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Department of
LAND, AIR AND WATER RESOURCES
University of California, Davis
Climate Change • Sustainable Agriculture
Environmental Quality • Landscape Processes

Mineralization of N from Soil Organic Matter and Organic Materials

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Organic Soil Fertility for Vegetables and Strawberries Short Course

Salinas, February 12, 2019

Content

- Introduction
- Factors affecting N mineralization
- Estimates of N mineralization in Central Valley and Salinas Valley soils
- Conclusions

Nitrogen turnover in soil

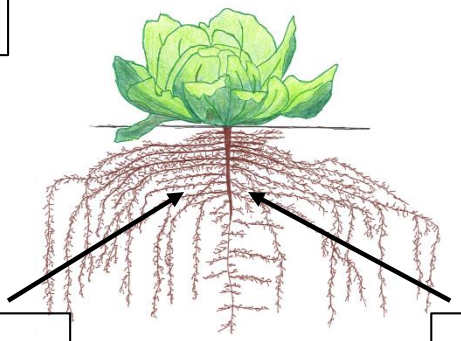
Organic N

Mineralization by soil microbes

Ammonium (NH_4^+)

Ammonia (NH_3)

Volatili-zation



Nitrification

Nitrate (NO_3^-)

N_2, N_2O

Denitrifi-cation

Soil microbes

Leaching

Nitrogen mineralization

- Soil microorganisms decompose residue
- Need N and C as building blocks for their own biomass
- C is also used as energy source
- **N mineralization:** Release excess N in the form of NH_4^+ into soil solution
- **N immobilization:** Uptake of NO_3^- or NH_4^+ from soil solution and incorporation into microbial tissue

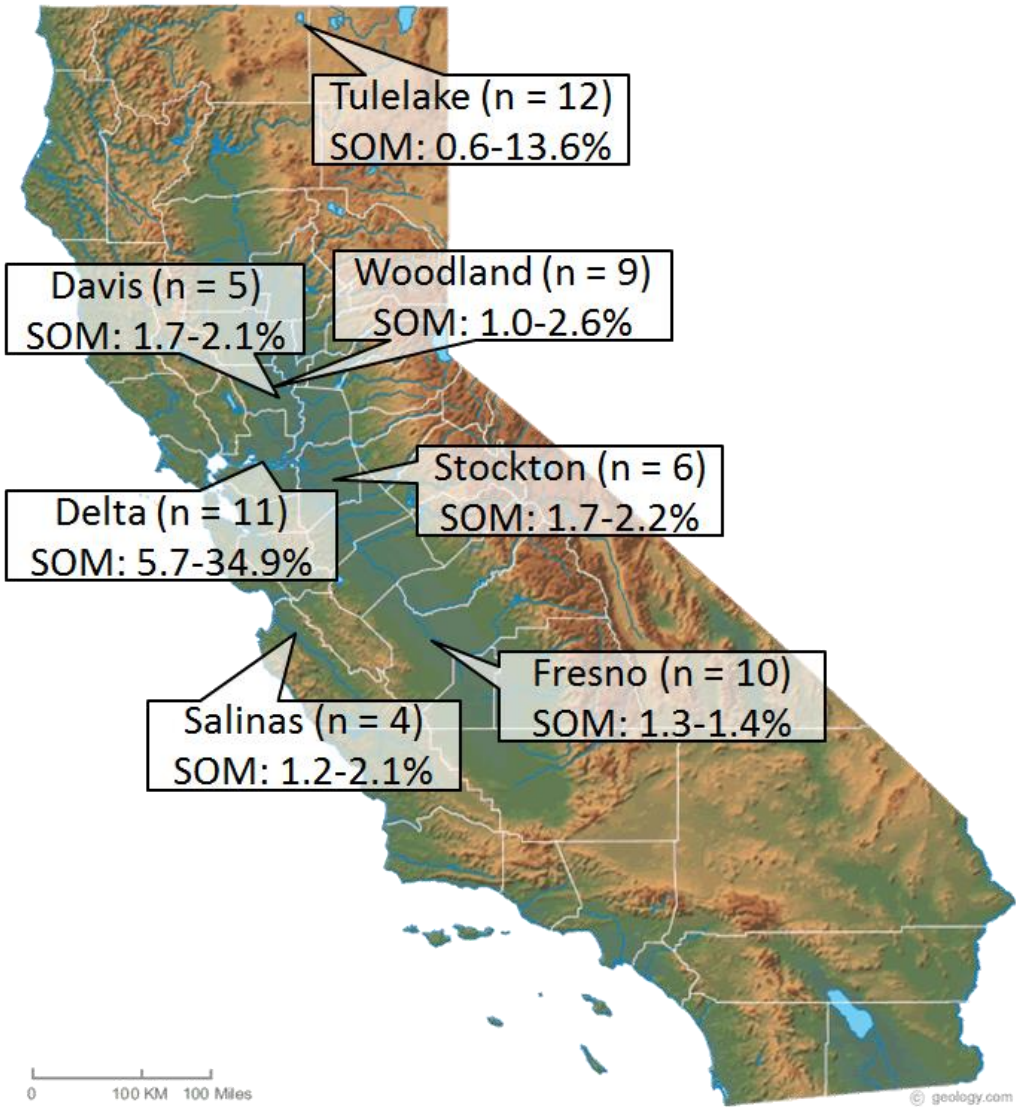
Factors affecting N mineralization

- Soil temperature
- Soil moisture
- Quantity and quality of organic inputs
  - Carbon to nitrogen ratio (C/N ratio)
  - Stage of decomposition
- Soil organic matter content and quality
- Crop management
  - Tillage
  - Irrigation
  - ….

Nitrogen mineralization study

- Undisturbed soil cores were sampled in spring 2016 and 2017 from 57 fields
- Additional samples for soil analyses were taken right next to cores
- Cores were kept at optimal moisture content and 41, 59, or 77 °F for 10 weeks
- Increase in nitrate during these 10 weeks was determined

Locations


Tulelake (n = 12)
SOM: 0.6-13.6%
Davis (n = 5)
SOM: 1.7-2.1%
Woodland (n = 9)
SOM: 1.0-2.6%
Stockton (n = 6)
SOM: 1.7-2.2%
Delta (n = 11)
SOM: 5.7-34.9%
Fresno (n = 10)
SOM: 1.3-1.4%
Salinas (n = 4)
SOM: 1.2-2.1%
0
100 KM 100 Miles
© geology.com

Factors affecting N mineralization

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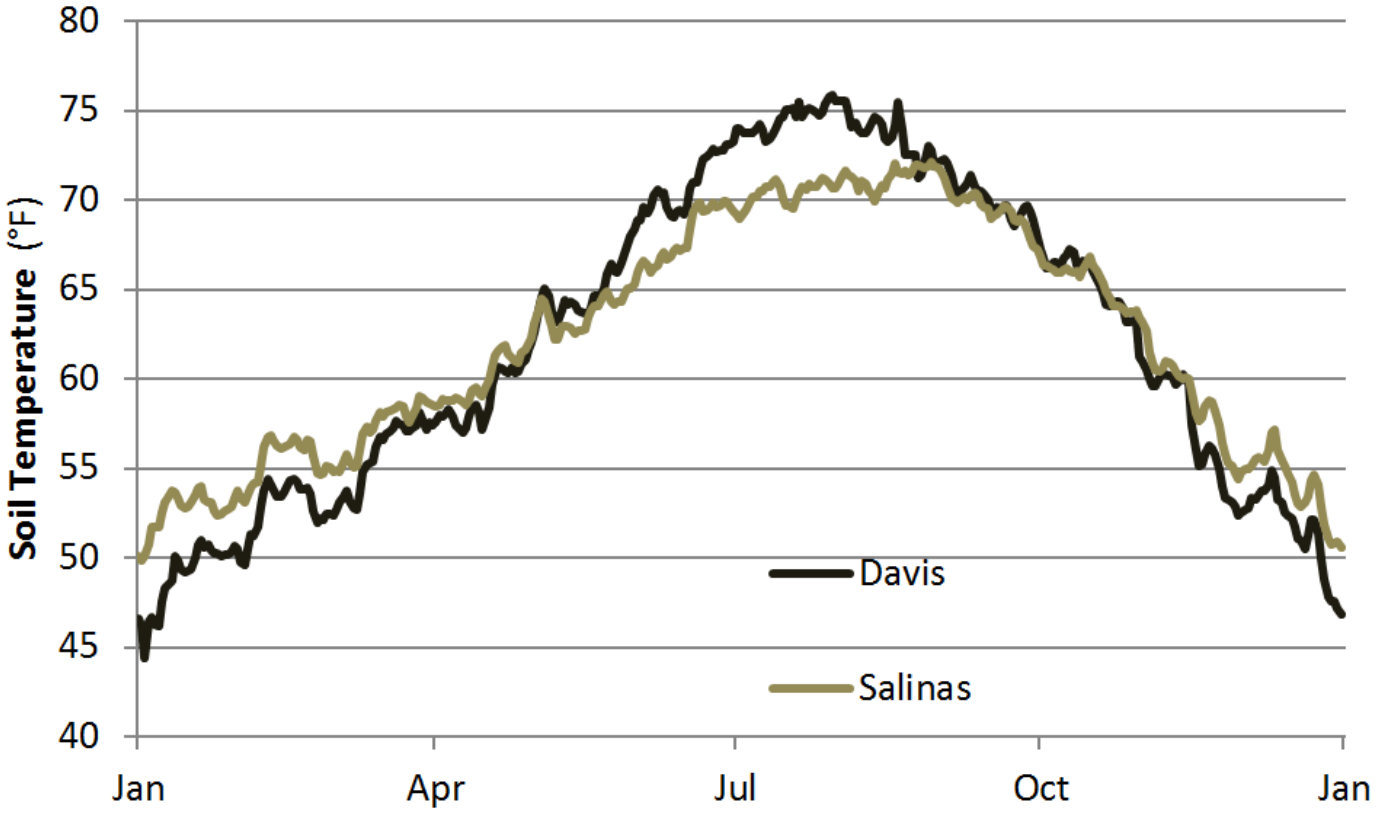
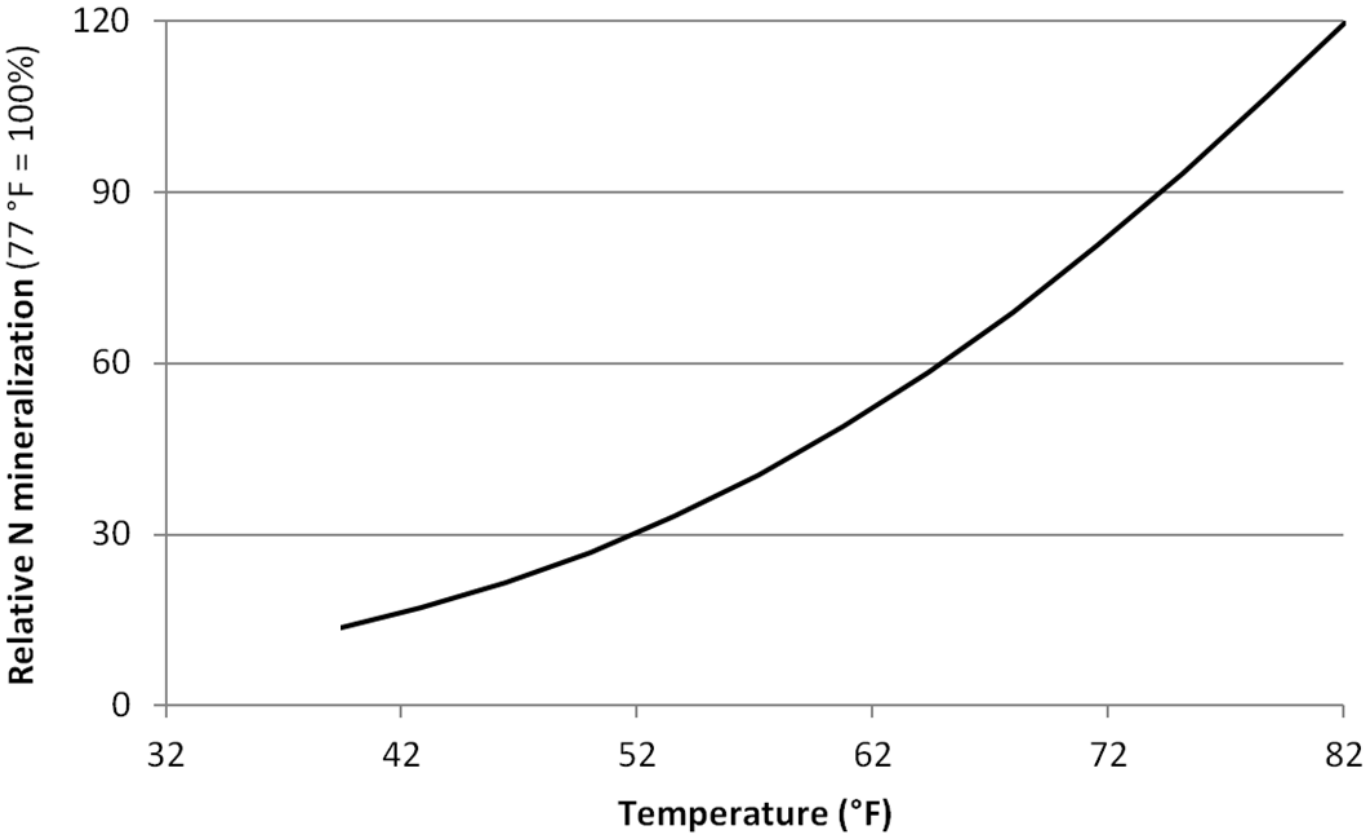
Soil temperature



