Soil and Plant Testing For Reducing Nitrogen Losses from Croplands

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Plant and soil tests

- Soil testing

To determine the proper fertilization for plants to be grown

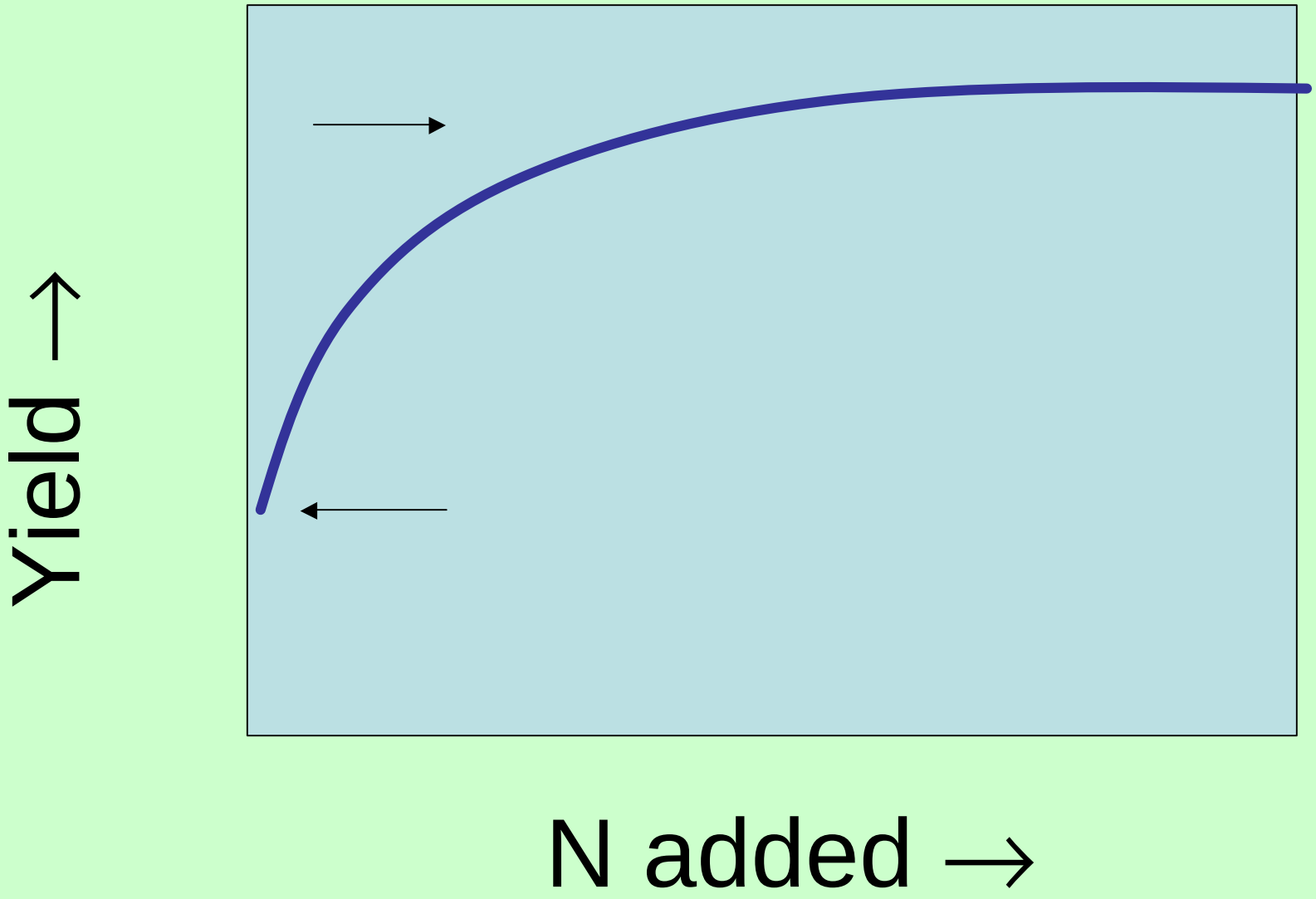
- Nutrient management plans

Conservation planning tool. “The process integrates ecological (natural resource), economic, and production considerations in meeting both the owner's/operator's objectives and the public's natural resource protection needs.”

University based recommendations

- Desire for simplicity
- Wide applicability
- Emphasis on crop yield
- Don’t consider cost of over application

“Question is not whether it is working but whether approach is reasonable”


Yield →
N added →

Estimates of labile organic N generated in the laboratory using:

1) a variety of extraction/solvation techniques where solution chemistry and reaction conditions vary in their intensity,
2) oxidation strategies,
3) incubation,
4) hydrolysis methods

Field based estimates of labile N

1) plant based measures

- plant productivity- N uptake from unfertilized soil, of labeled fertilizer etc., field N balance studies
- plant N content; stalk N tests
- optical properties; chlorophyll meters
- species specific response to N abundance and form (eg: Ellenberg N values, functional N index for plant species)

2) *in situ* incubation strategies to quantify NO_3 and NH_4 accumulation

- timely sampling of inorganic N (eg: PSNT)
- buried bags cores, lysimeters, or on exchange resins
- conductivity based estimates of NO_3

Variable N Application for Irrigated Corn:
Nitrogen-use Efficiency and Yield Potential

J.P. Schmidt,

The recommended N application for maize
(Kansas State University, AES and CES, 1994)

- Nrec = (YG x 1.35) STA - PCA - PYM -PNST

- Nrec = N recommendation (lb N acre -1)
- YG = yield goal (bu acre -1)
- STA = soil texture adjustment,
- PCA = previous crop adjustment (lb N acre -1),
- PYM = previous years manure (lb N acre -1),
- and PNST = profile N soil test (lb N acre -1).

