Soil fertility in organic systems: lessons from long-term studies

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Talking points

- Organic agriculture: quality over production
- Managing soil fertility in organic systems
  - Soil organic matter
- Organic and crop rotation effects on soil
- Manipulating nutrient availability
- **Nutrient issues in organic systems**

Agricultural drivers

	Last Century	Today
Economics	-Increasing yield → -Solving resource issues → -Land expansion	-Genetic manipulation -Biological property issues -Food processing
Social	-Increasing population → -Food supply →	-Human health -Poverty -Animal rights -Food safety Organic production
Environment	-Water quality → -Pesticides	-Water quality -Air quality -Greenhouse gas emissions -pesticides

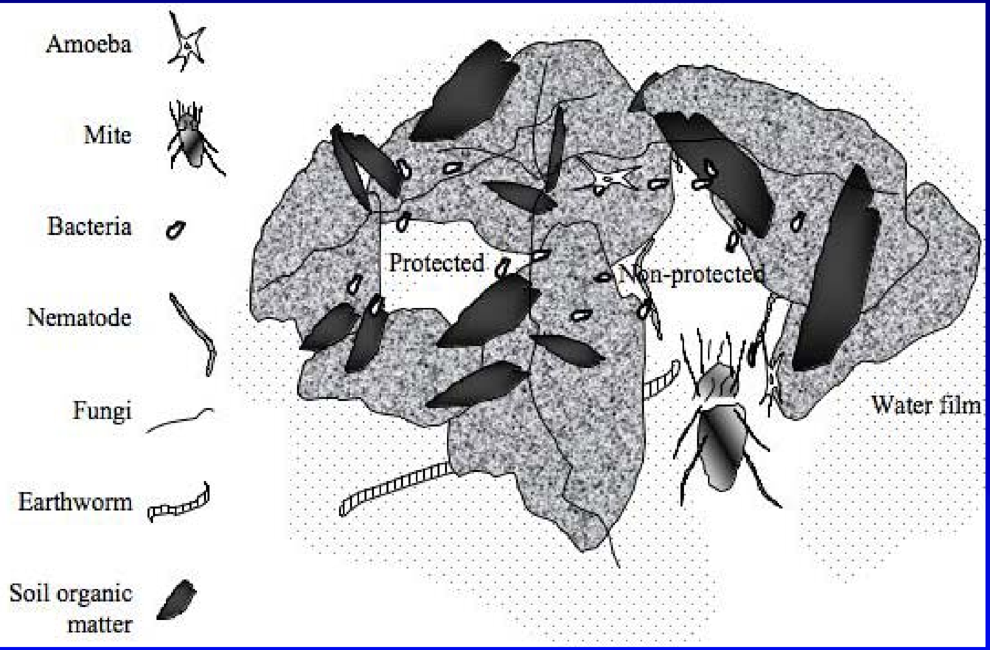
Converting to organic systems

- Challenge is to use fertilizers with variable nutrient contents
- Nutrient availability is also inconsistent
- Key to organic fertilizer management is to realize that nutrient demand is likely not met on an annual basis.

Managing long-term nutrient availability

- Key is to manage not only the amount of soil organic matter but also the rate and timing of nutrient release

Soil Organic Matter

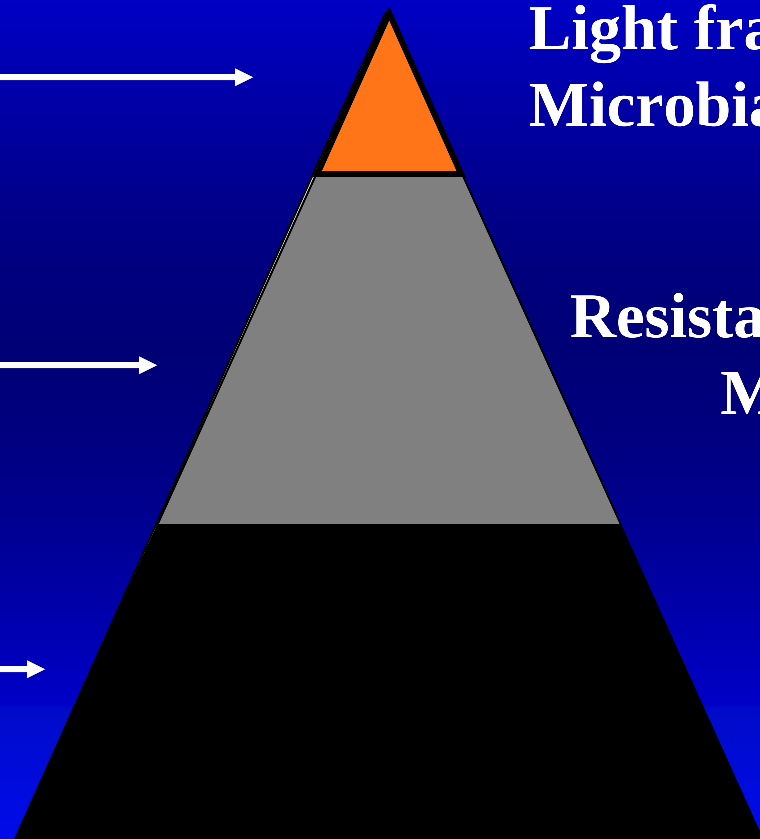


- Cation Ion Exchange capacity
    - 300 to 700 cmol(+)/kg
- Capacity to chelate metals
- Enhance soil physical properties
    - Water Holding capacity
- Source of nutrients
    - C/N/S/P = 100/10/1/1
- Positive influence on soil properties

