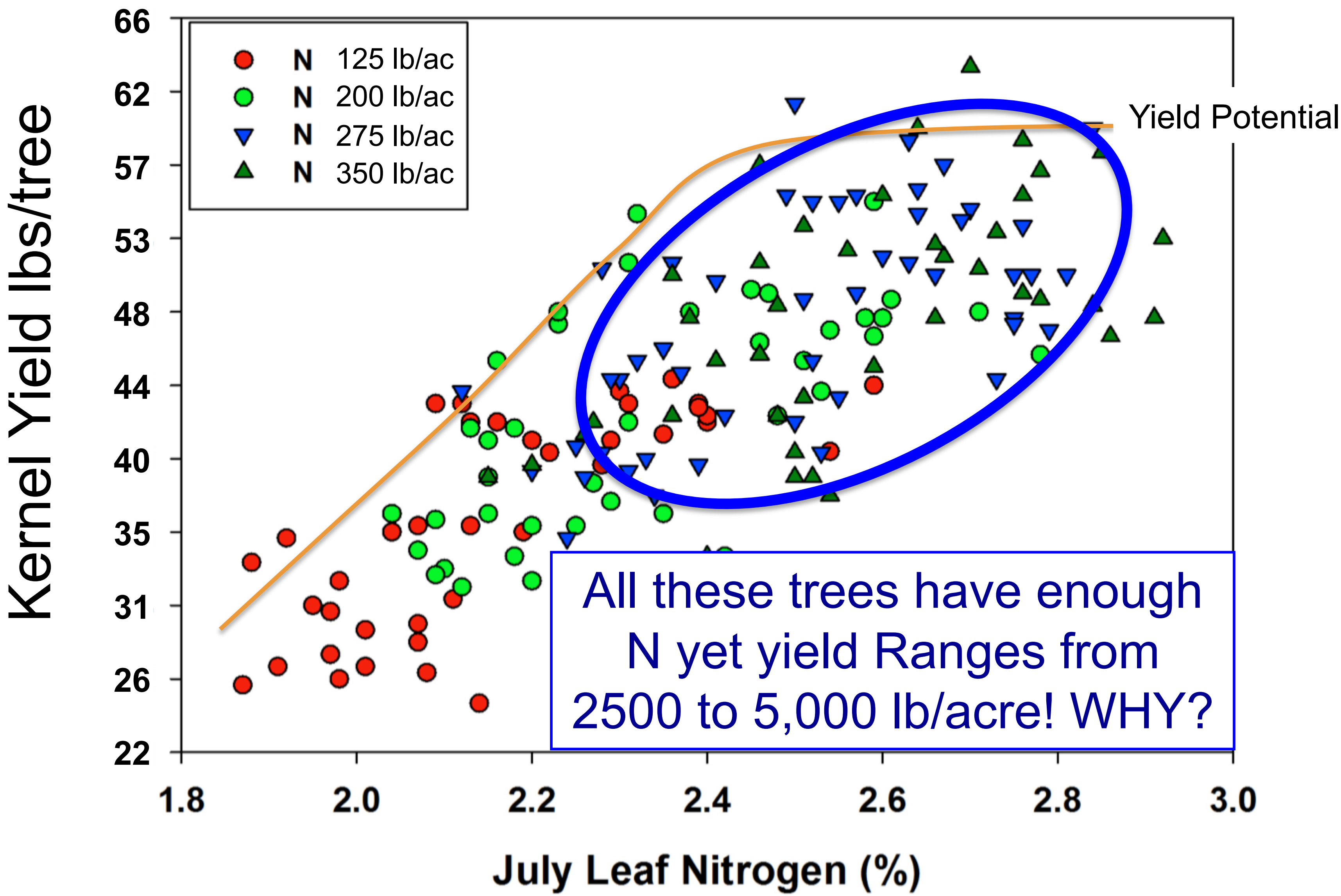


THE LAW OF MINUMUM Justus Von Leibig, 1863

If any nutrient is inadequate - Yield is lost AND a response to other elements cannot occur.