SOIL-NITROGEN TEST FOR IMPROVED RECOMMENDATIONS FOR CORN

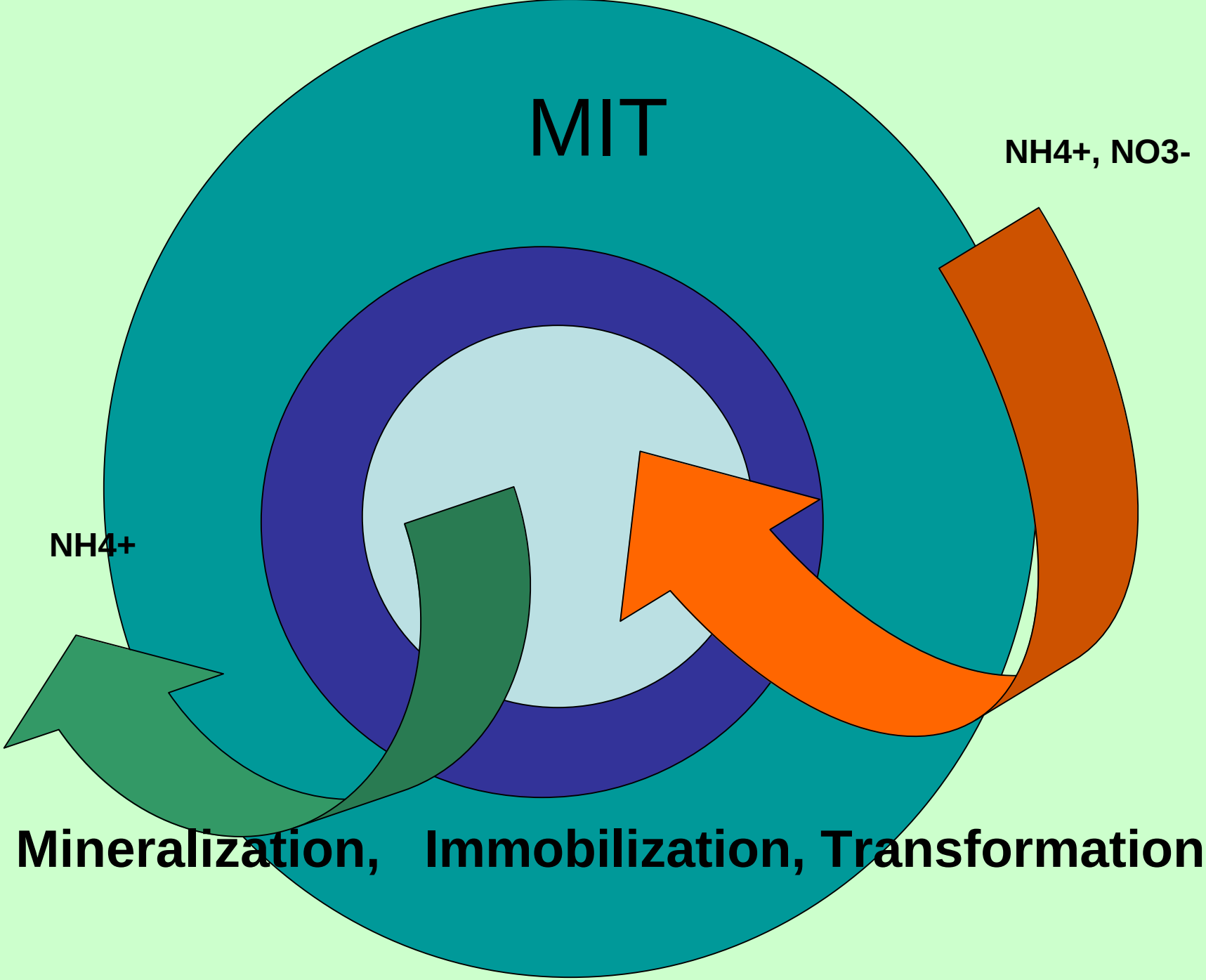
SCHMITT

- Nitrogen rate response experiments were conducted at 54 sites throughout the corn-growing region of Minnesota from 1989 through 1992.

- Nitrate-N concentration in the surface 2 ft taken in the spring before planting provided a sound, useable relationship for a soil N test (R2 = 0.51)

- A linear relationship R2 = 0.51 was measured between soil nitrate-N in the proposed N test and soil N credit.

- Soil N credit was calculated for each site-year by subtracting the optimum N rate, which was measured experimentally, from the tabular N recommendation presently used


MIT
NH4+, NO3-
NH4+
Mineralization, Immobilization, Transformation

Mineralization

$$\text{complex proteins} \rightarrow R\text{-}NH_2 \xleftrightarrow{2H_2O} NH_4^+ + R\text{-}OH$$

- **Laboratory incubations**
  - Timing
  - Moisture and drainage
  - Duration
  - Biotic composition