Soil Organic Matter

Labile SOM
Active fraction
~2 year old

Light fraction/
Microbial biomass



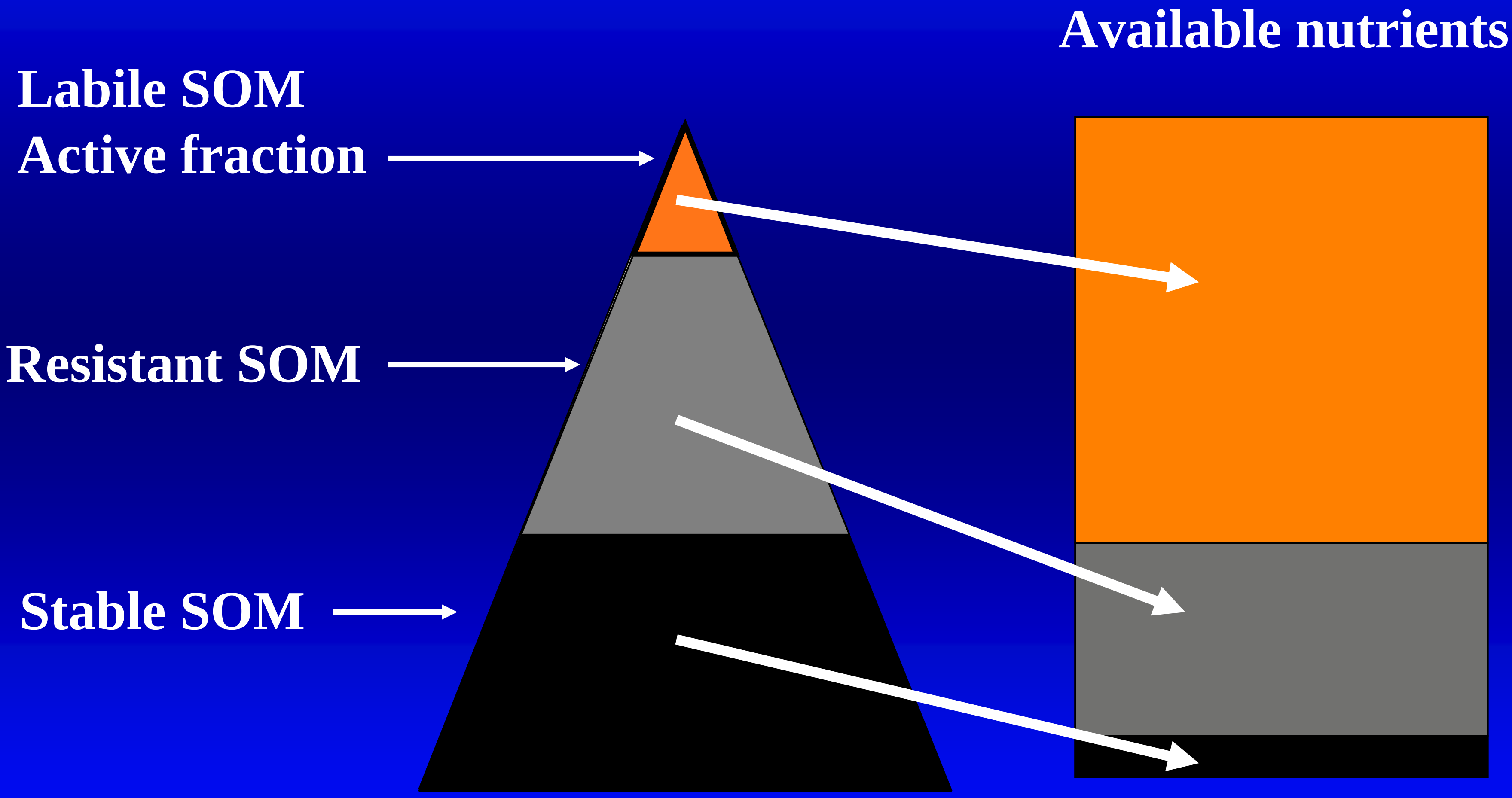
Resistant SOM
~5 to 100 years old

Resistant Organic Matter

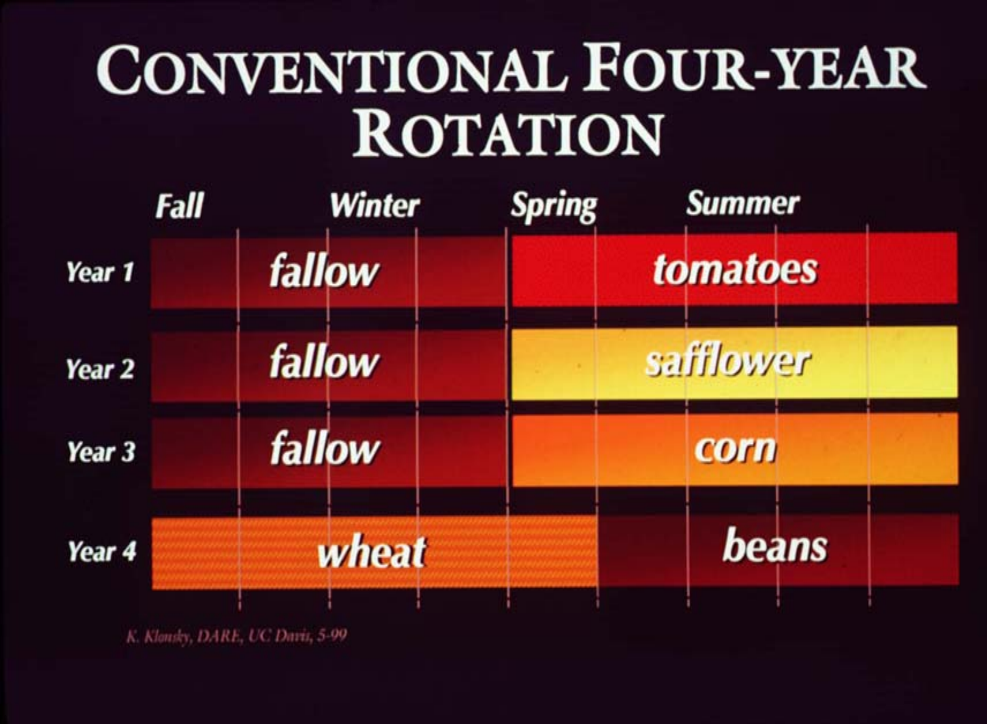
Stable SOM
>1000 years old

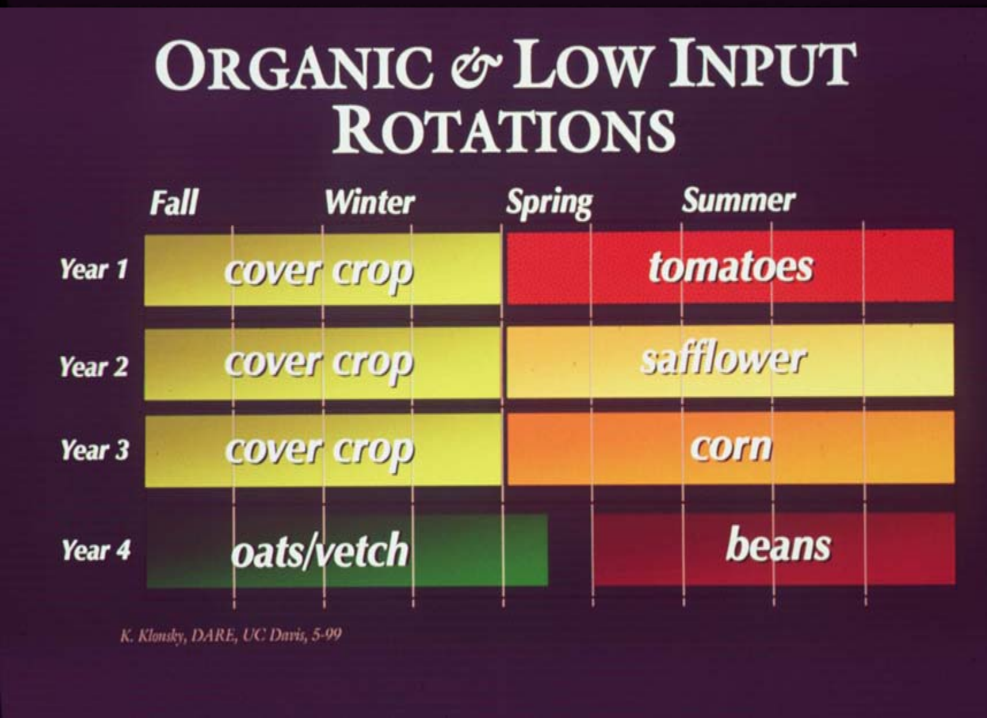
Very Stable Organic Matter

Contribution of Soil Organic Matter Fractions To available soil nitrogen



Organic and crop rotation effects on soil


CONVENTIONAL FOUR-YEAR ROTATION
Fall
Winter
Spring
Summer
Year 1
fallow
tomatoes
Year 2
fallow
safflower
Year 3
fallow
corn
Year 4
wheat
beans
K. Klonsky, DARE, UC Davis, 5-99


ORGANIC & LOW INPUT ROTATIONS
Fall
Winter
Spring
Summer
Year 1
cover crop
tomatoes
Year 2
cover crop
safflower
Year 3
cover crop
corn
Year 4
oats/vetch
beans
K. Klonsky, DARE, UC Davis, 5-99


SUSTAINABLE FARMING SYSTEMS
A UC DAVIS PROJECT COMPARING CONVENTIONAL AND LOW-INPUT SYSTEMS
INITIATED IN 1989

Soil C and N in Sustainable Agriculture Farming System project under different management.