Effect of temperature on N mineralization



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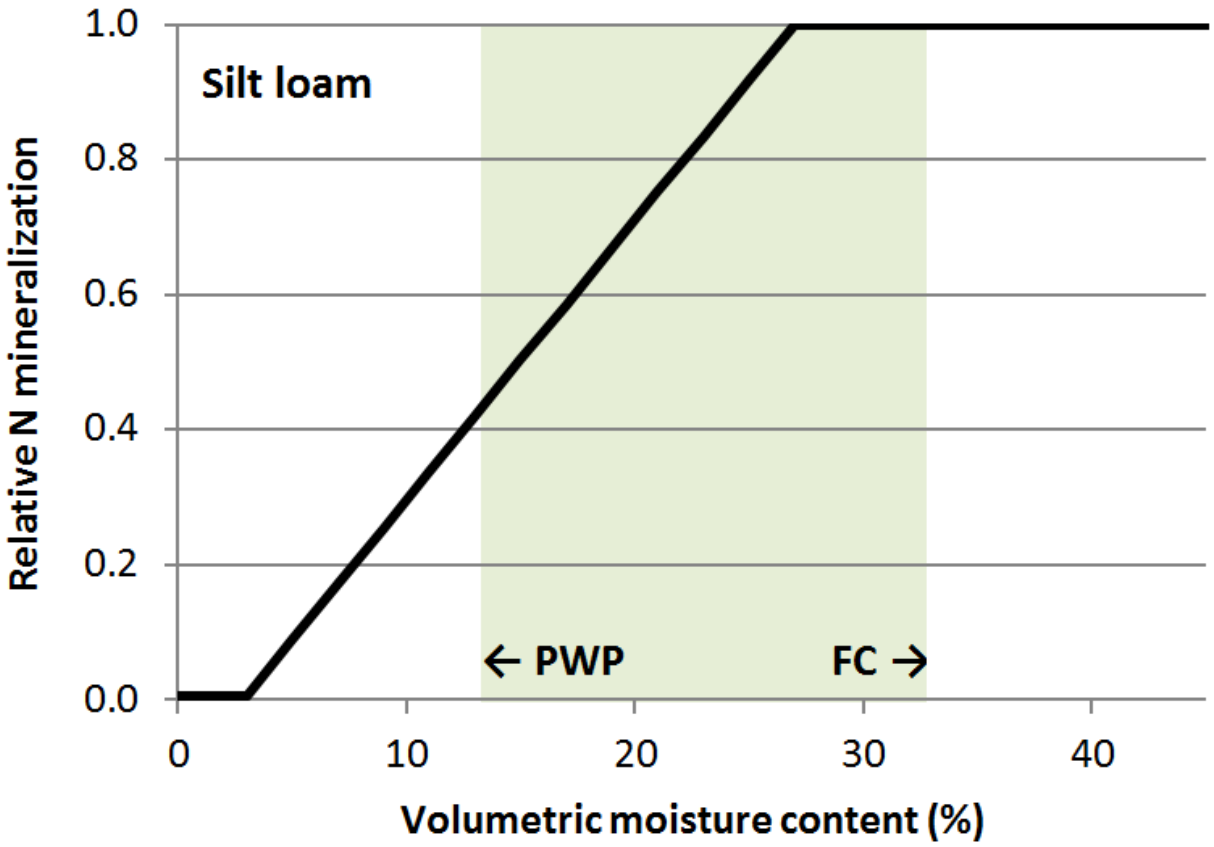
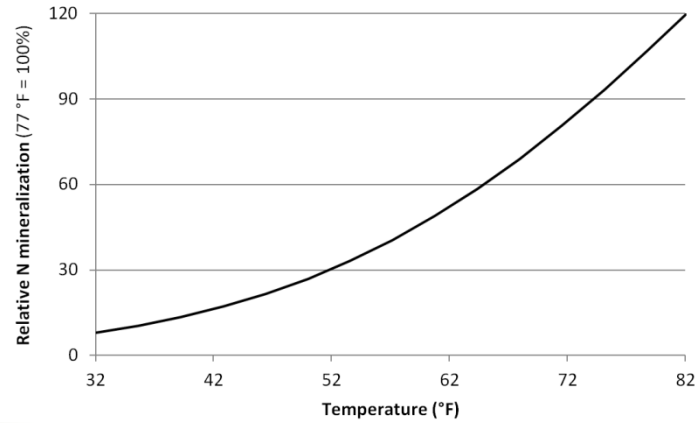
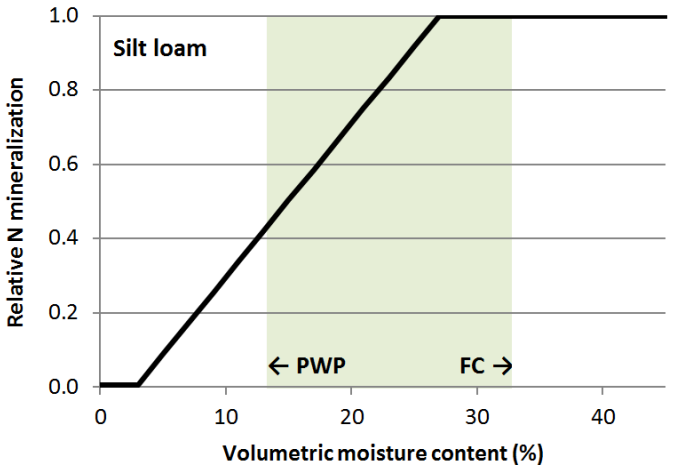
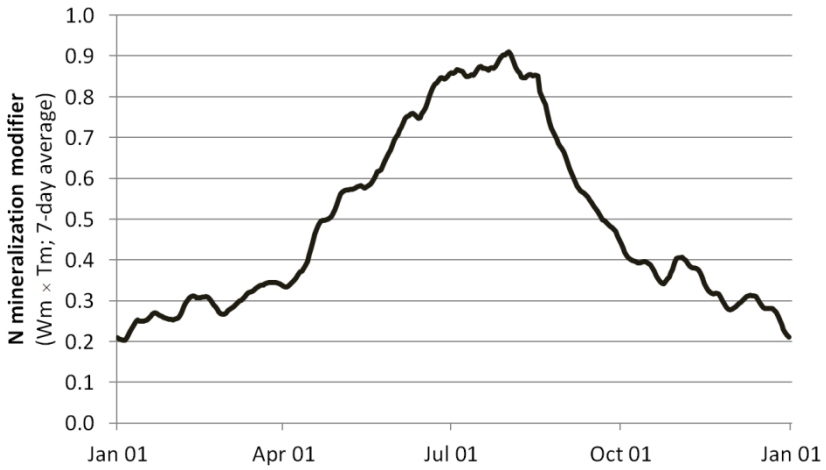
Effect of soil moisture



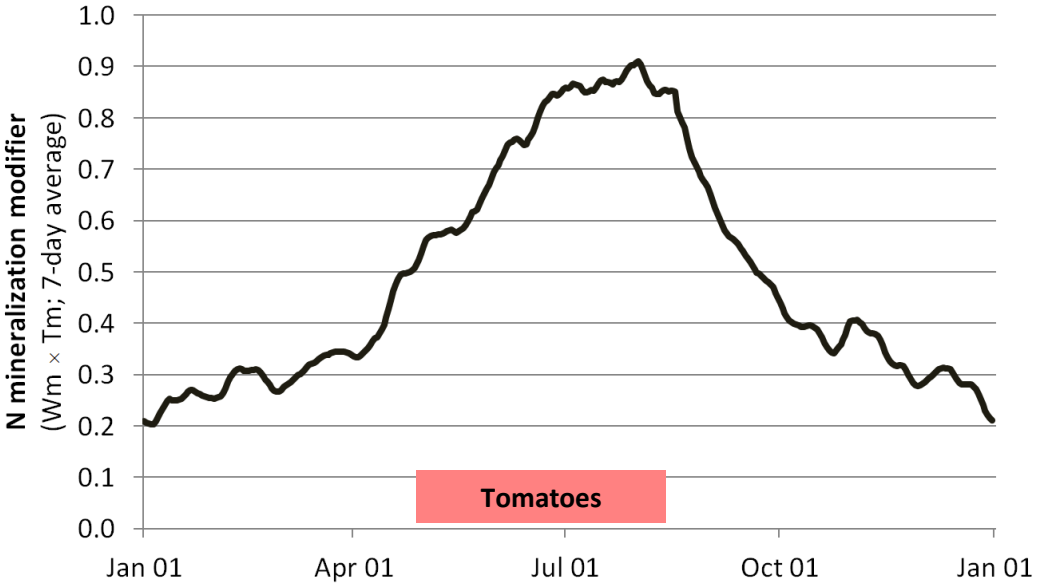
Temperature and moisture effects







N mineralization throughout the year



- Winter, spring: Temperature is limiting
- Fall: moisture is limiting

⇨ In furrow irrigated fields, about half of the N is mineralized during a 4-month growing season

Factors affecting N mineralization

- Soil temperature
- Soil moisture
- **Quantity and quality of organic inputs**
  - **Carbon to nitrogen ratio (C/N ratio)**
  - Stage of decomposition
- Soil organic matter content and quality
- Crop management
  - Tillage
  - Irrigation
  - ….