$$\text{Net N production} = No(1-e^{-kt})$$

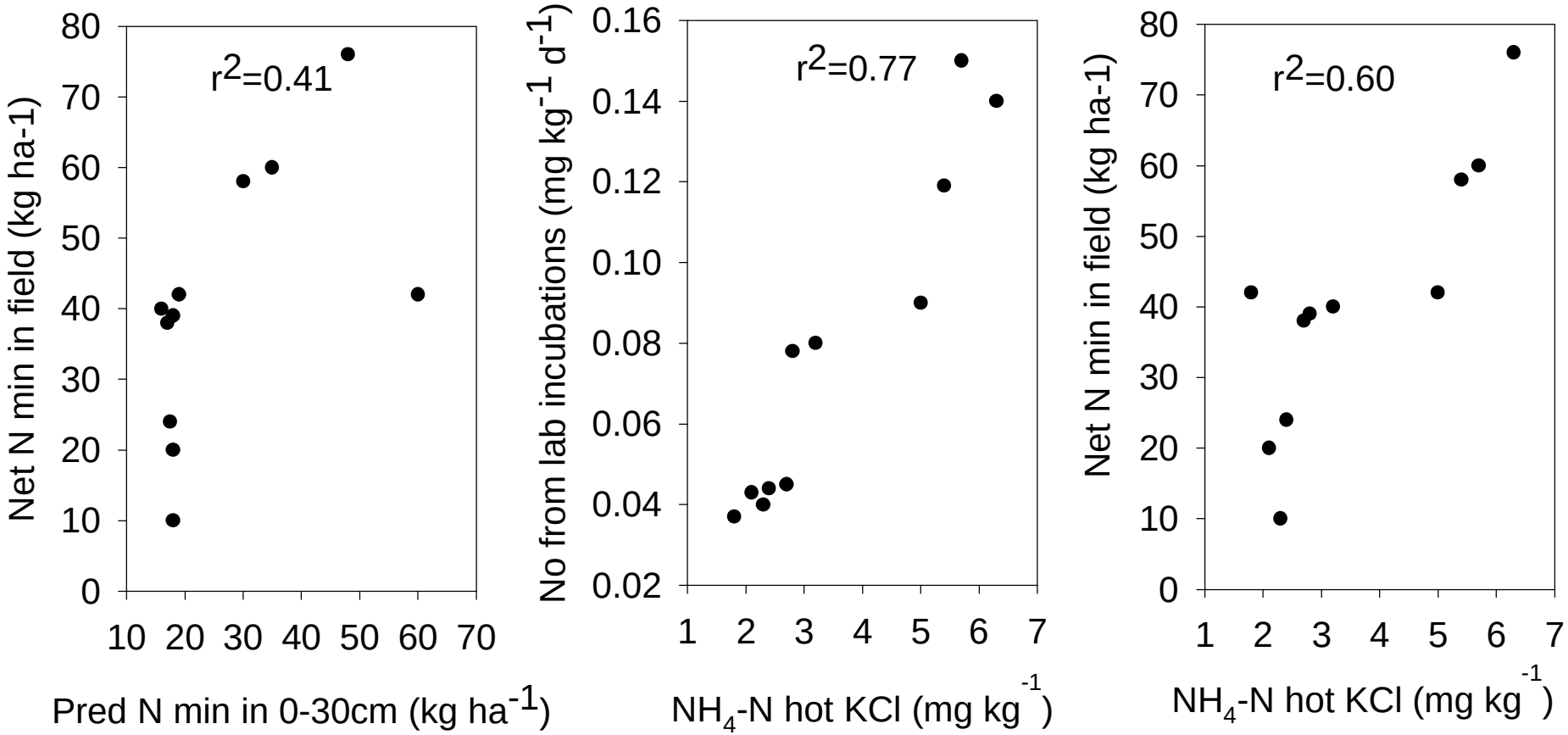
Model using simple functional approaches or mechanistically including C and N cycling through microbial biomass (Benbi and Ritcher, 2002)

Evaluating rapid methods

Index	CO_2 3d	Hot KCl	N min 24d	SMB C	TC	TN
$Ca(ClO)_2$	0.85	0.93	0.77	0.90	0.95	0.93
CO_2 3d		0.85	0.80	0.90	0.83	0.83
Hot KCl			0.79	092	0.91	0.89
N-min 24				0.74	0.73	0.72
SMBC					0.90	0.91
TC						0.96