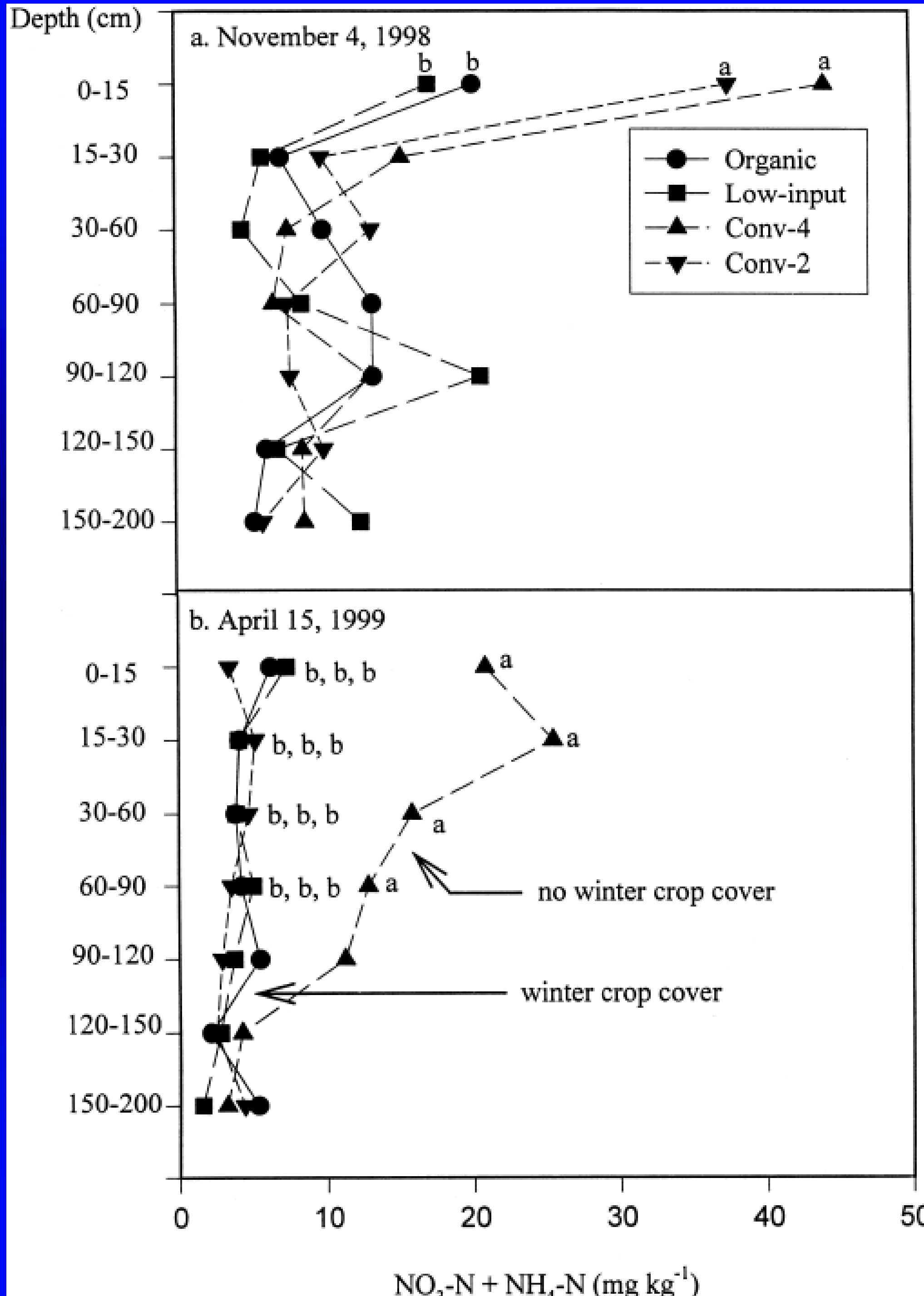
System	*Soil %C* Fall 1988	Fall 1996	Fall 2000	*Soil %N* Fall 1996	Fall 2000
Organic	0.83	1.08	1.13	0.117	0.116
Low-input	0.83	1.03	1.04	0.111	0.107
Conv-4	0.83	0.90	0.92	0.094	0.095
Conv-2	0.83	0.84	0.88	0.092	0.094

Carbon

Organic 5.3 t C ha^{-1}
Cover crop 3.4 t C ha^{-1}

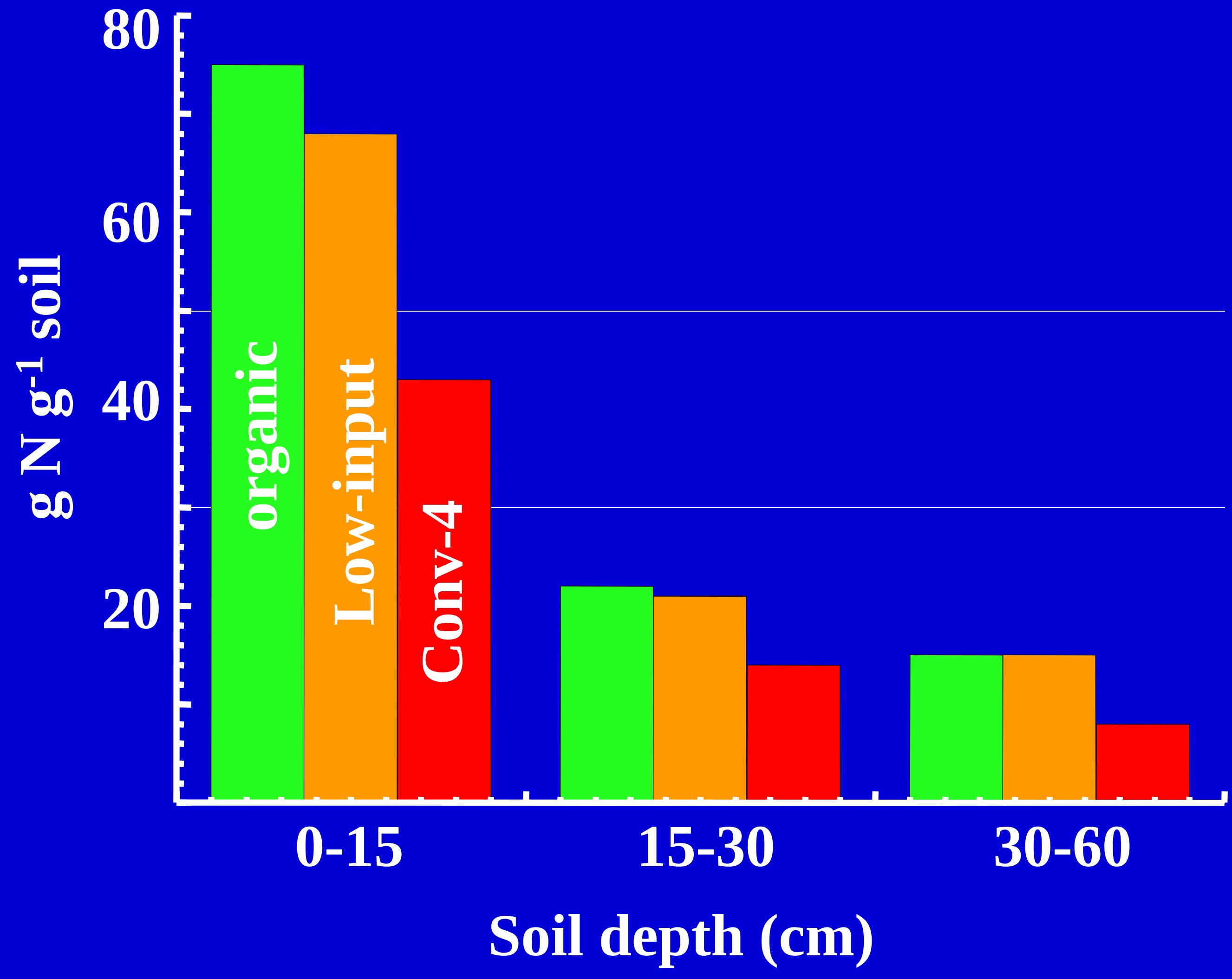
Nitrogen

Organic 462 kg N ha^{-1}
Cover crop 273 kg N ha^{-1}



Depth (cm)
a. November 4, 1998
0-15
15-30
30-60
60-90
90-120
120-150
150-200
b b a a
Organic
Low-input
Conv-4
Conv-2
b. April 15, 1999
b, b, b
a
no winter crop cover
winter crop cover
0
10
20
30
40
50
NO3-N + NH4-N (mg kg-1)