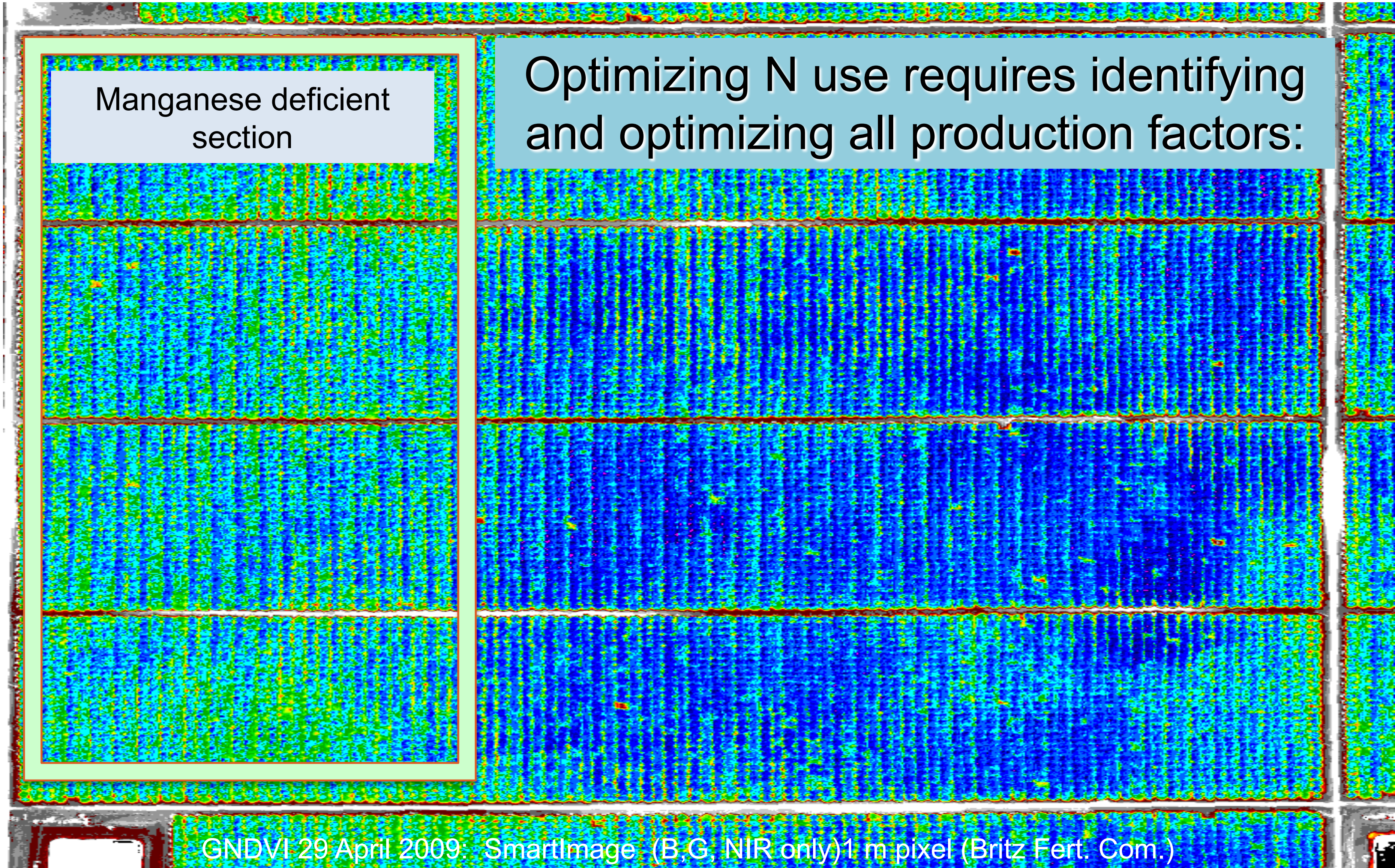
If any nutrient is oversupplied - Money is wasted

Nitrogen Management Alone is Not Enough



Right Source: N Management Alone is Not Enough

Manganese deficiency can limit crop response to N:



Right Place: Where Does N Uptake Occur?