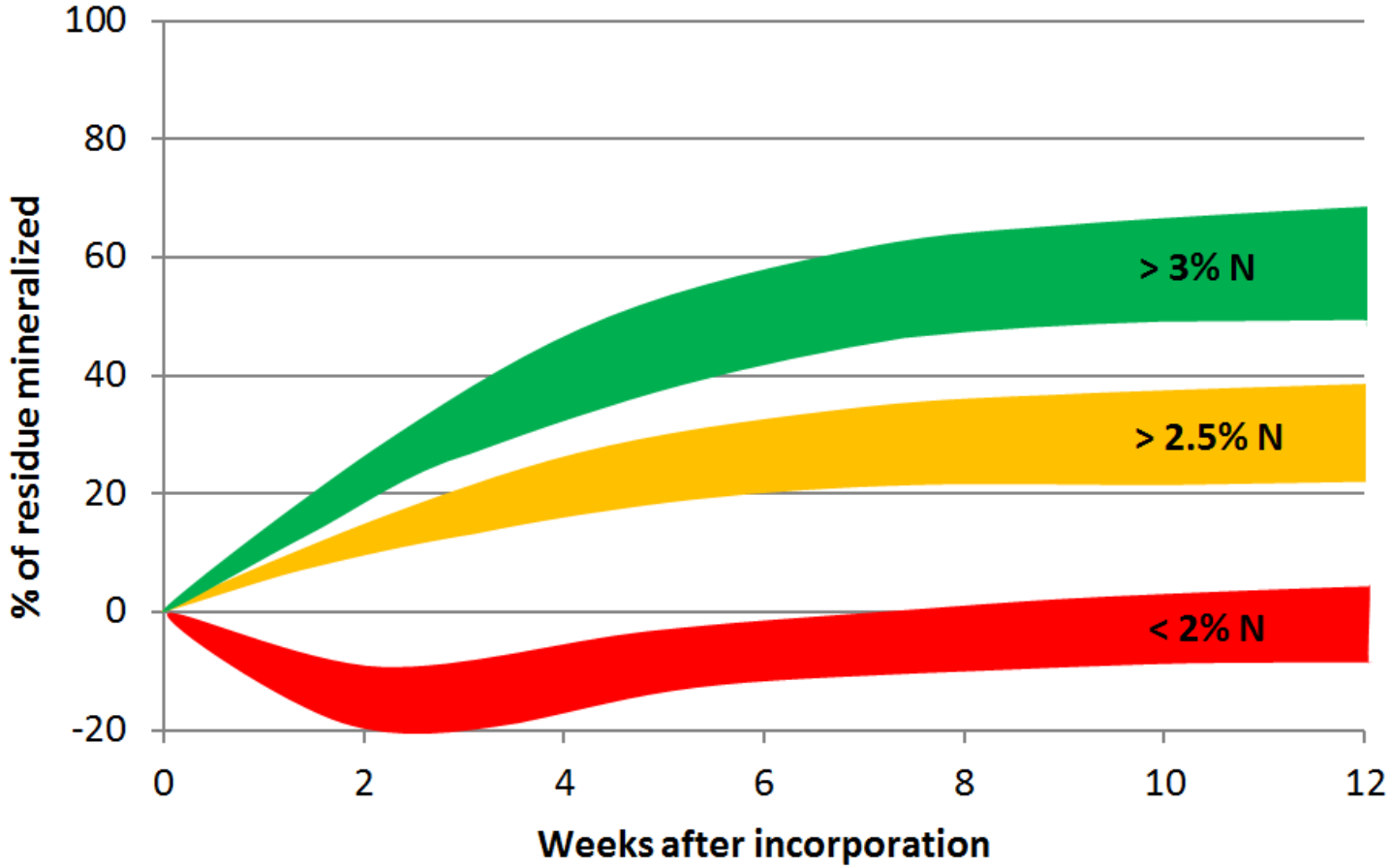
Net mineralization or immobilization?

- Depends mainly on the C/N ratio of the organic substrate
  - C/N < 20: Net mineralization
  - C/N > 30: Net immobilization

- Availability of C and N in substrate

  Highly decomposed SOM has a favorable C/N ratio, but both C and N are not readily available

Net mineralization or immobilization?



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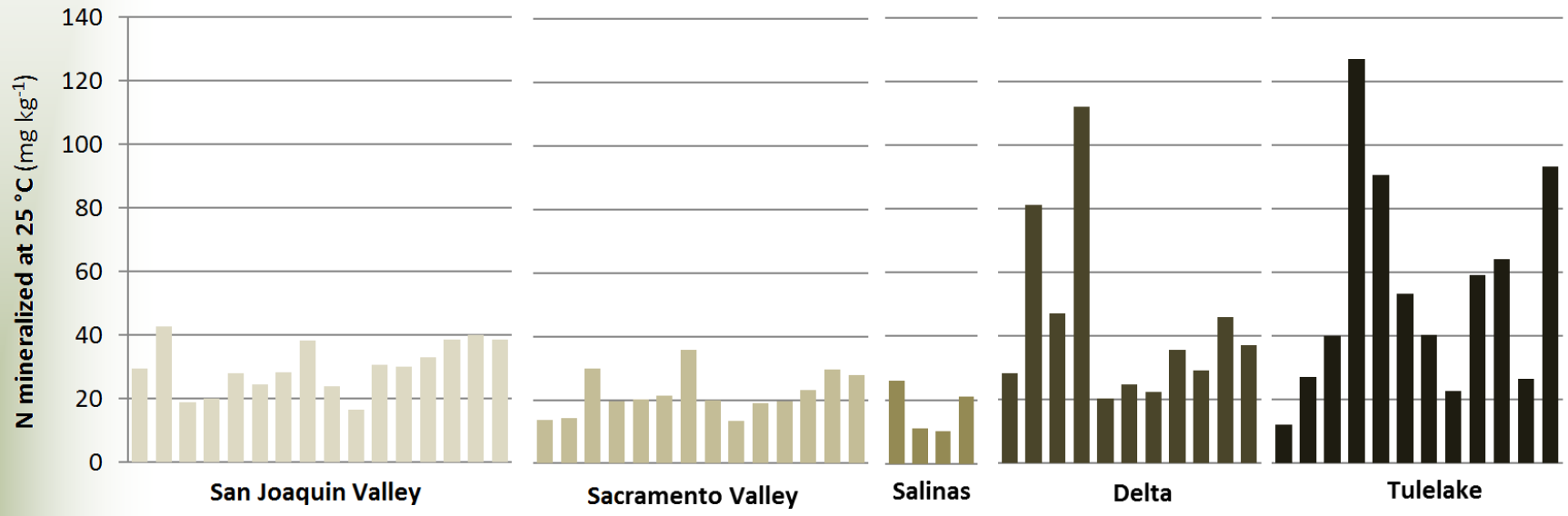
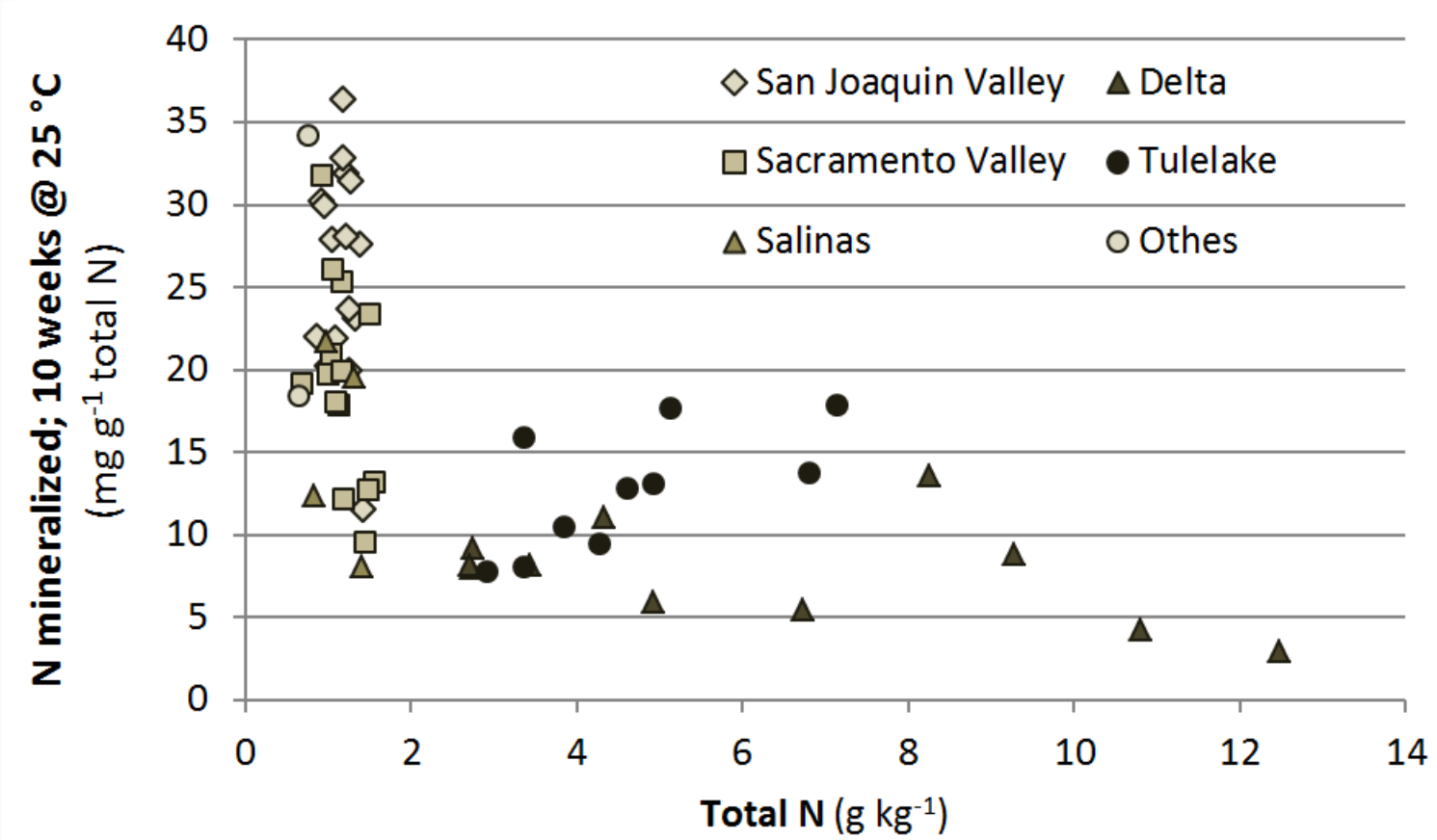
N mineralization rate in undisturbed soil cores