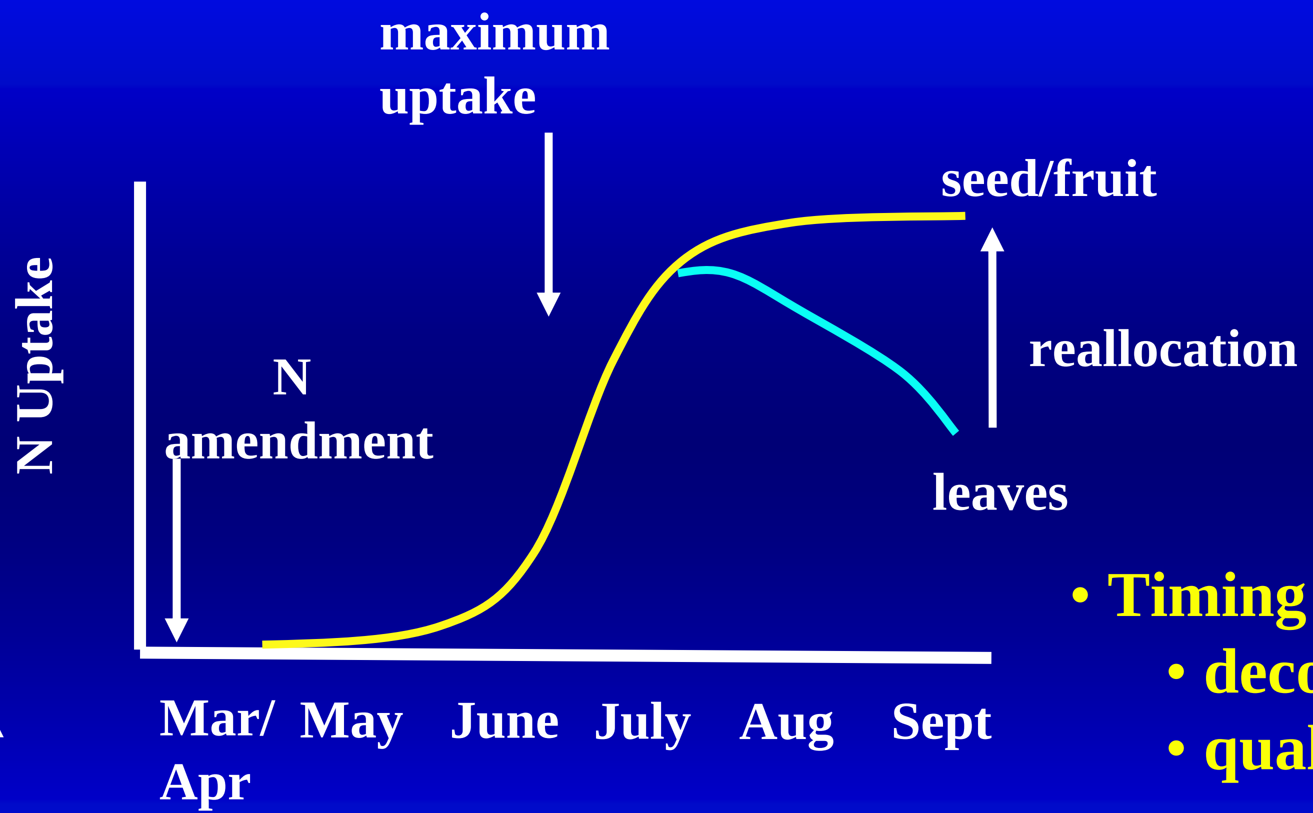
Microbial Biomass after 10 years of management at SAFS



Nutrient availability

Soil Carbon Change over 10 years

Fertilizer & Soil N availability and synchrony



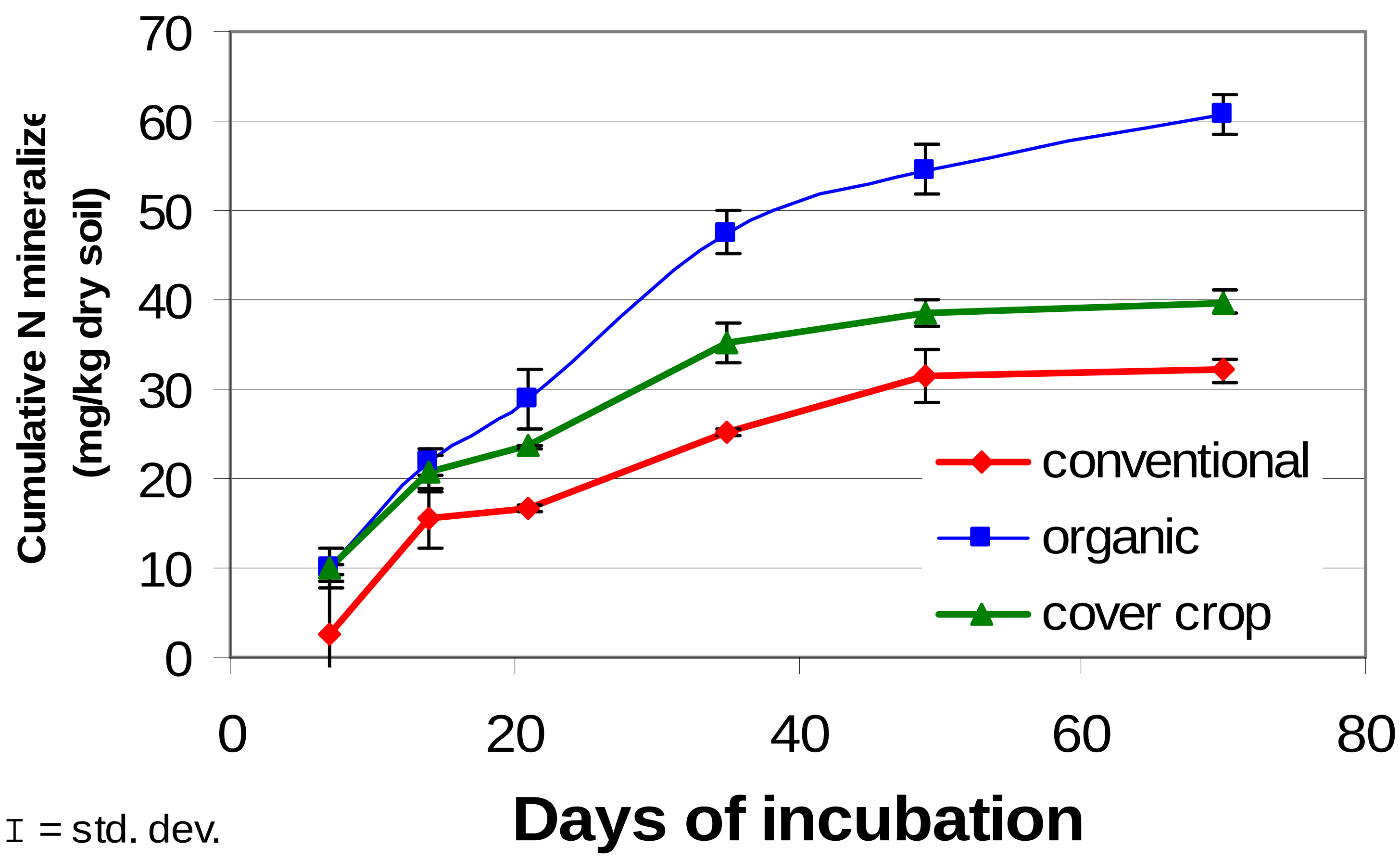
- Timing of incorporation
  - decomposition
  - quality (C/N)
  - amount