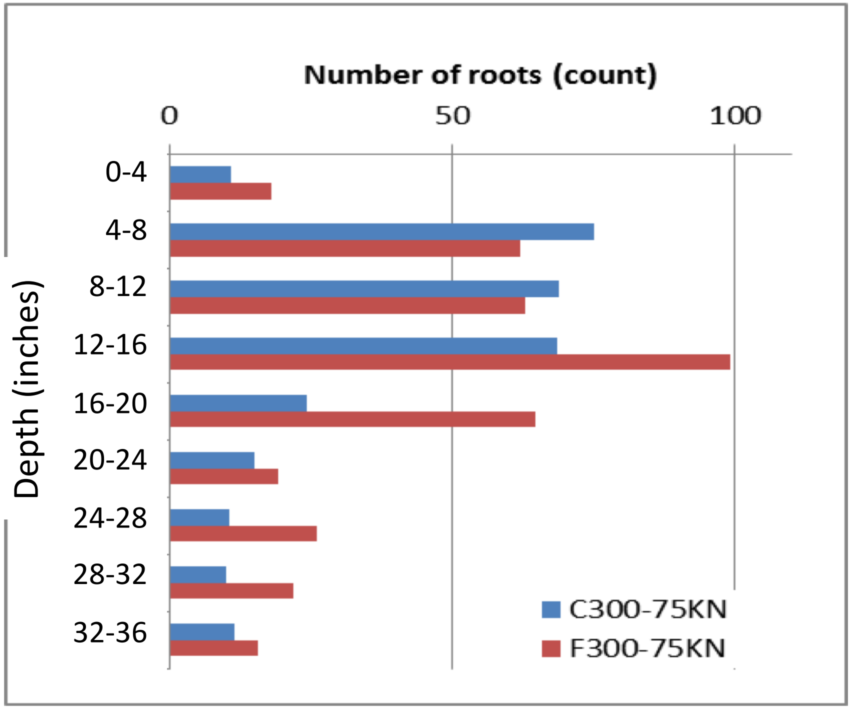
Soil and irrigation practices will influence this greatly:

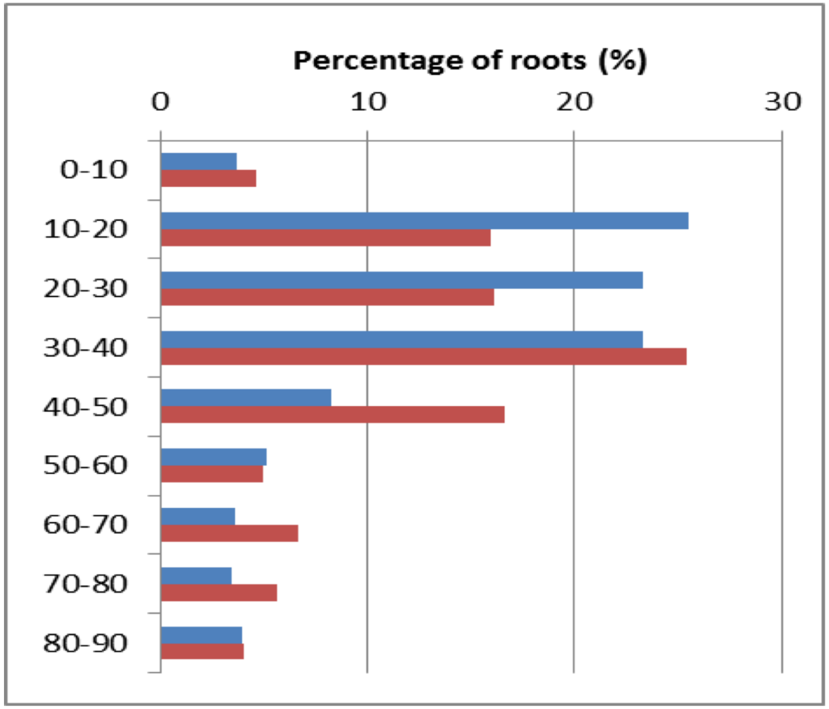
Specie	Depth of Main Root Zone (inches)	Reference
Almond	8-23	Dziljanov and Penkov 1964b
Apricot	8-16	Ghena and Tercel 1962
Cherry	4-16	Tamasi 1975
Peach	0-32	Dziljanov and Penkov 1964b
Plum	10-24	Tamasi 1973
Walnut	0-16	Kairov et al. 1977

(Adapted from: Atkinson, 1980. The Distribution and Effectiveness of the Roots of Tree Crops. Horticultural Reviews.)