Picone et al. 2002

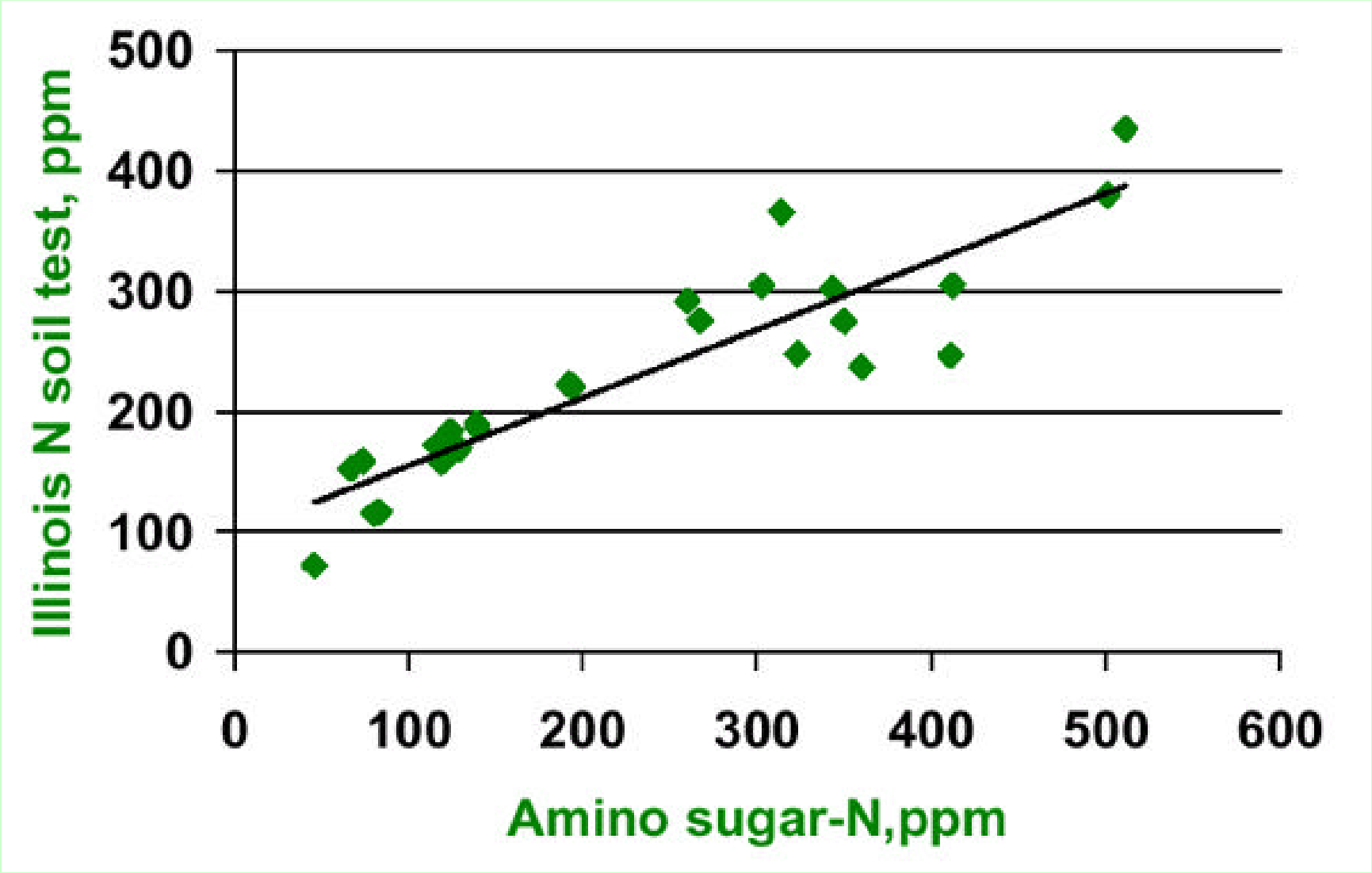
Relate Lab to Field

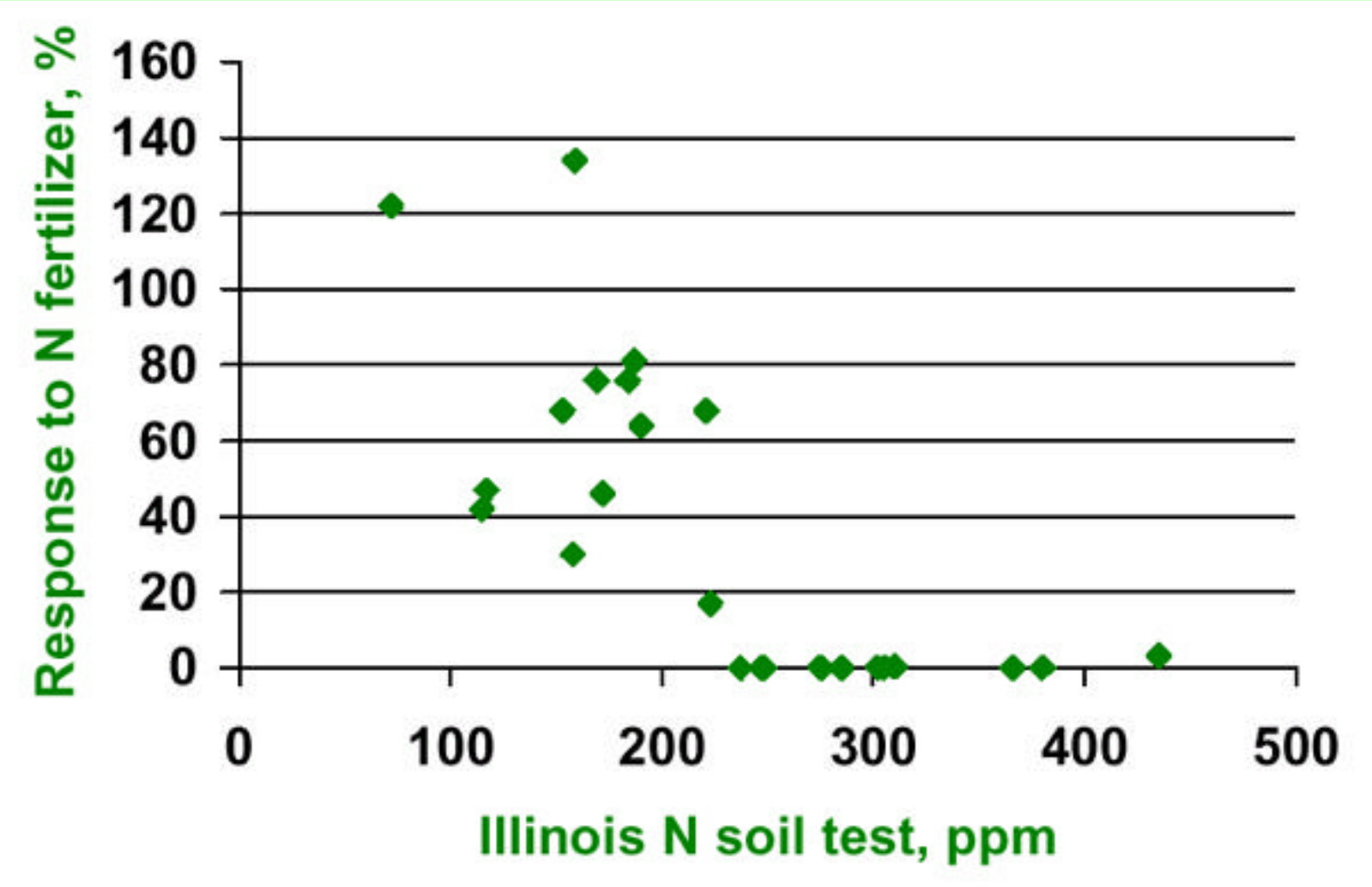


Egelkraut et al. 2003

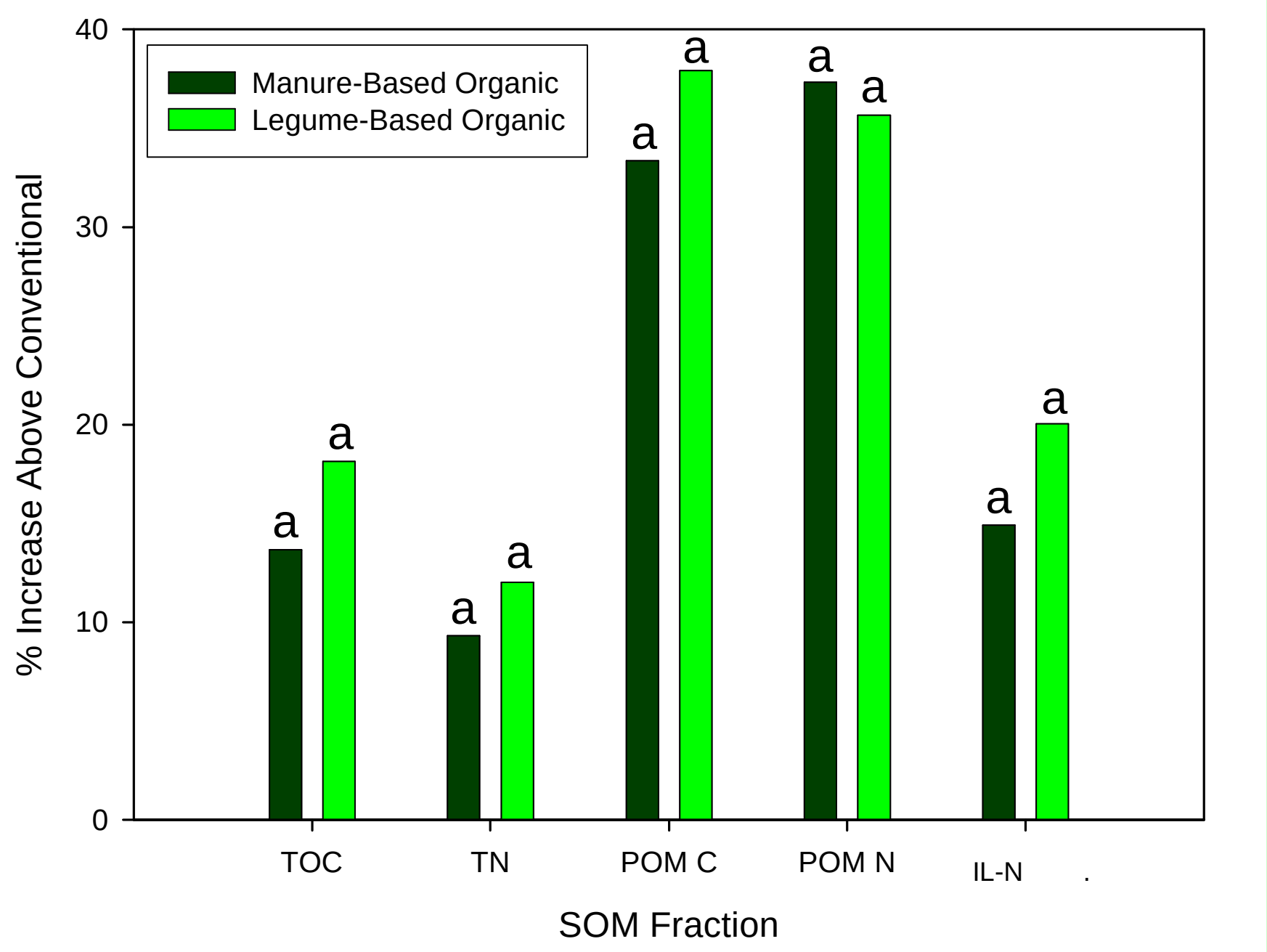
Bundy and Andraski (2004) - Wheat in MN-

Time sampling	Test	Depth	R2 linear response plateau EONR
Preplant (Sept)	UV200- NaHCO3	30	0.28
	UV260- NaHCO3	30	0.09
	NO3-N- 2M KCl	30	0.36
	“	60	0.46
	“	90	**0.53**
Predorm (Nov)	NO3-N	30	0.20
	“	60	0.32
	“	90	0.44
GS 25 (April)	NO3-N	30	0.12
	“	60	0.16
	“	90	0.21
GS 30 (April)	Plant N uptake		0.26
	Tissue N		0.13
	Minolta SPAD		0.12


Illinois N soil test, ppm
500
400
300
200
100
0
0
100
200
300
400
500
600
Amino sugar-N,ppm