incorporate

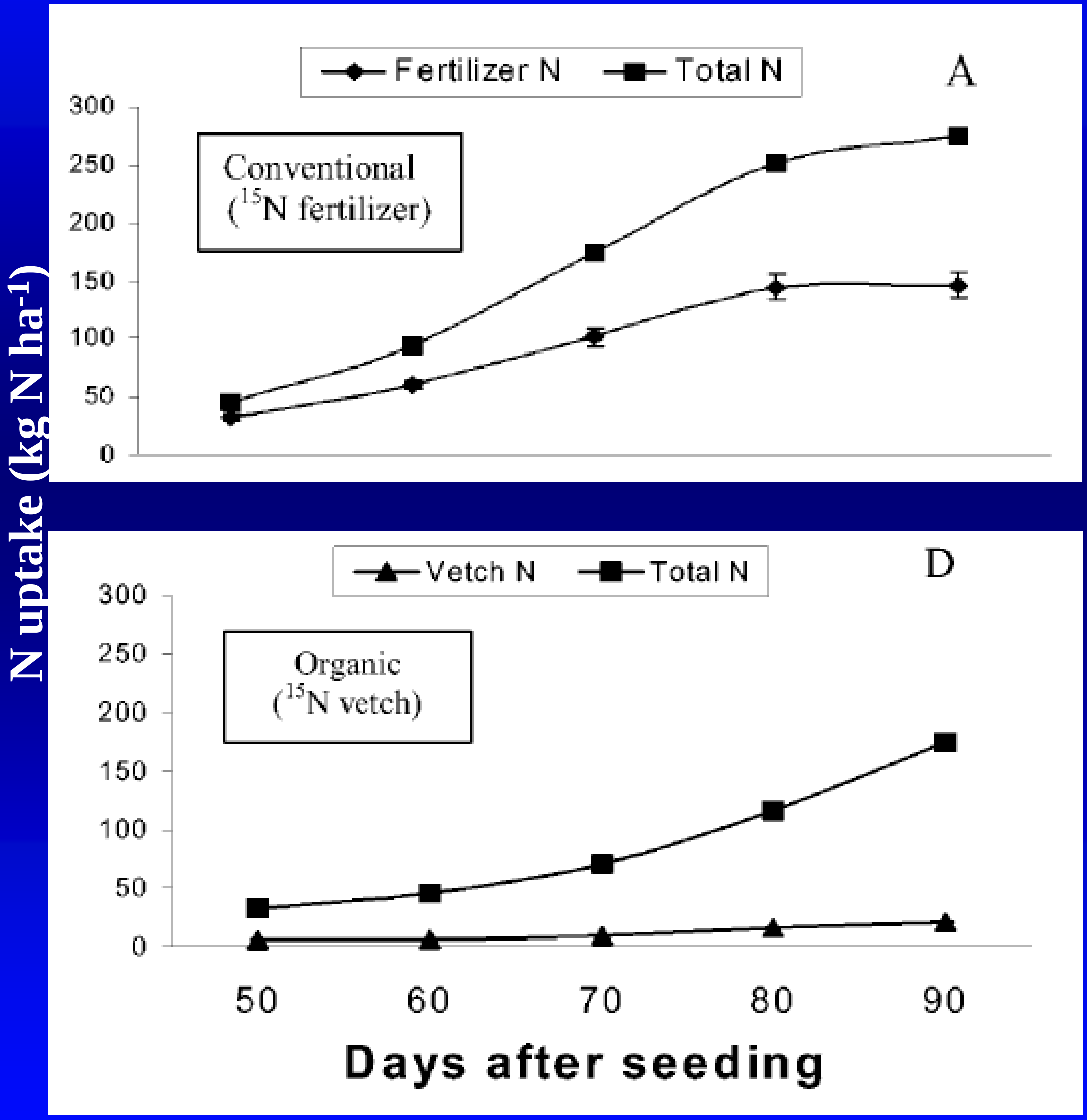
availability

Cover crop/organic amendment

Nitrogen mineralization potential in different Farming Systems



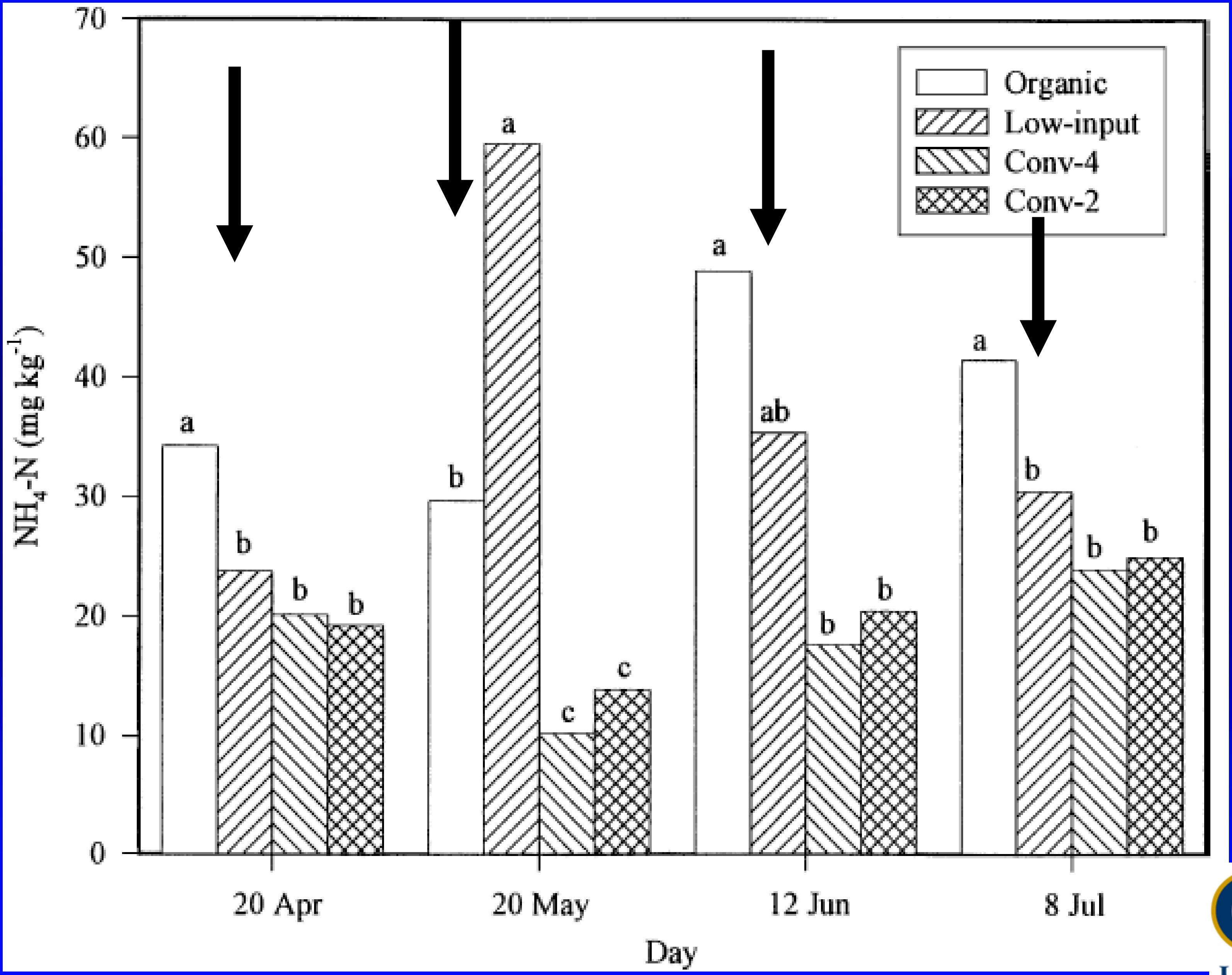
N requirement varies depending on cropping system SAFS



	CONV	ORG
Grain Yield (kg ha^{-1})	11,930a	11,500a
Total N uptake (kg ha^{-1})	270a	180b
Yield/ N uptake	44.2	63.9