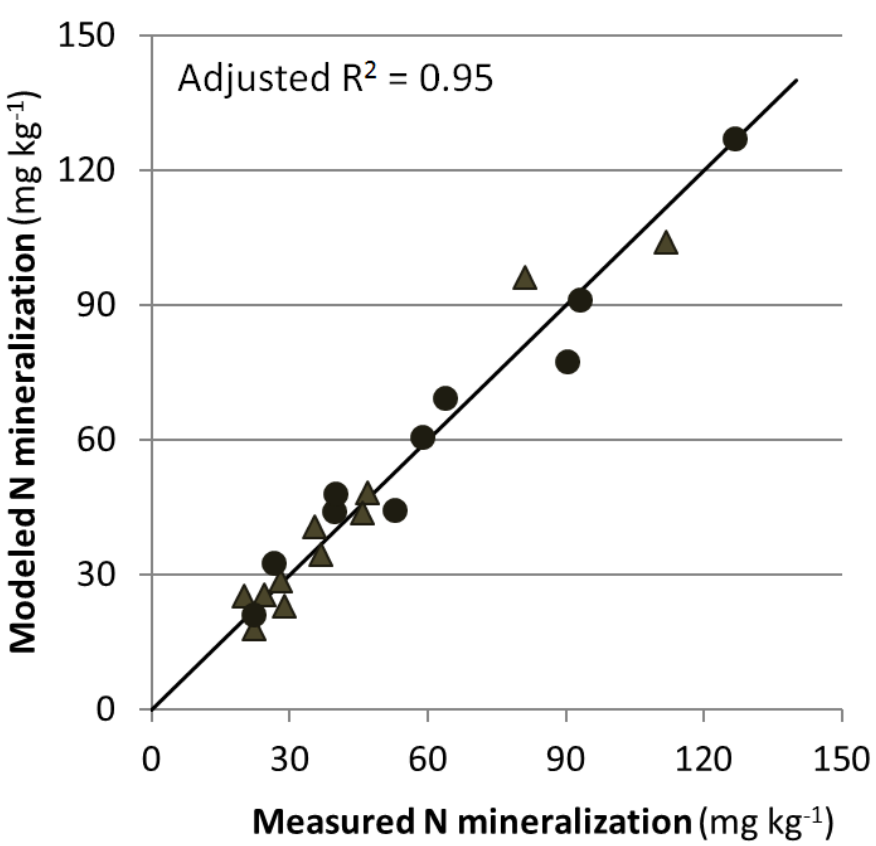


The cores were kept at 77 °F and a soil moisture content near field capacity for 10 weeks

N mineralization as related to total soil N



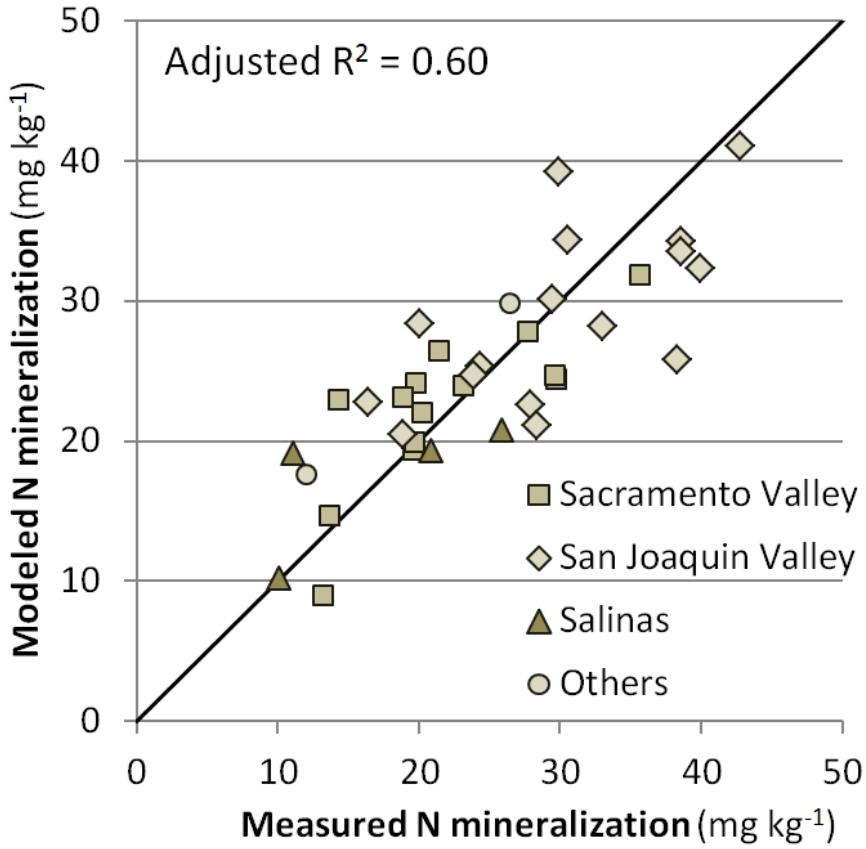
Soil properties and N mineralization: Soils with a high SOM content



Relevant soil properties:

- Total carbon
- Total nitrogen
- Particulate organic matter
- Sand

Soil properties and N mineralization: Soils with a low SOM content



Relevant soil properties:

- Total carbon
- FDA hydrolysis
- Silt

Sources of mineralizable N

- Plant residues
- Roots
- Root exudates
- Organic amendments

- Degradation of soil organic matter (SOM)

Sources of mineralizable N in our Central Valley soils

- Plant residues
- Roots
- Root exudates
- ~~Organic amendments~~

- Degradation of soil organic matter (SOM)

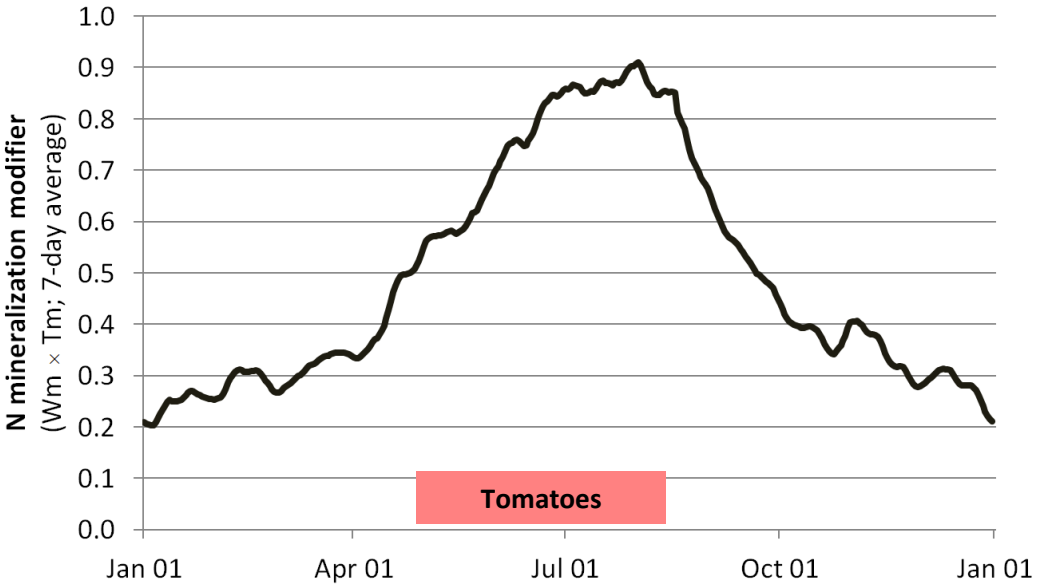
Organic N inputs to Central Valley soils I

Crop	n	N input (lbs/acre per year)		
		Residue	Roots	Residue & roots
Wheat	6	48	18	66
Corn	5	68	29	97
Sorghum	1	50	15	66
Sunflower	2	44	2	46
Tomatoes	12	53	5	58
Alfalfa	3			100
Fallow	1	0	0	0
Weighted average				**70**

Organic N inputs to Central Valley soils II

N source	lbs N/acre per year
Average annual N input with roots and residues:	70
Rhizodeposition	23
Input with decreasing soil organic matter content:	17
Total organic N input:	**70-110**

N mineralization throughout the year



- Winter, spring: Temperature is limiting
- Fall: moisture is limiting

⇨ In furrow irrigated fields, about half of the N is mineralized during a 4-month growing season

⇨ Mineralization contributes roughly 40 lbs/acre during growing season

Residue and root-N input in broccoli-lettuce systems

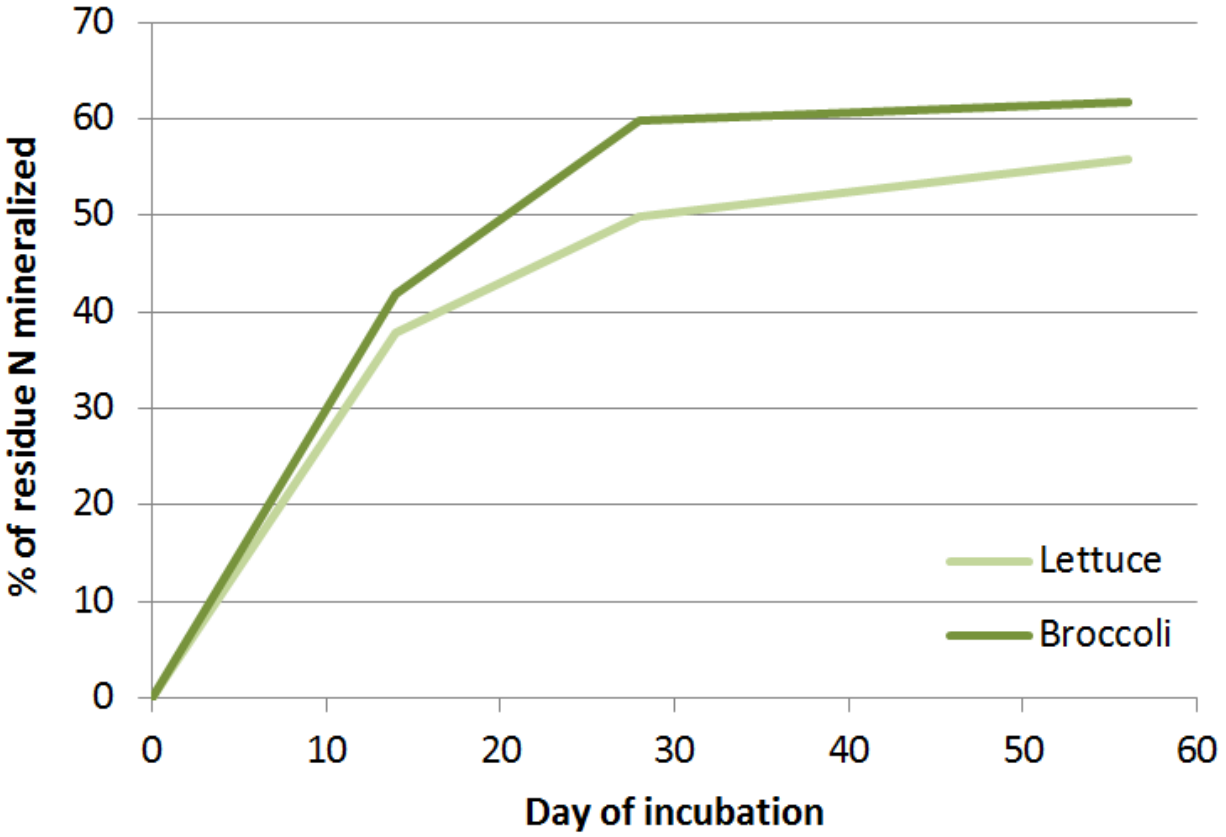
Crop	Total N uptake	N removed	Residue N
	lbs/acre	%	lbs/acre
Broccoli	300	30	210
Lettuce	140	55	63
Annual Residue N input			273
Including N in roots			**340**