Right Place: Where Does N Uptake Occur?
Almond Example

In all crops grown Mediterranean and Arid conditions, uptake occurs from the irrigated root zone



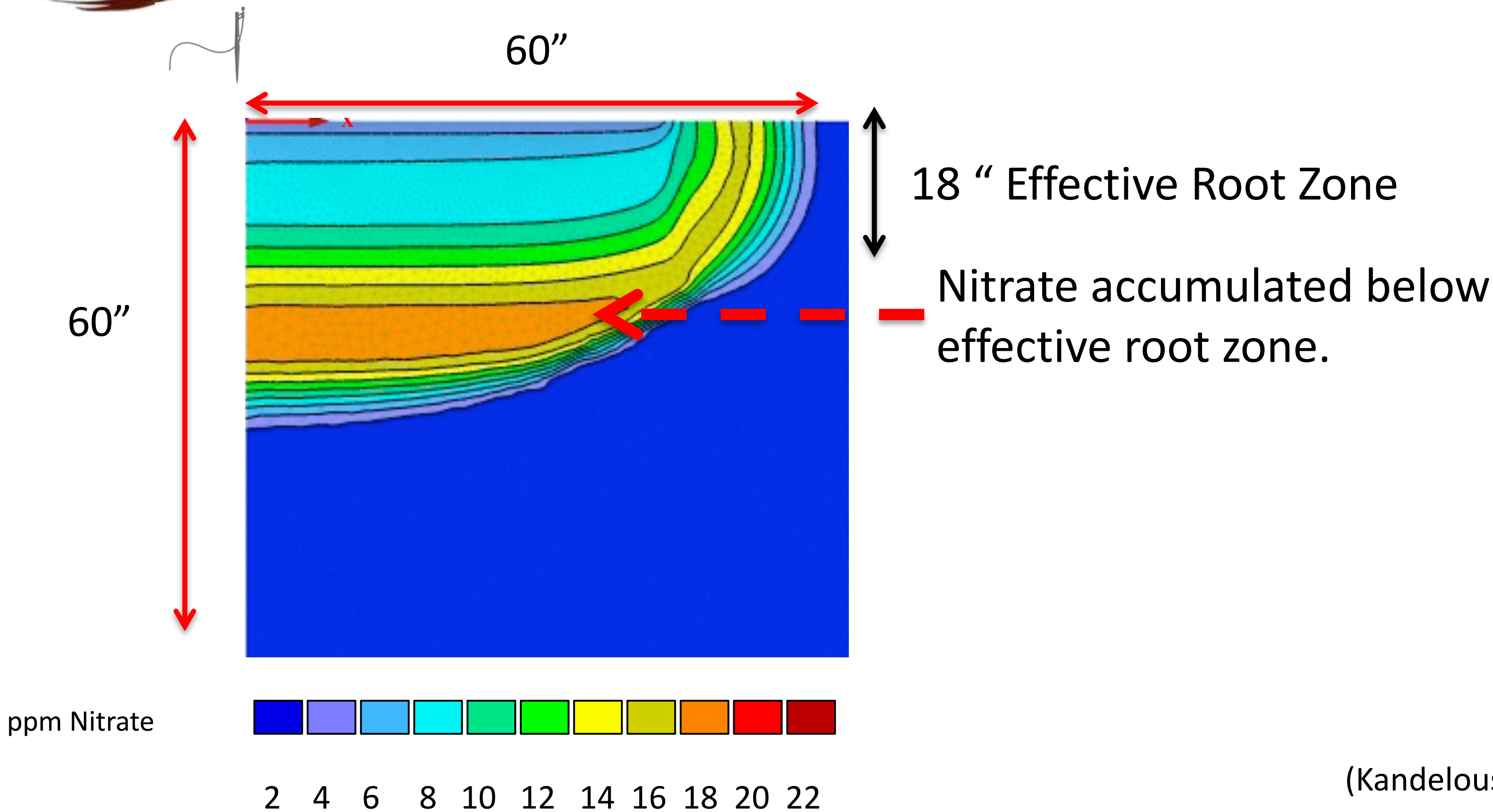


→ In almonds, the majority of roots are in the top 18 inches of soil.