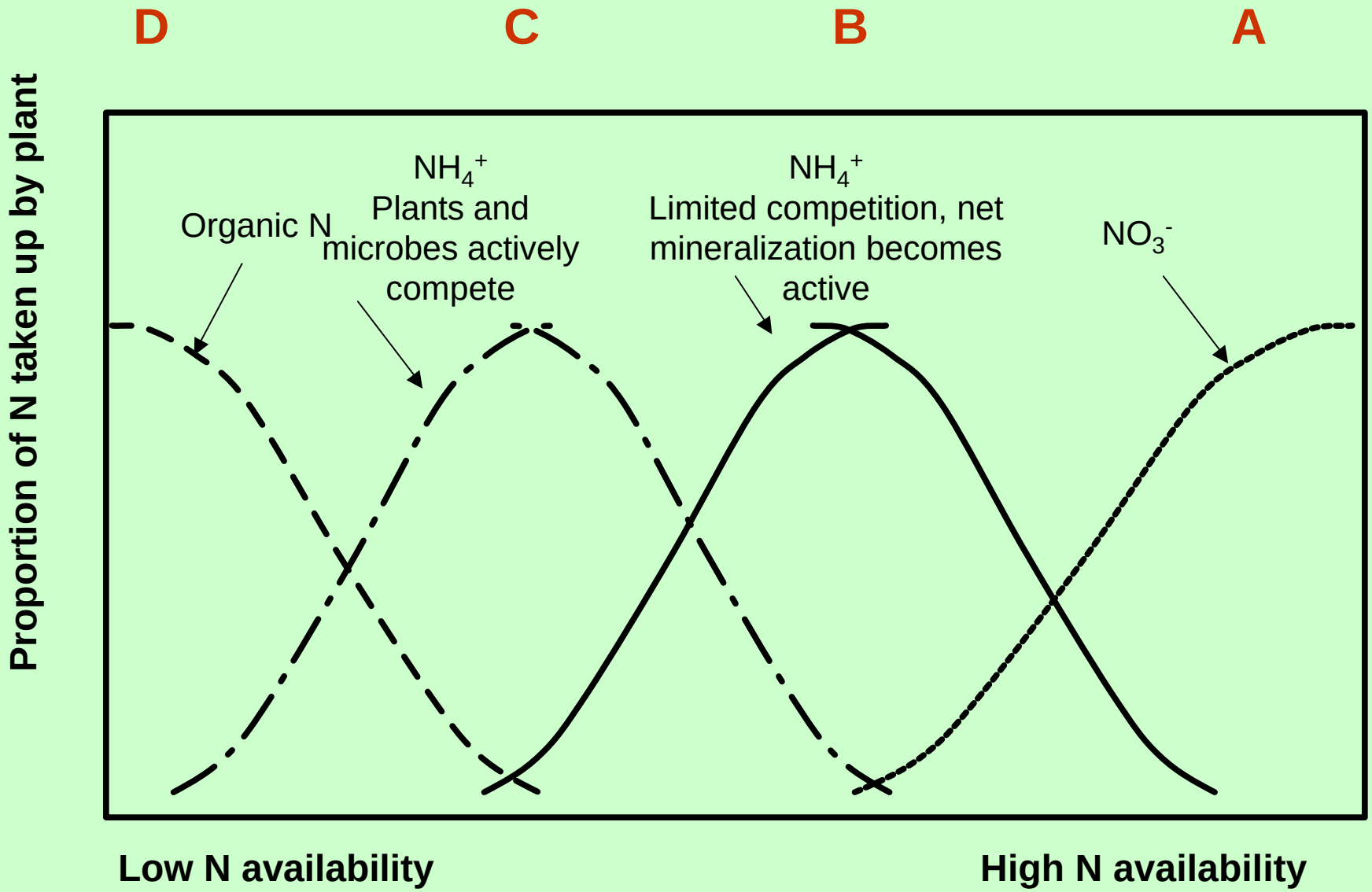


Mulvaney et al. (2001); Mulvaney and Khan (2001)