Critical N concentration varies by cropping system

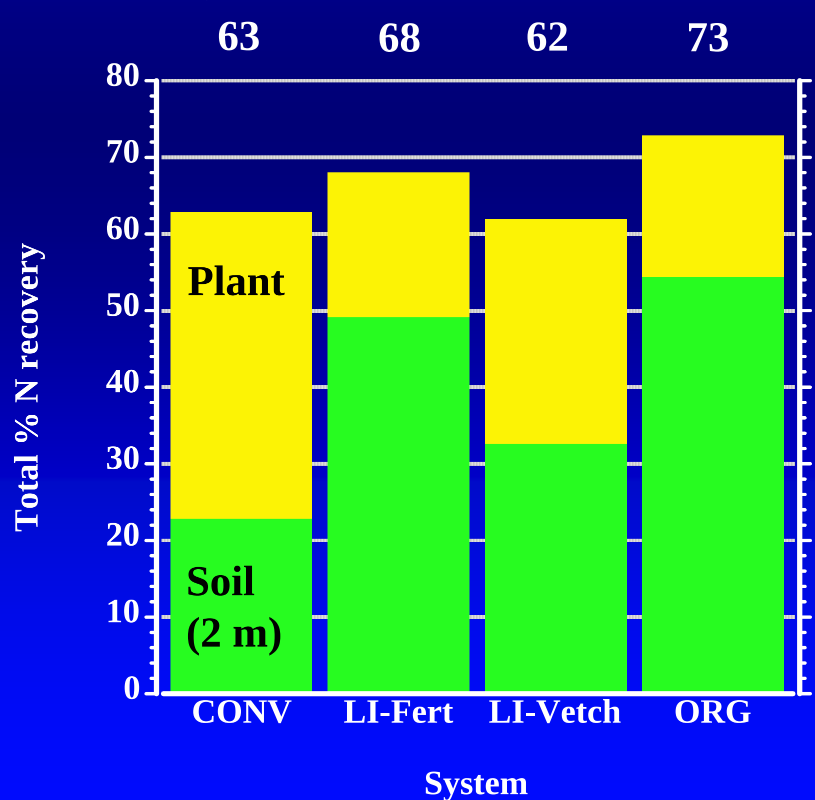
Mineralizable N over growing season



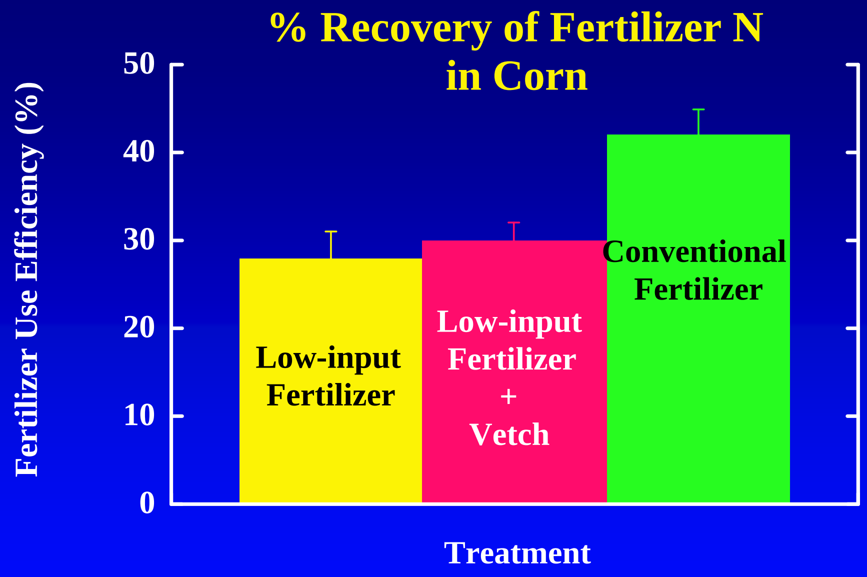
Systems recovery of N using stable N isotope methods
SAFS