Higher inputs than in the Central Valley:

- 2 crops per year
- Smaller proportion of total N removed

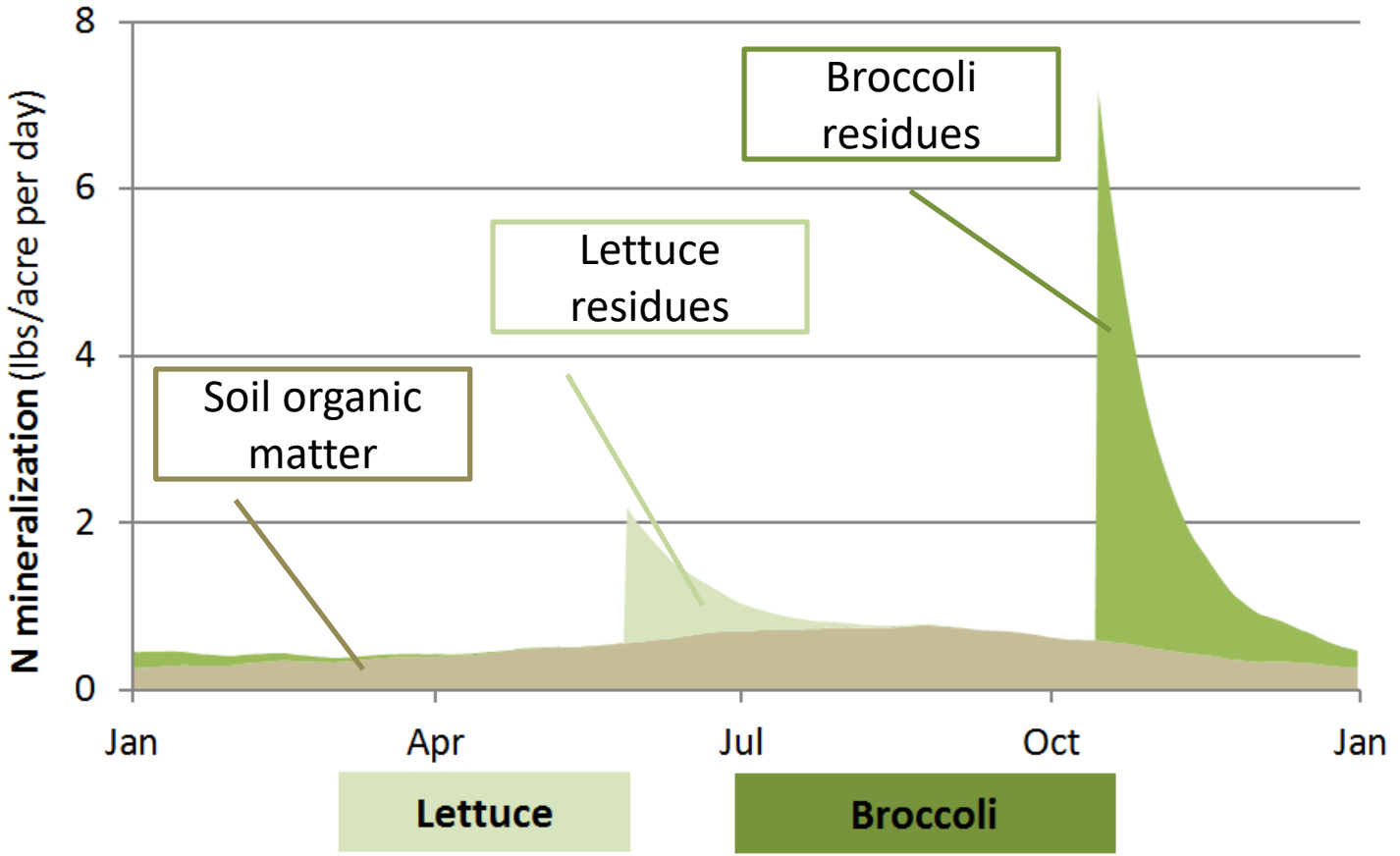
Source: Tim Hartz

N mineralization pattern of lettuce and broccoli residue

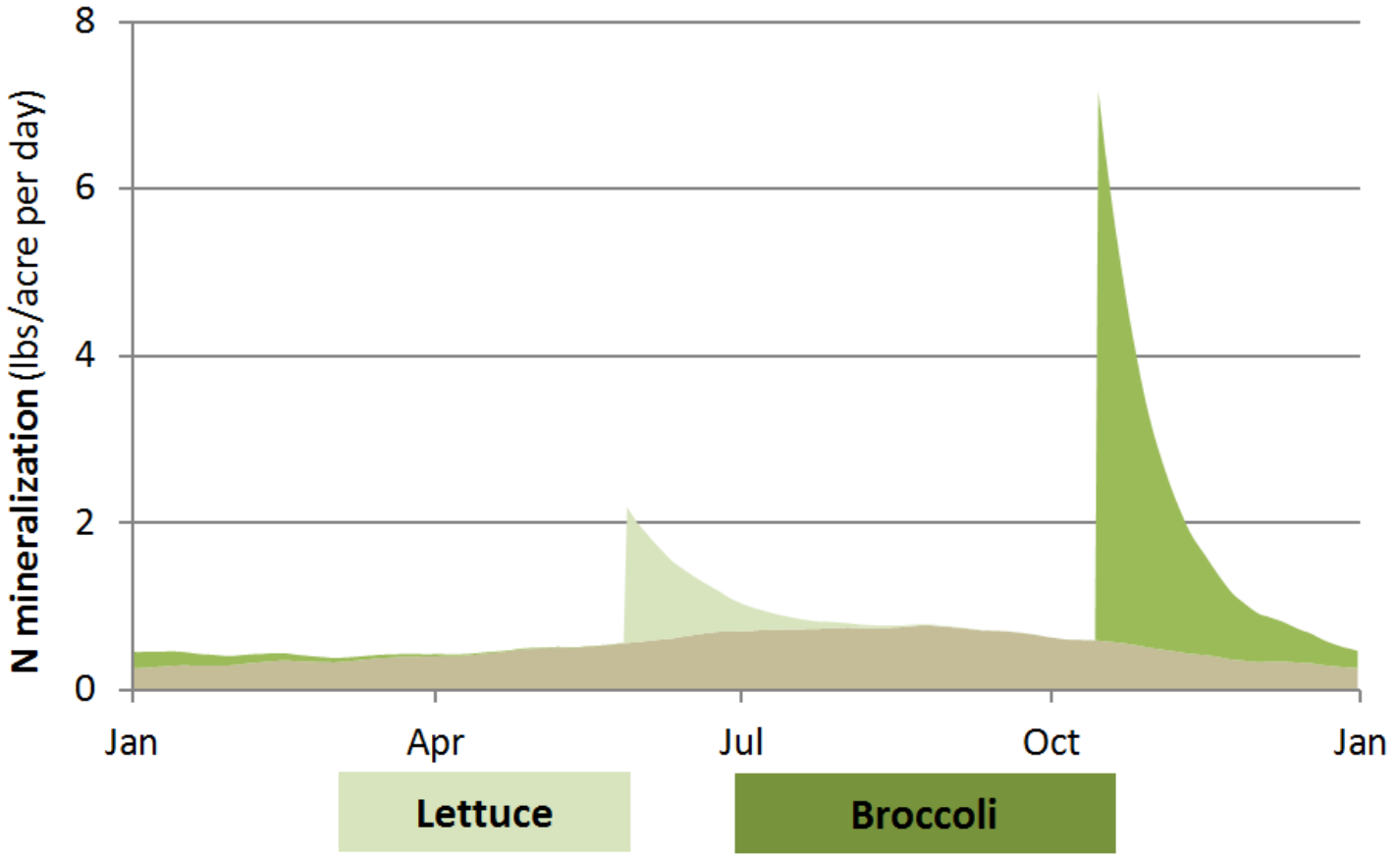