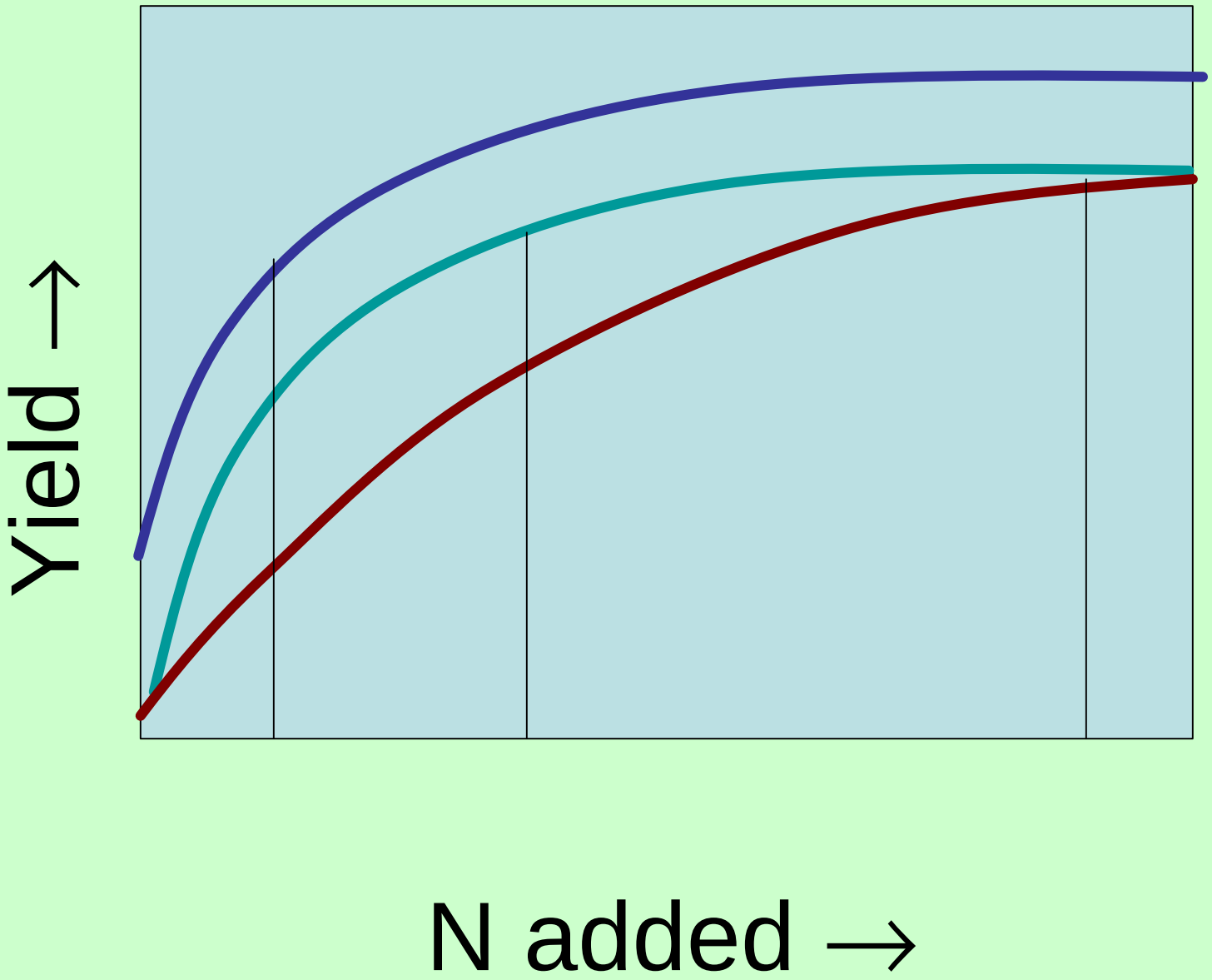

Manure-Based Organic
Legume-Based Organic
% Increase Above Conventional
40
30
20
10
0
a
a
a
a
a
a
a
a
a
a
TOC
TN
POM C
POM N
IL-N
SOM Fraction

Factors influencing stock size

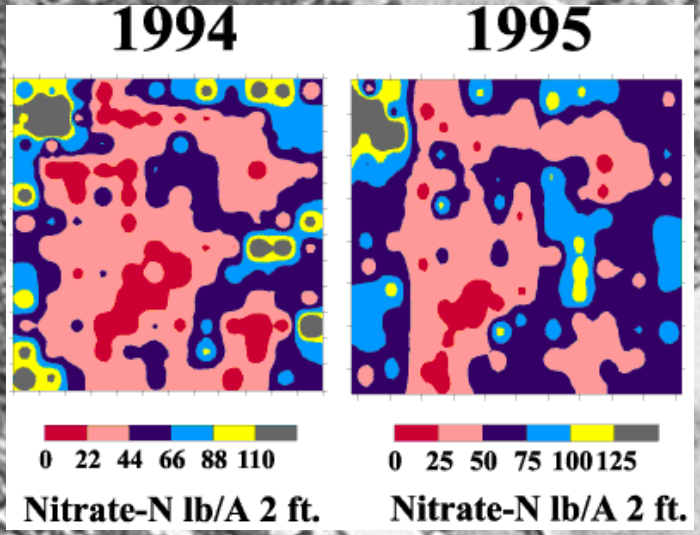
	Model	Partial R^2 values‡				
Dependent variable†	adjusted R^2 value	MAT	MAP	% clay	% silt	age
All systems						
SOC	0.788***	0.211	n.s.	**0.514**	**0.086**	n.a.
IL-N	0.789***	0.239	n.s.	**0.450**	**0.123**	n.a.
POM-C	0.398***	n.s.	0.420	n.s.	n.s.	n.a.
Organic systems						
SOC	0.851***	0.222	n.s.	**0.608**	**0.049**	n.s.
IL-N	0.857***	0.231	n.s.	**0.570**	**0.083**	n.s.
POM-C	0.615***	n.s.	n.s.	n.s.	n.s.	**0.639**

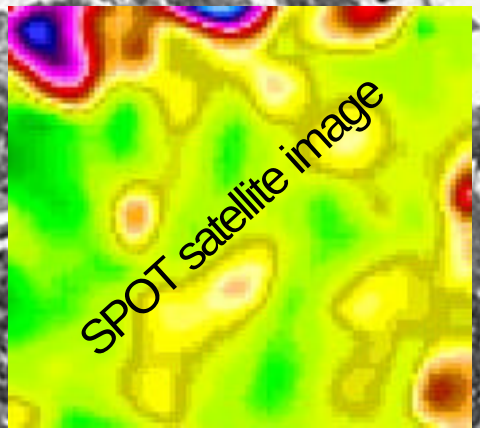


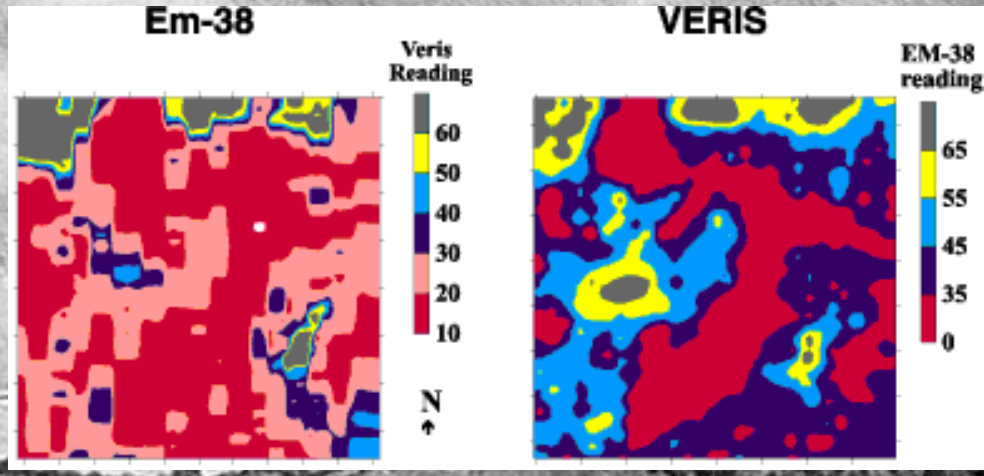
Adapted from Schimel and Bennett, 2004


Yield →
N added →

What test is best?