N allocation differs by system

No significant difference in N recovery

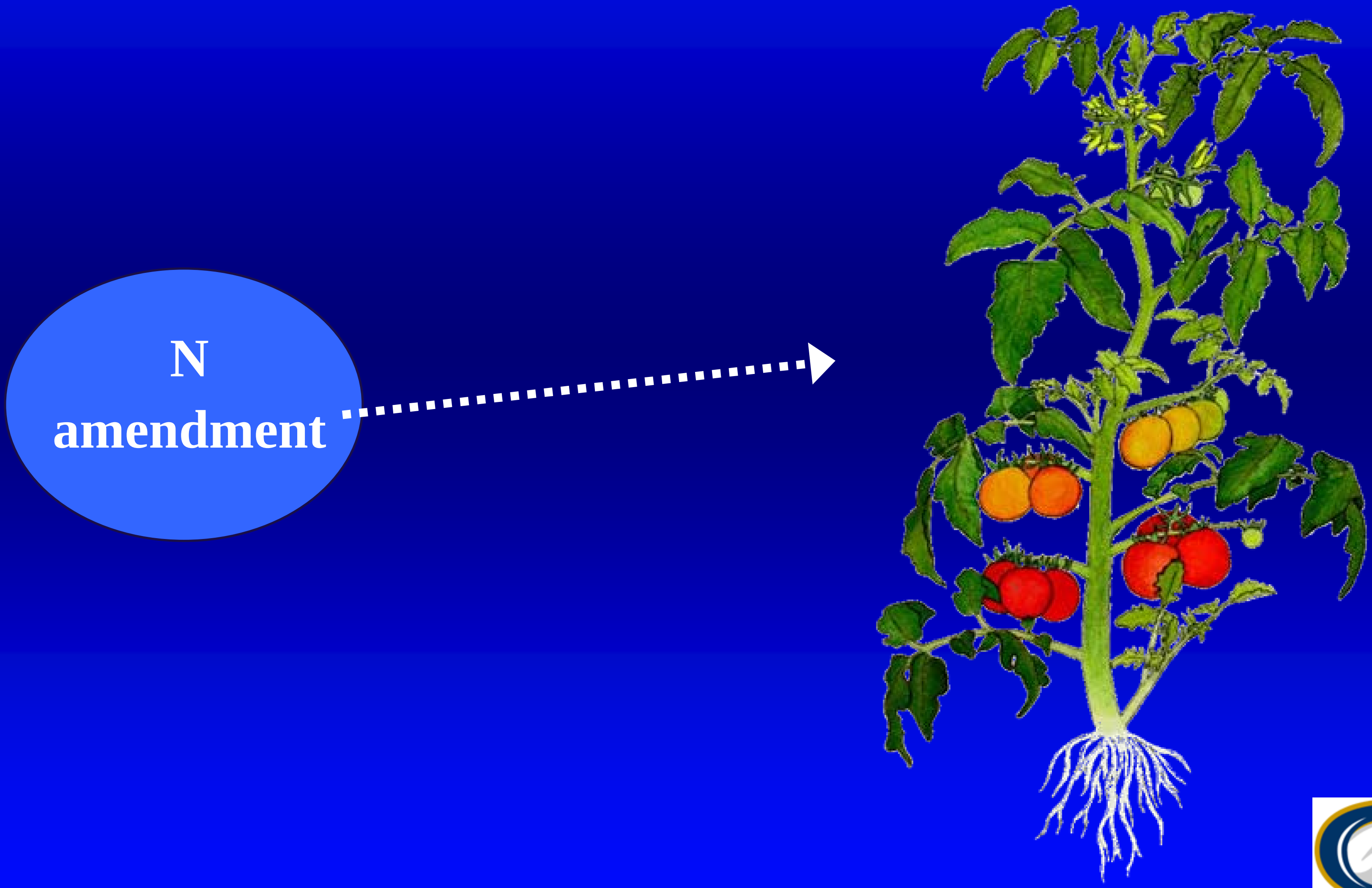


Fertilizer use highest in conventional management



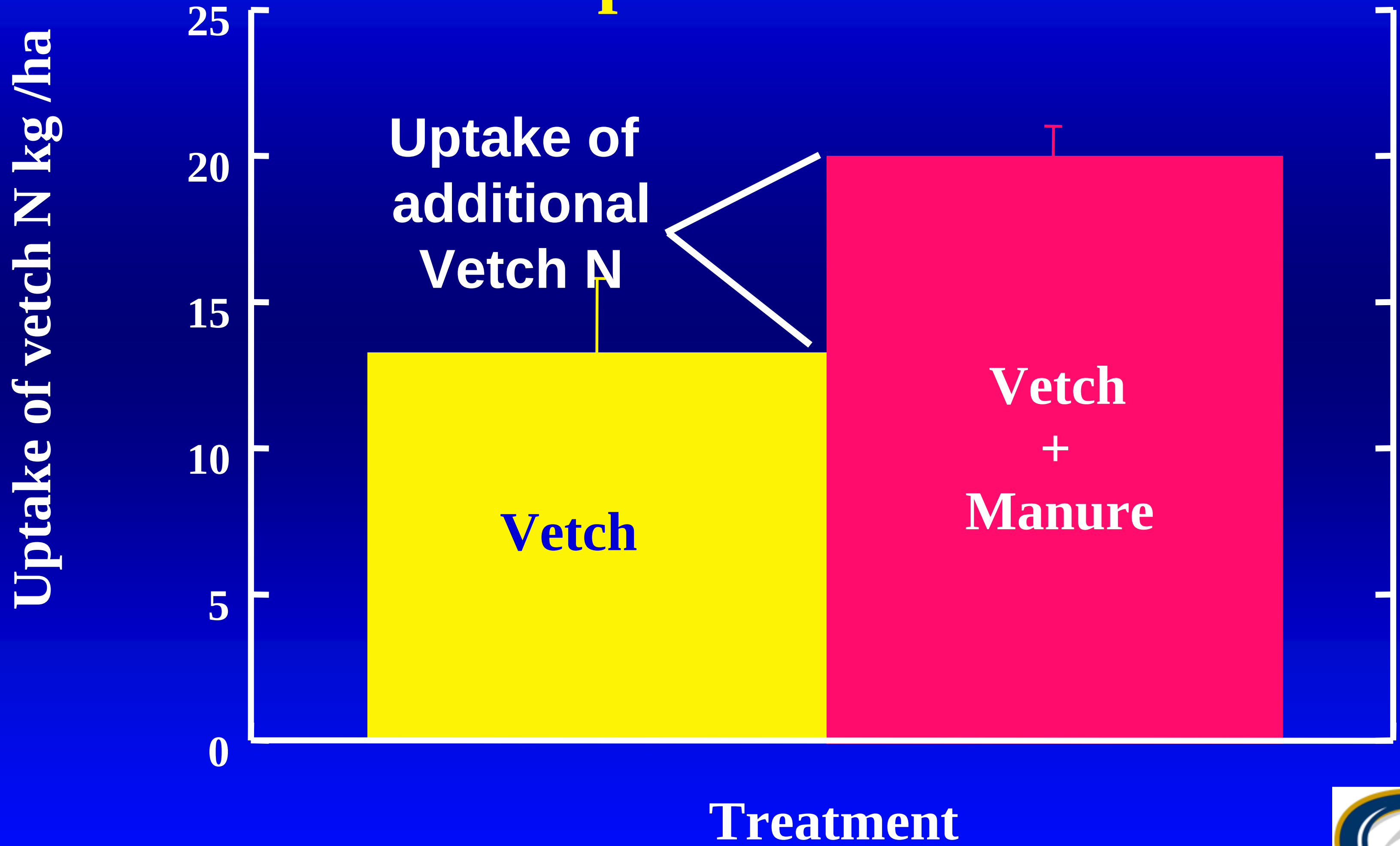
Manipulating nutrient availability

Fertilizer and Soil N Availability

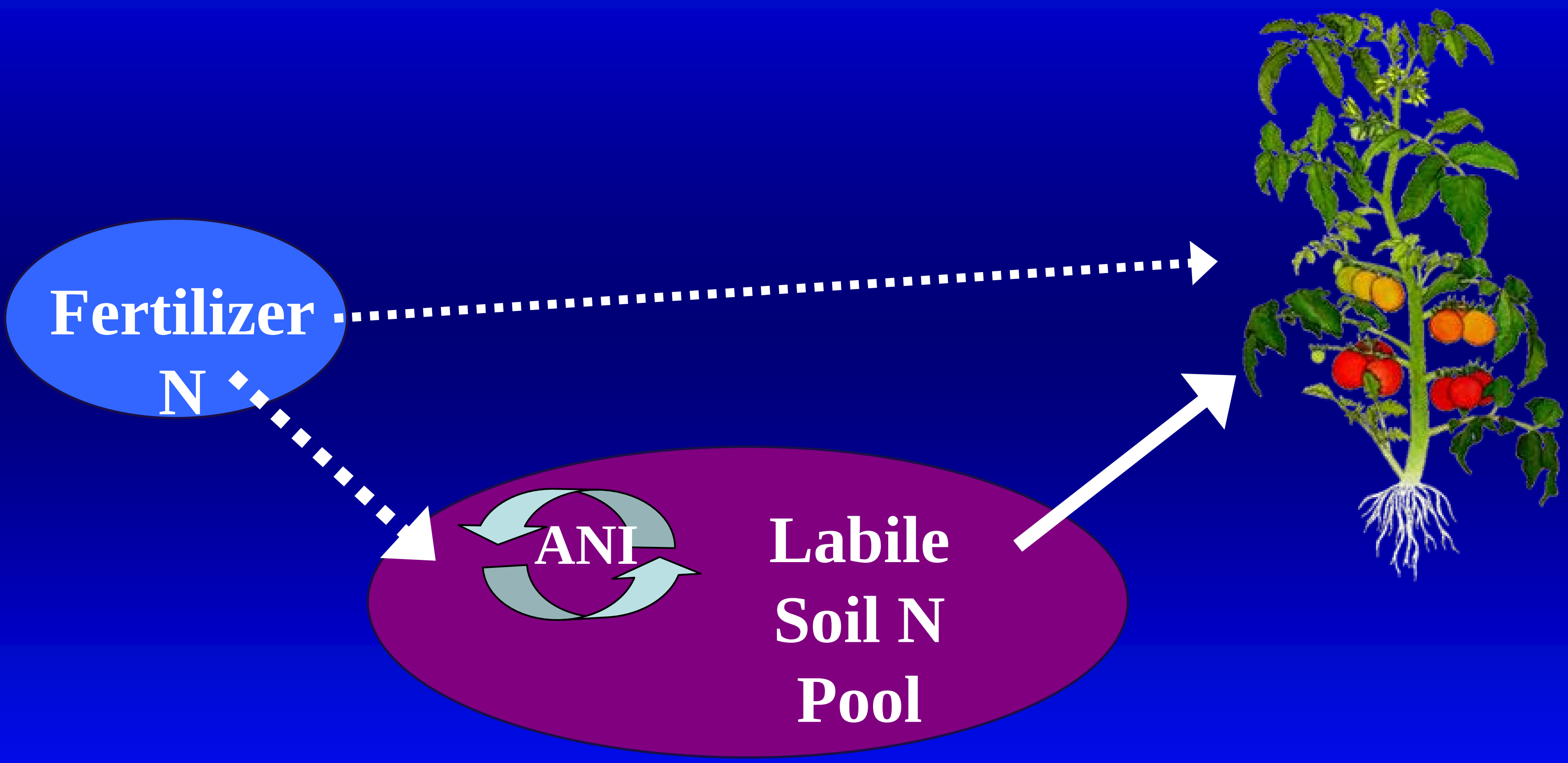


SAFS

Organic Rotation
Uptake of Vetch N

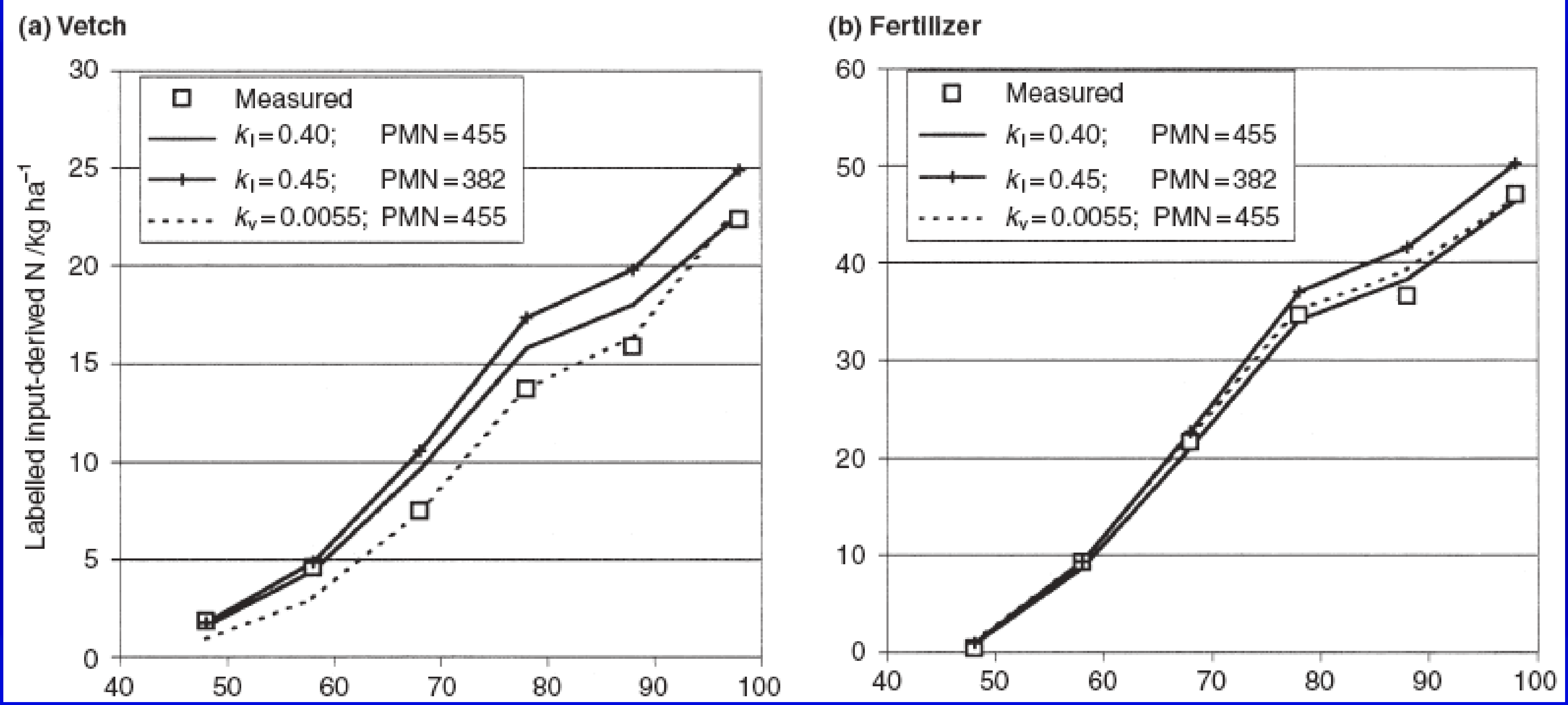


Fertilizer and Soil N Availability



How does cropping system management change pathways and allocation?