Source: Tim Hartz

Seasonal N mineralization pattern



Seasonal N mineralization pattern



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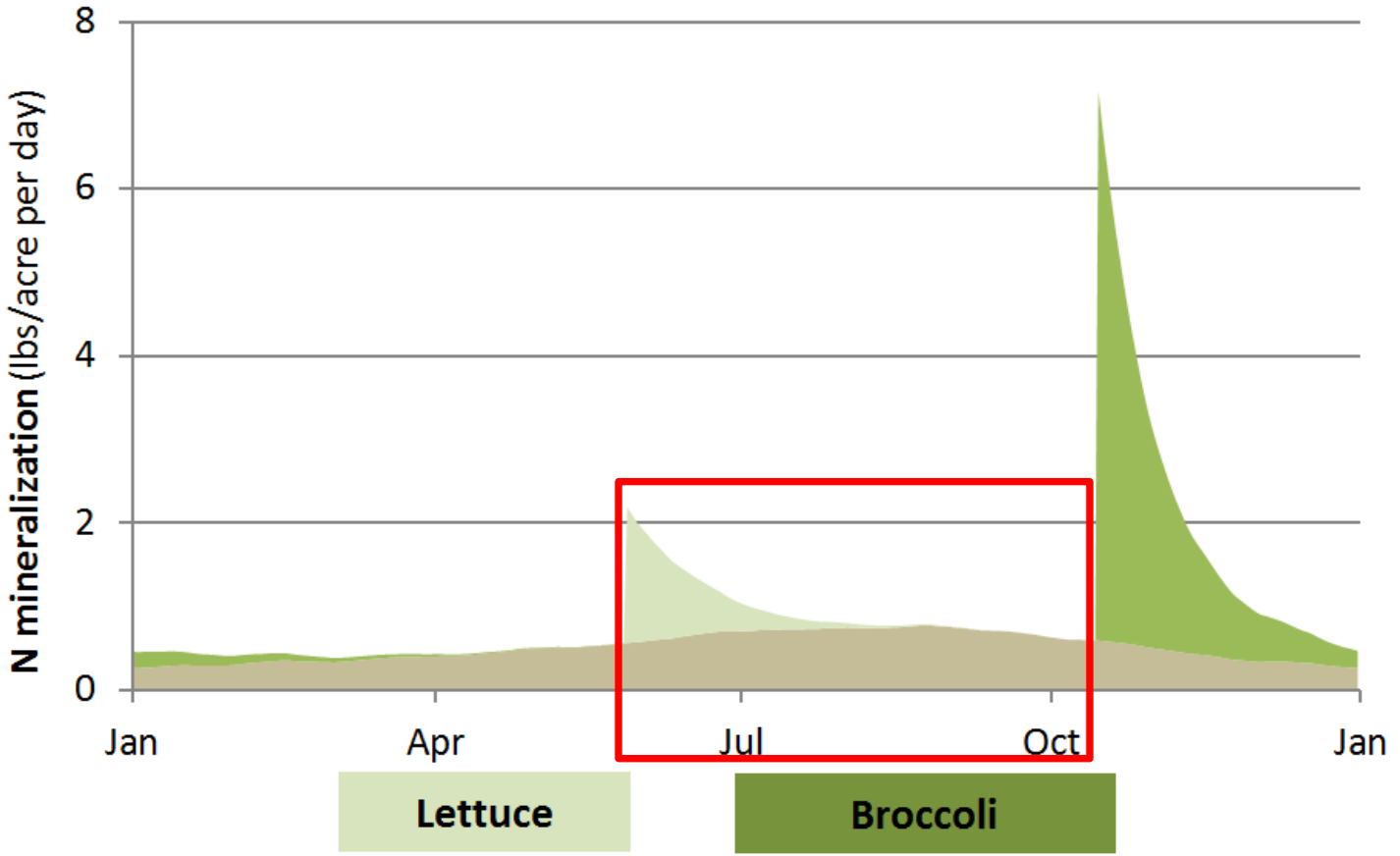
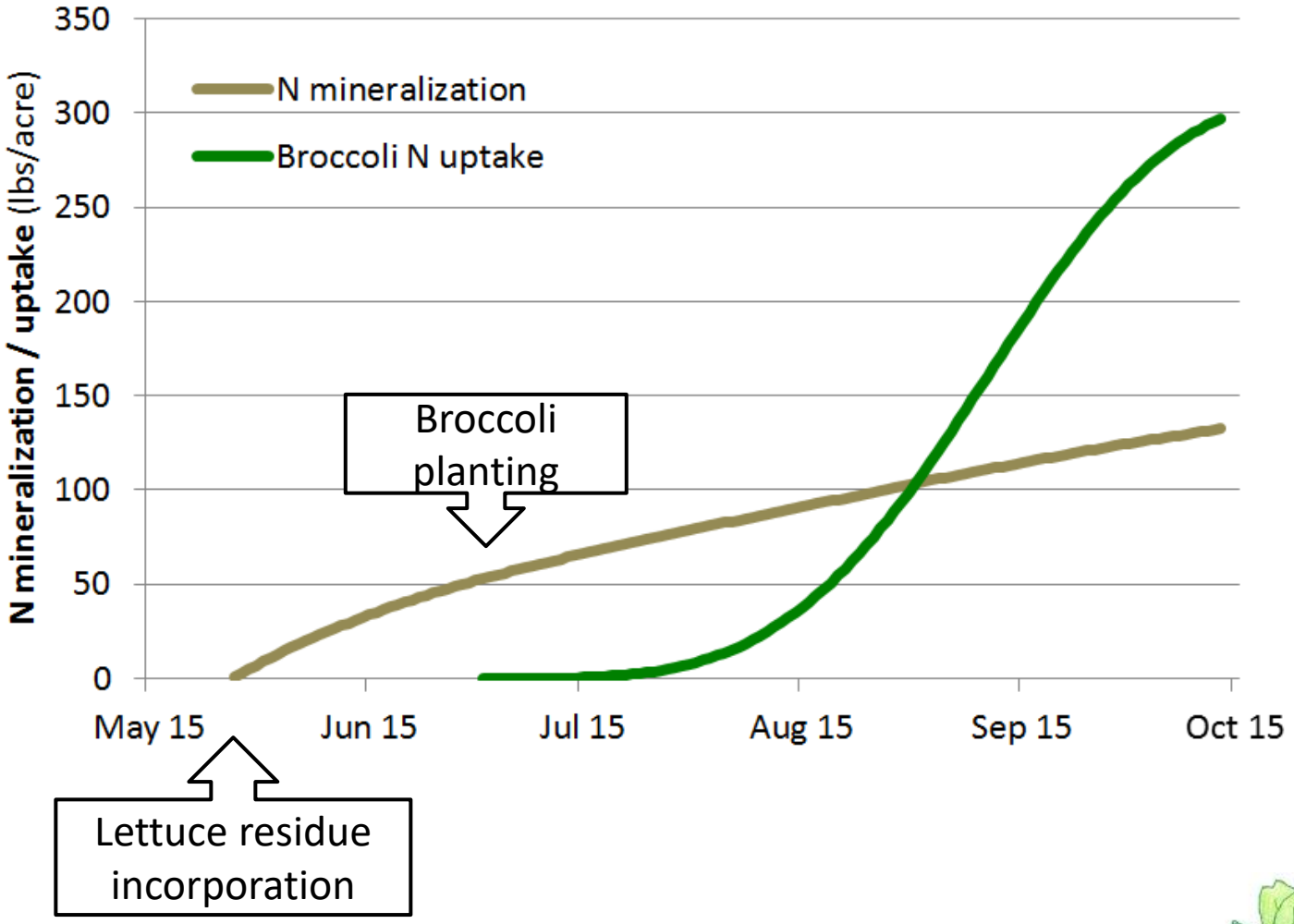