(Olivos, Unpublished)

Right Place: Impact of Fertigation Timing on Nitrate Uptake

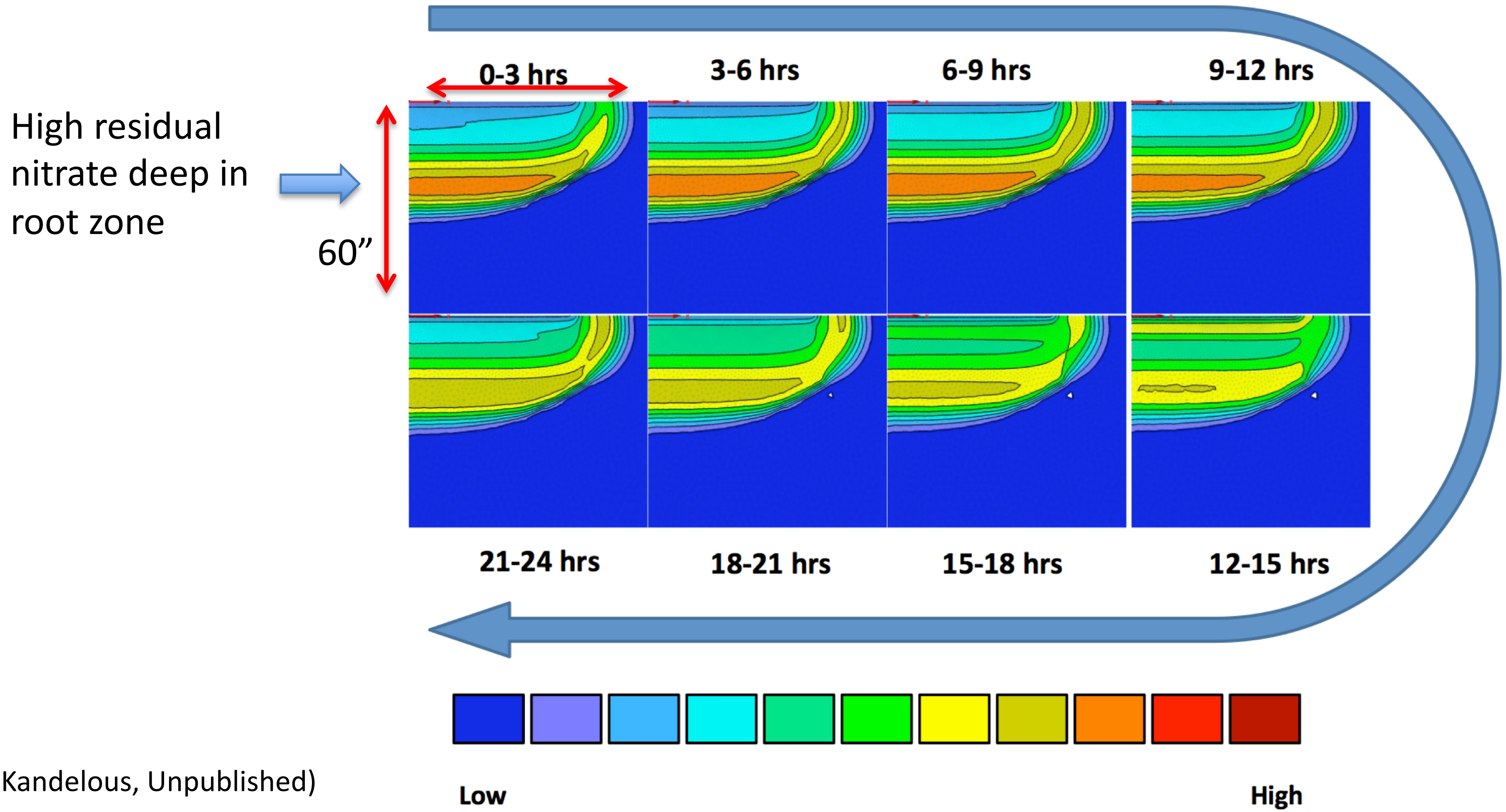
At what point during an irrigation event should nitrogen be applied?



(Kandelous, Unpublished)