Uptake of vetch N compared to fertilizer N

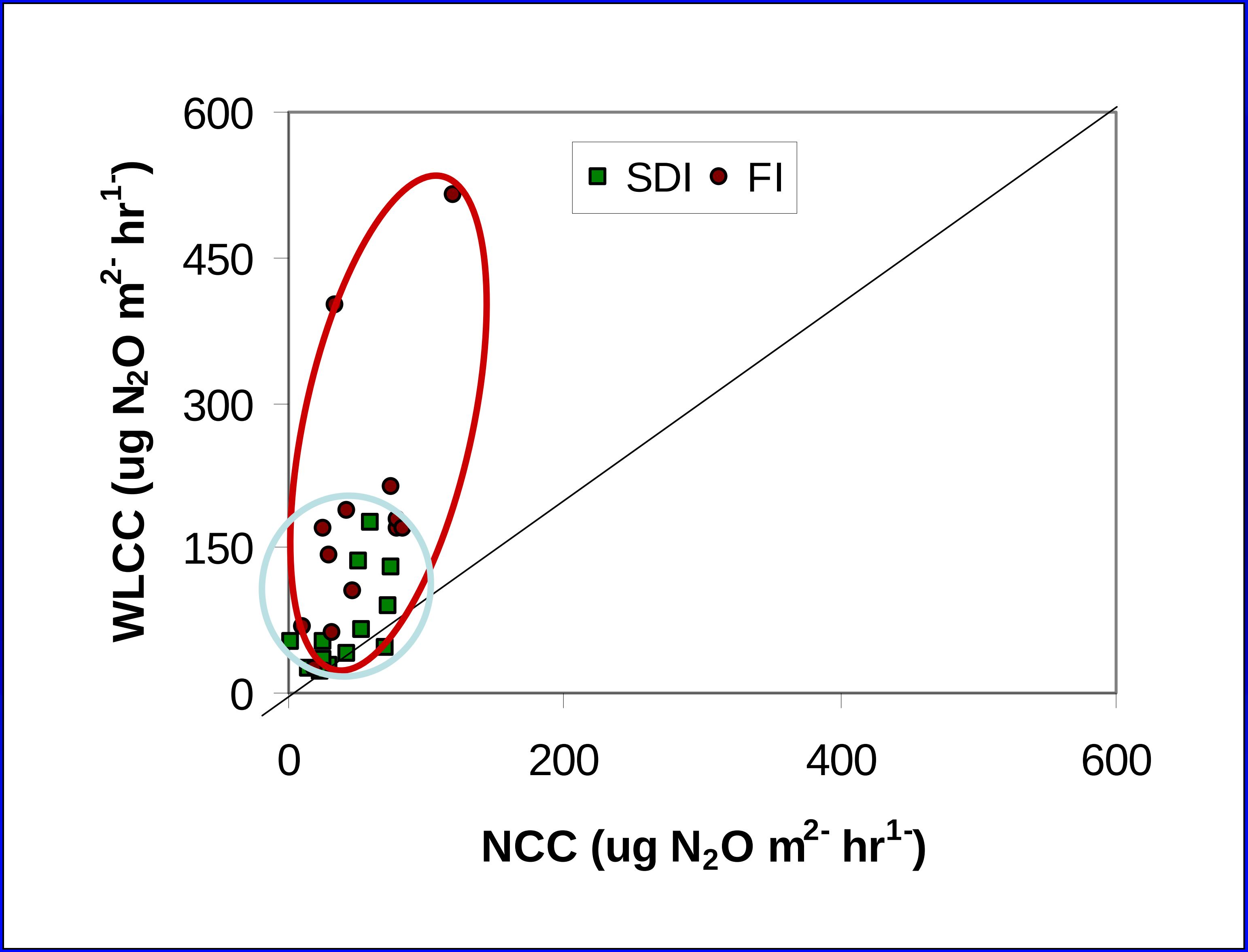


Nutrient issues in organic systems

Average yield (ton ha^{-1}) of tomato among different cropping systems.

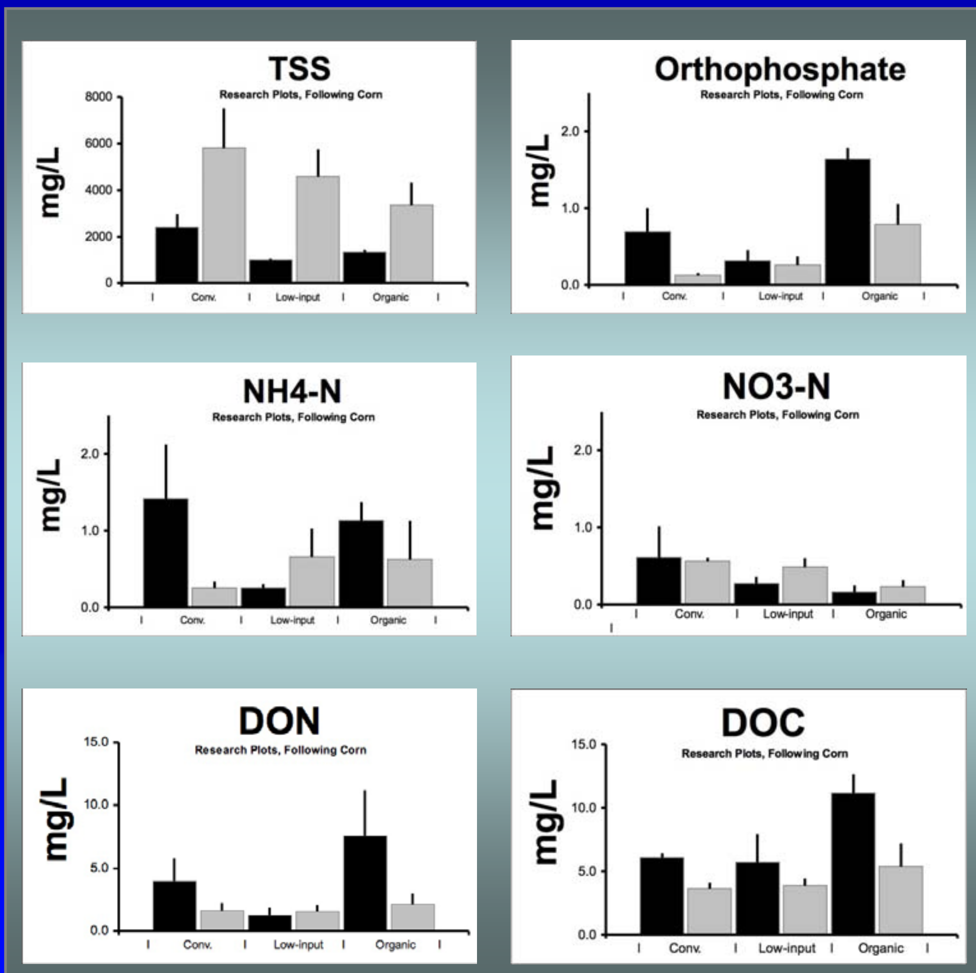
Cropping System	Marketable Yield	Unmarketable Yield	Total Yield
Conventional	72.2	19.7	91.9
Low-input	72.6	25.4	98.0
Organic	69.0	26.9	95.9

Point N_2O Emissions from SDI and FI (µg m^{-2} h^{-1}) Compared by Cover Crop Treatment



Runoff Water Quality
Seasonal Volume-Weighted Average Concentration

Standard Tillage | **Conservation Tillage**



- **TSS CT > ST**

All Other Constituents
<u>of Concern (COC)</u>

- **No substantial difference between treatments**
- **Orthophosphate, NH4-N, NO3-N all below 2mg/L**

Summary

- **With appropriate combination of amendments sufficient amount and synchrony of nutrient delivery can be achieved**
  - **Limiting factor is the soil can only store finite N**
  - **Key is to manipulate the size of mineralizable N pool**
- **Interactions of amendments with other amendments and soil nutrient pools needs further research to fine tune nutrient delivery**
- **Organic management can impact the environment**