N mineralization and uptake



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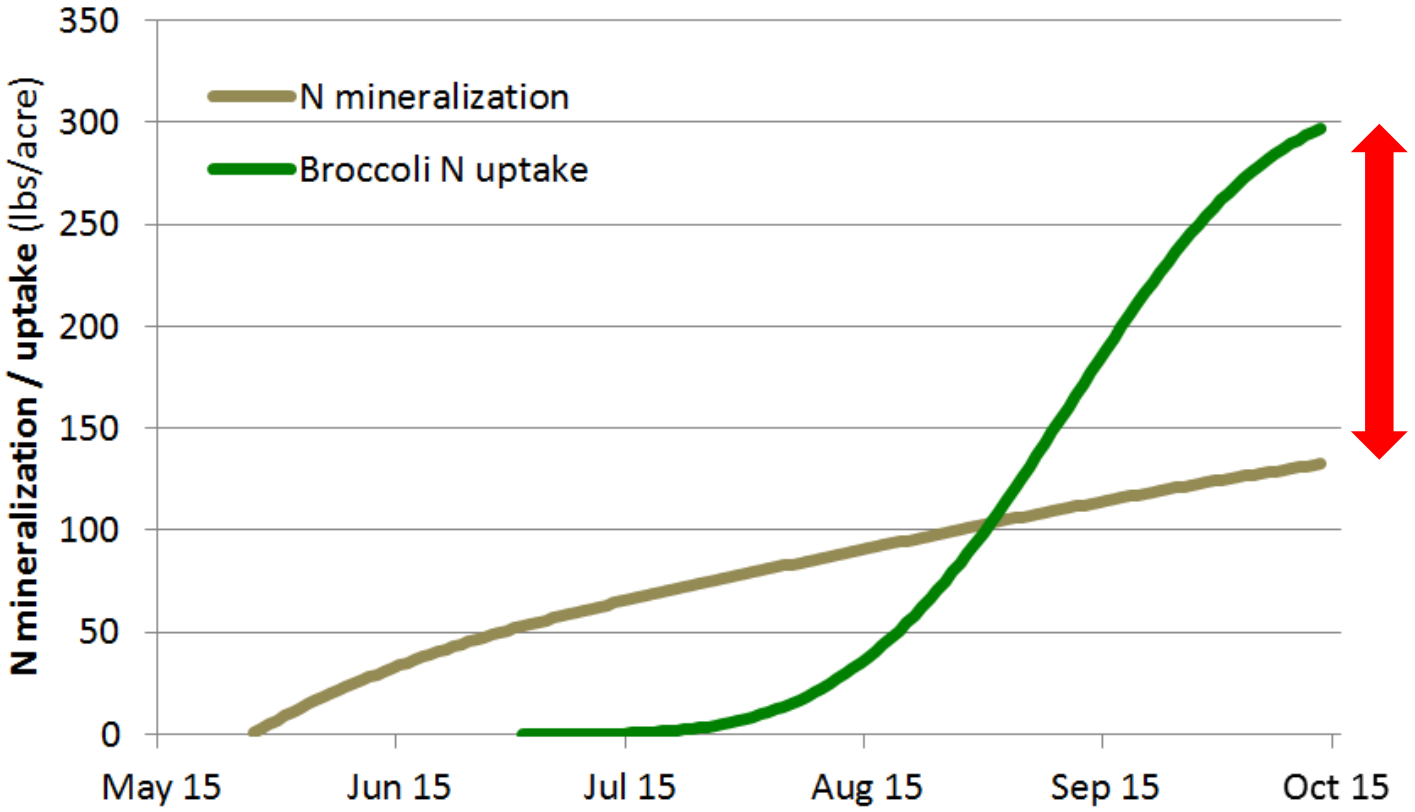
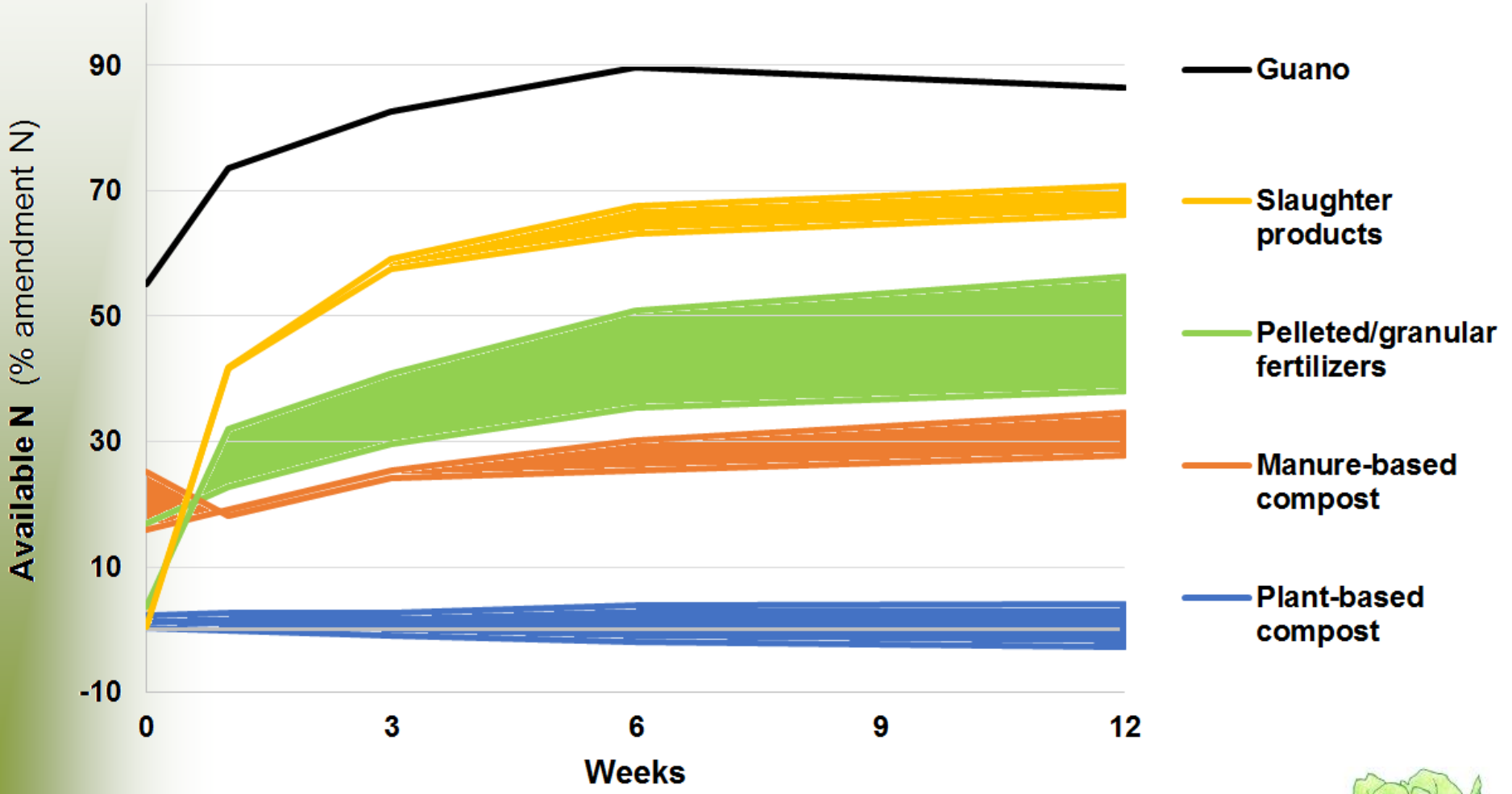
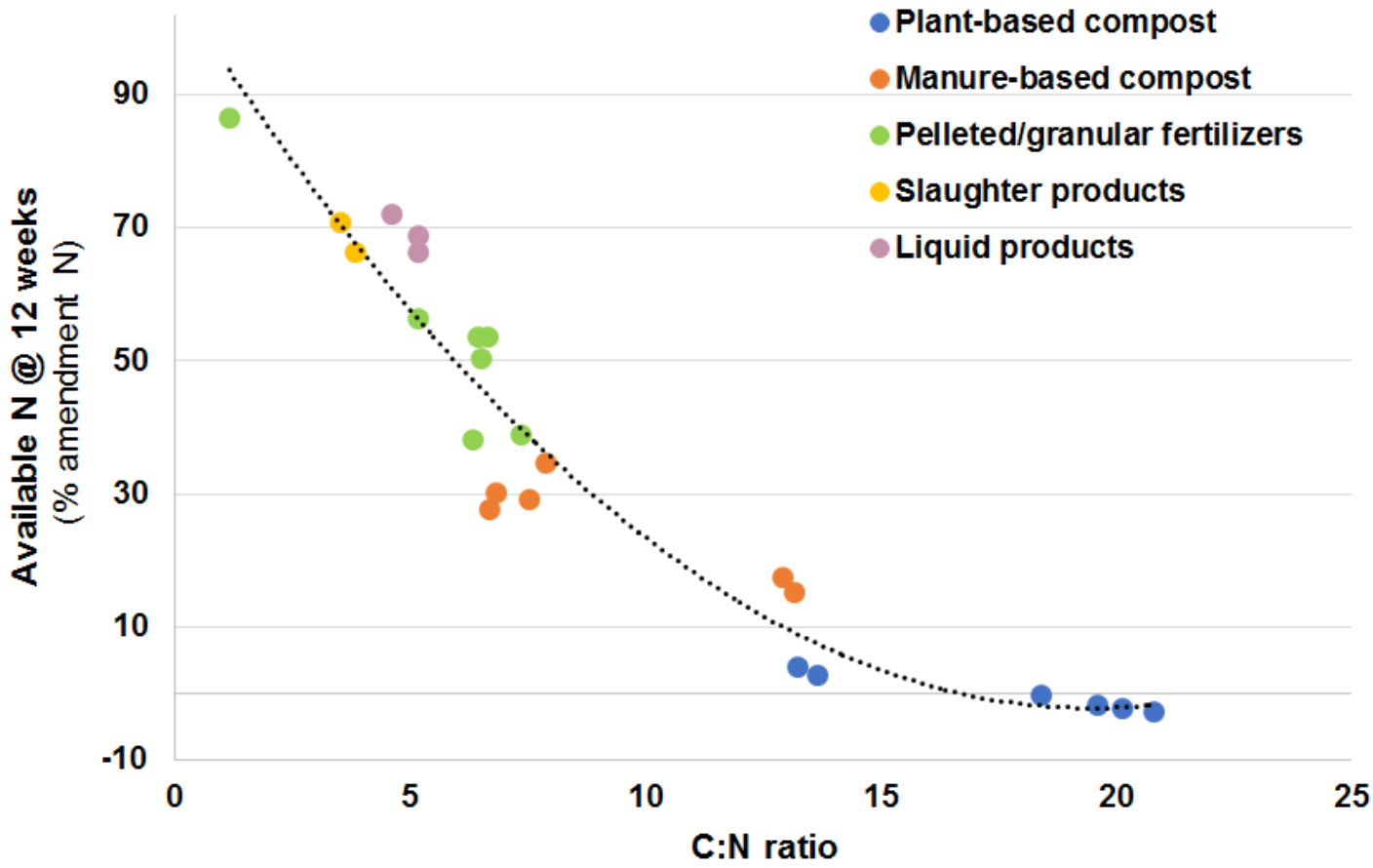


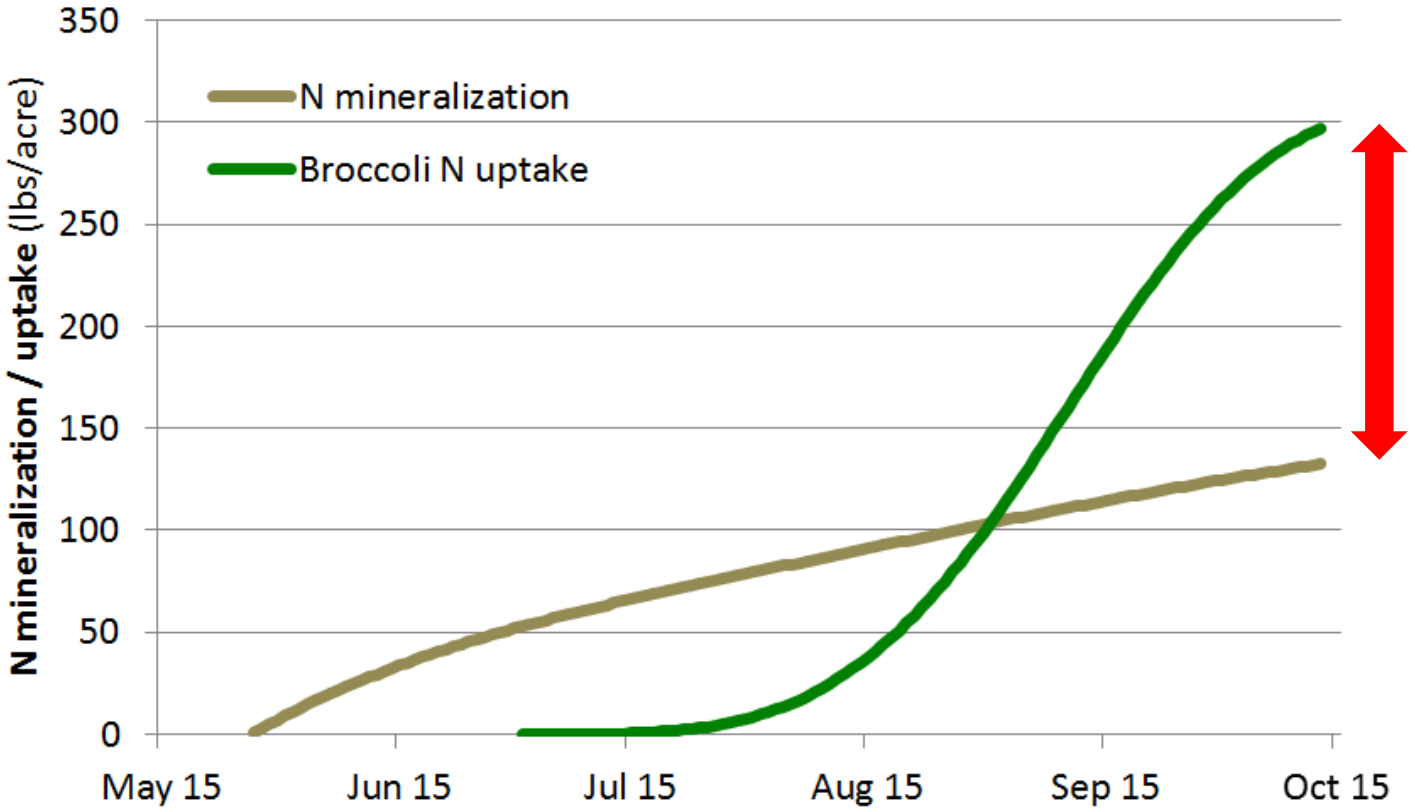
Nitrogen mineralization from organic amendments