Tailor management to be site, system specific

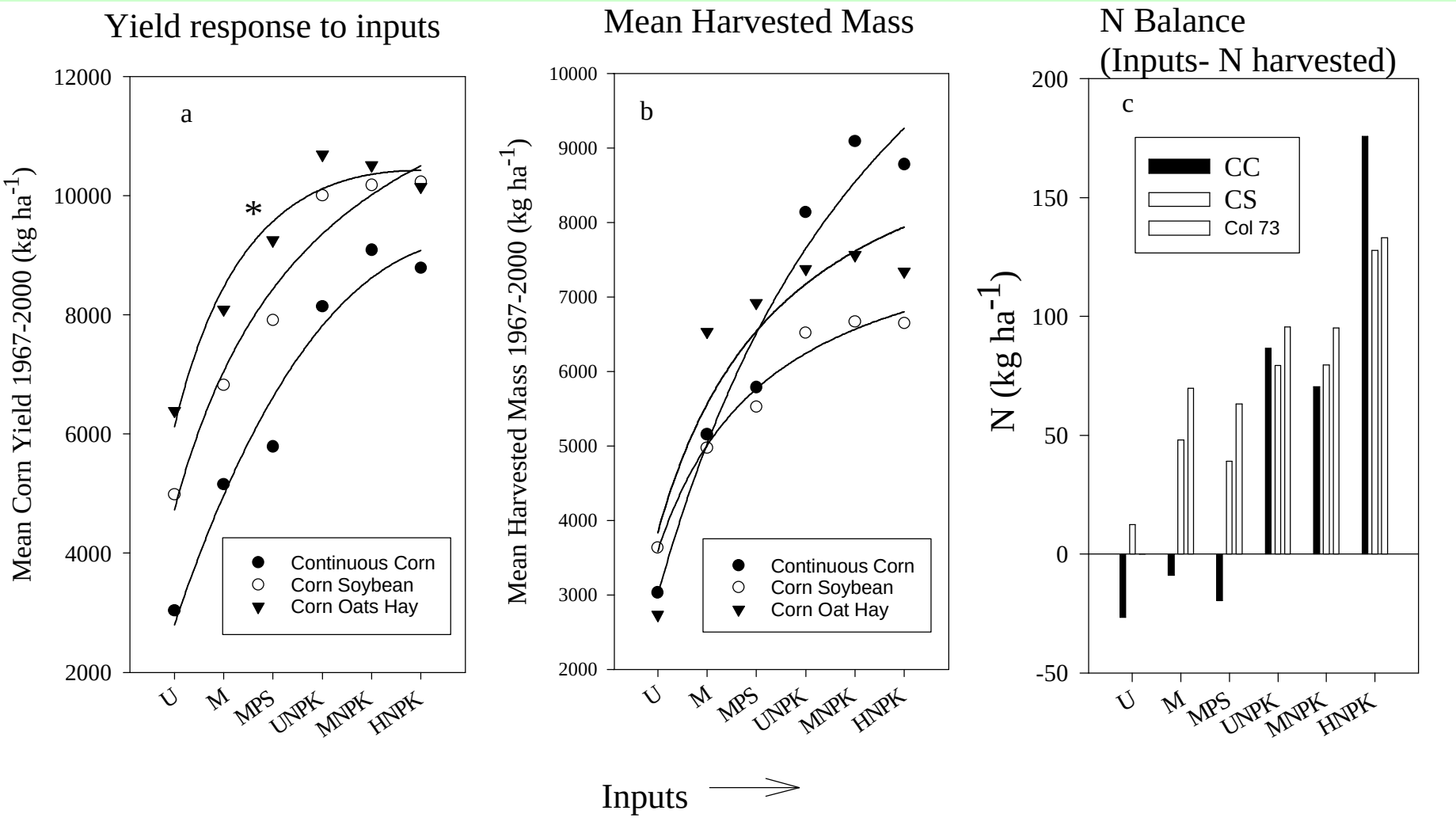
A- high intensity, plant testing to apply when N insufficient, split application and or spatial tailoring

B- more extensive systems, soil testing, check plots

C- diversified systems, alternate or minor crops, budgeting, *regular testing

Challenge for educators

- Help devise a practical strategy to address goals, weaknesses in the system of interest
- Point out trade-offs
- Align testing and objectives


Yield response to inputs
Mean Harvested Mass
N Balance
(Inputs- N harvested)
a
b
c
Mean Corn Yield 1967-2000 (kg ha-1)
Mean Harvested Mass 1967-2000 (kg ha-1)
N (kg ha-1)
12000
10000
8000
6000
4000
2000
9000
7000
5000
3000
200
150
100
50
0
-50
*
Continuous Corn
Corn Soybean
Corn Oats Hay
Corn Oat Hay
CC
CS
Col 73
U
M
MPS
UNPK
MNPK
HNPK
Inputs

Aligning tests and objectives

- If we had the perfect test for plant available N our problems would not be solved
- Numerous tools are on hand that could be used to optimize yield and conservation considerations
- When the industry standard sees value in conservation, tools and approaches can be used to get N management right

Grand unified field theory

NO_3

A. Simple agronomic systems that rely on inorganic N/ P and are frequently C limited

Organic N

NH_4
Limited competition, Net mineralization important

C. Natural and diversified systems that are C rich and N/P limited

B. Diversified systems that are C and N/P rich

NH4+
Plants and microbes actively compete and partner