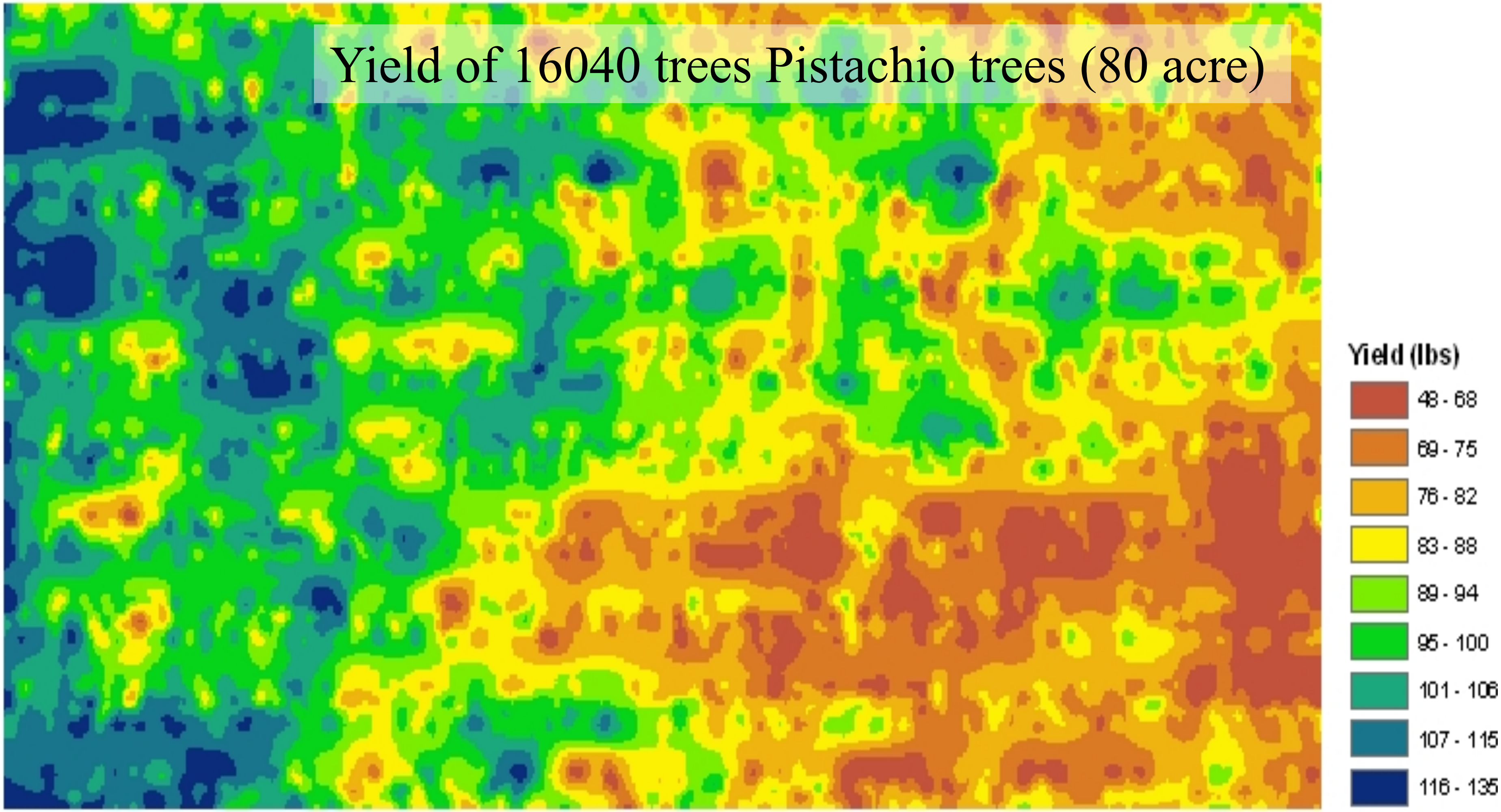
Right Place: Fertigation Timing and Nitrate Uptake

The fate of 8 different 3-hour fertilizer injection events (day 0) timed at different parts of a 24 hour 1.5” irrigation event. Nitrate location in the soil profile at 21 days after the fertigation, prior to the subsequent fertigation. The later the application the greater the recovery of N.



(Kandelous, Unpublished)

Right Place & Rate:
Yield is not uniform in any field.



If managed as a single plot– larger fields will always be less nutrient efficient than smaller fields.

Opportunity: Improved fertigation systems (by cultivar, soil type)
Precision Applications.

NUE: Nitrogen Use Efficiency

The highest NUE is achieved by the best combination of right rate, right time, right place and right source.

- Understanding the dynamics of nitrogen in the soil and the plant (Modules 2, 3 and 5)
- Choosing right rate, right timing, right placement (all modules) and right fertilizer source (Module 2, 3 and 4)
- Managing water properly (Module 6)
- Nutrient Budgeting (Module 5)
- Crop specific optimization (Module 7)

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Course materials available at:

ciwr.ucanr.edu/NitrogenManagement

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