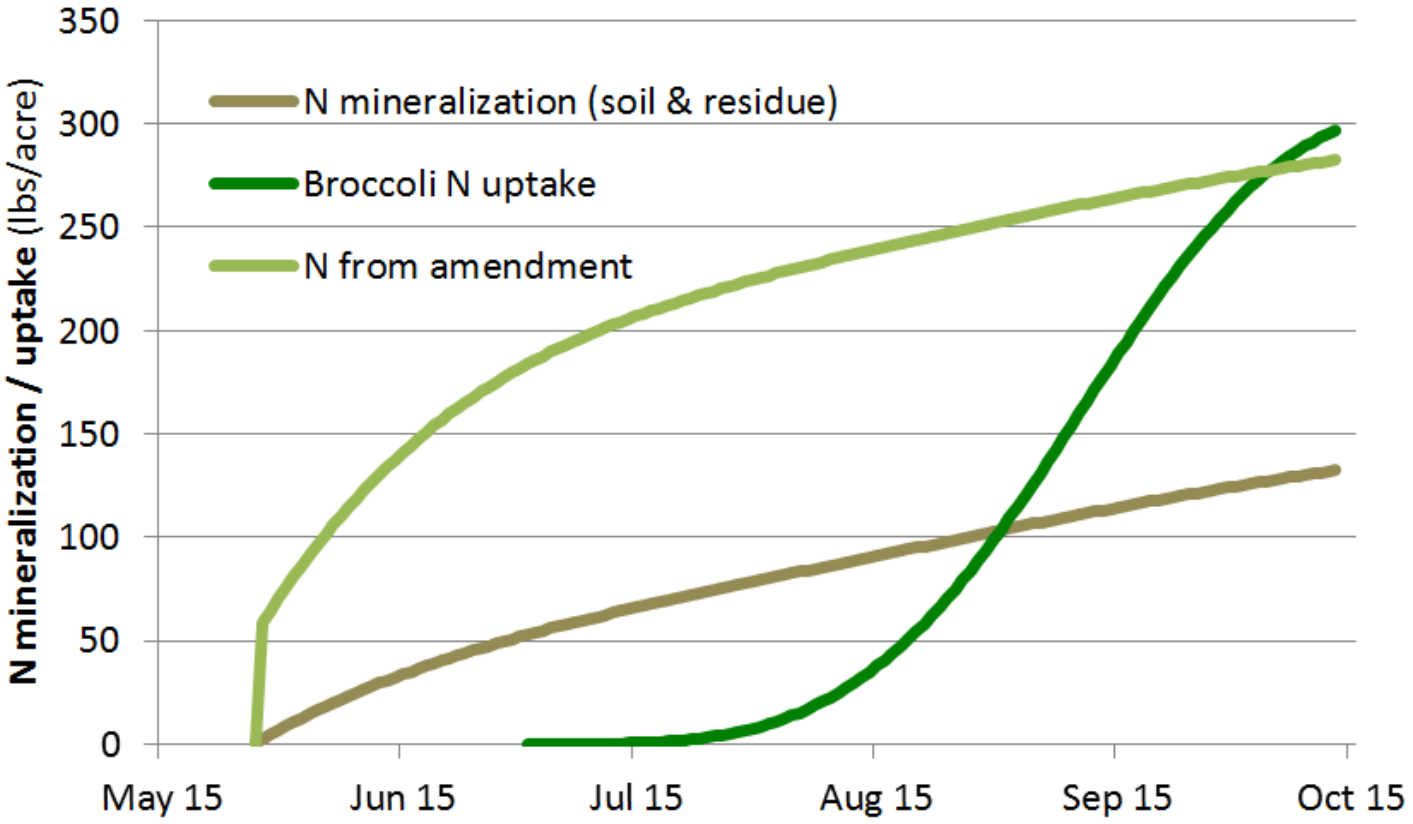
Effect of C to N ratio on N release



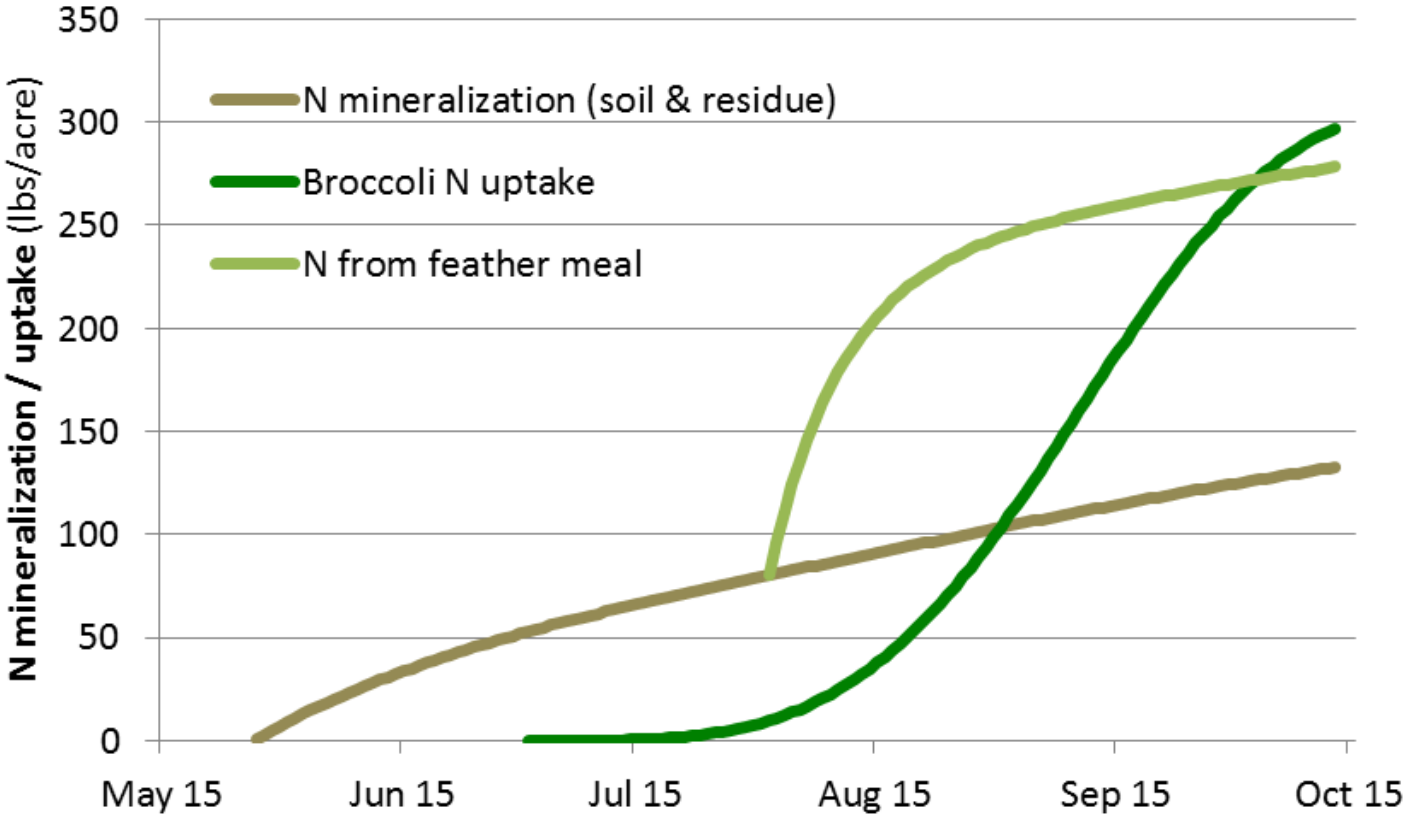
N mineralization and uptake



N mineralization and uptake



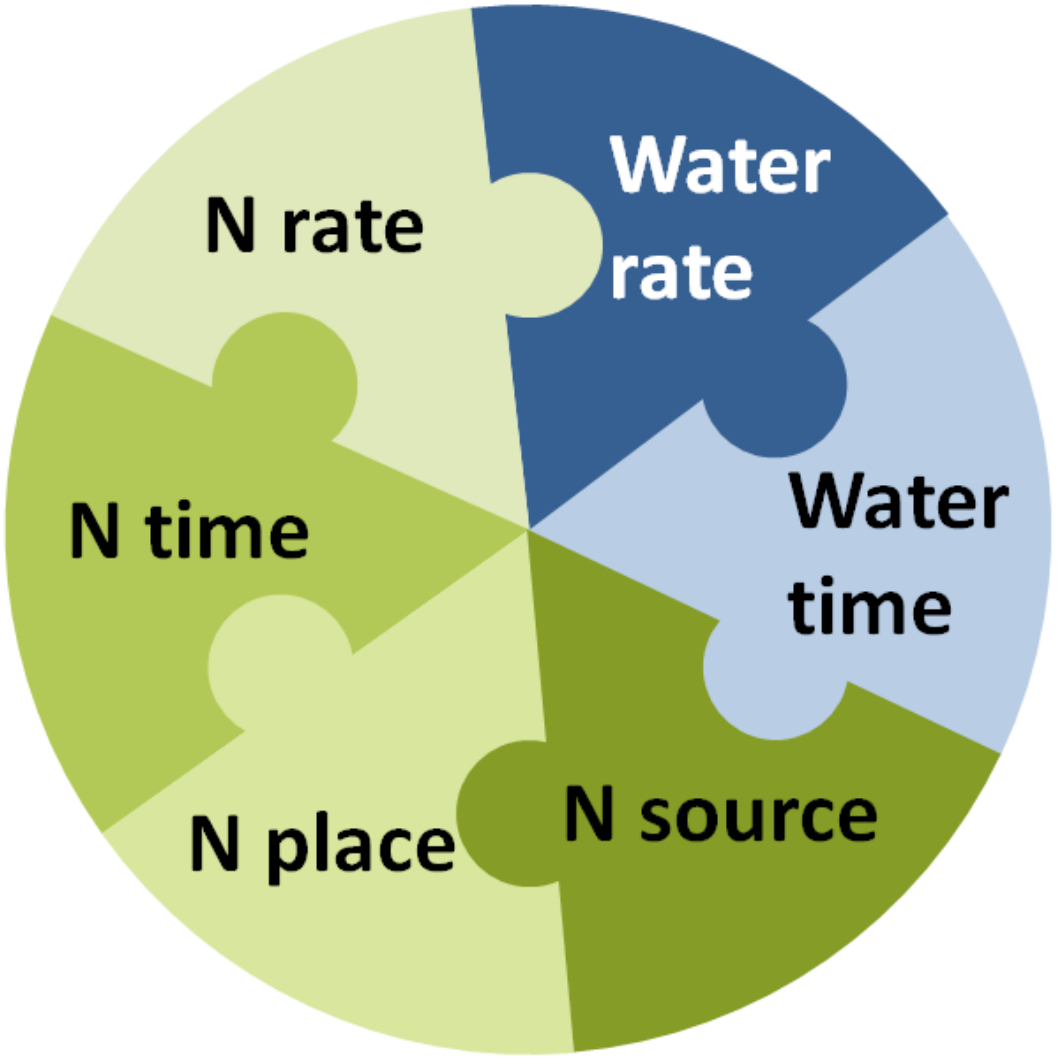
N mineralization and uptake



Conclusions

- N mineralization is highly temperature dependent
- Incorporation of vegetable residues results in bursts in N mineralization
- In organic systems, soil nitrate often needs to accumulate pre-plant to meet the high demand during the season
- Risk of leaching with pre- or early season irrigation
- Leaching with winter rains a major concern when residue is incorporated in fall

The 6 Rs of N management in irrigated agriculture



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