Nitrogen fertilizer rate recommendations – How close can we really get?

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Topics

- Variability in corn yield response to N fertilization
- Relationship of optimum N rate to yield and soil N
- Predictability of soil N availability
- Improving N recommendation tools

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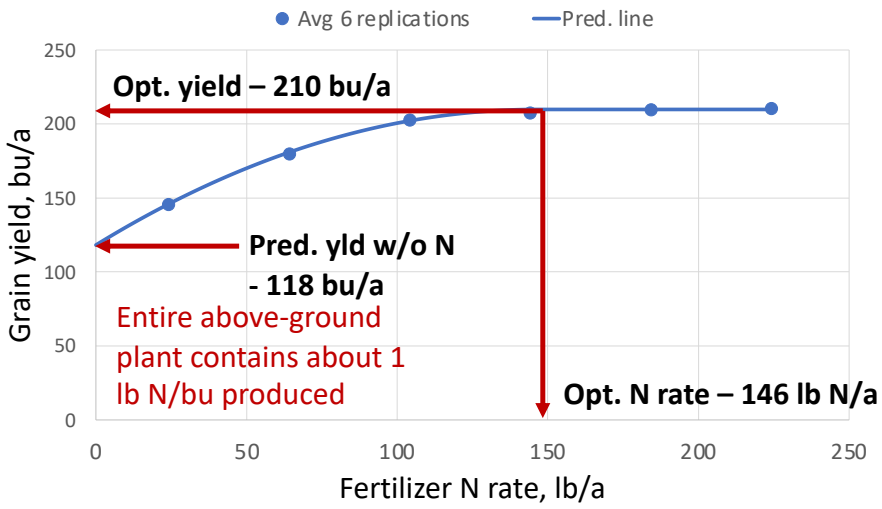
Corn yield response to N rate



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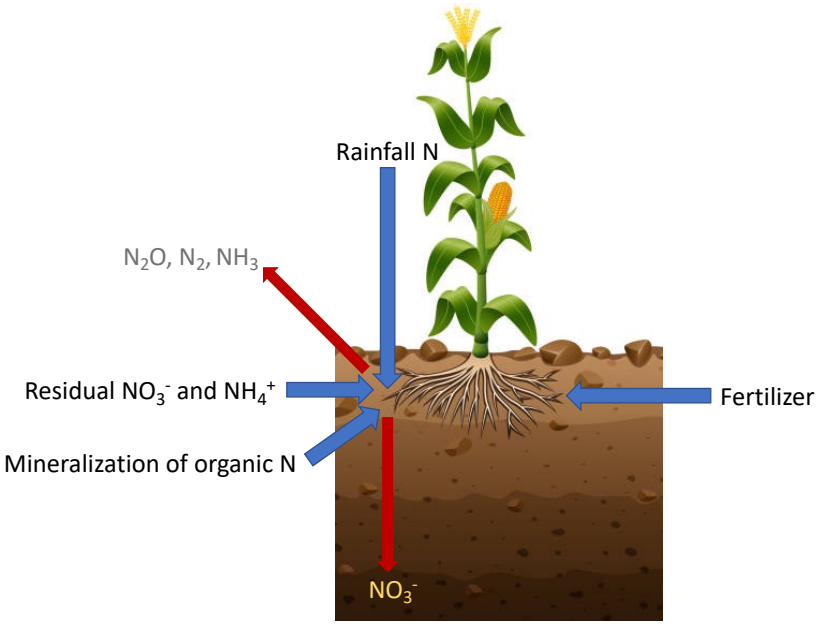

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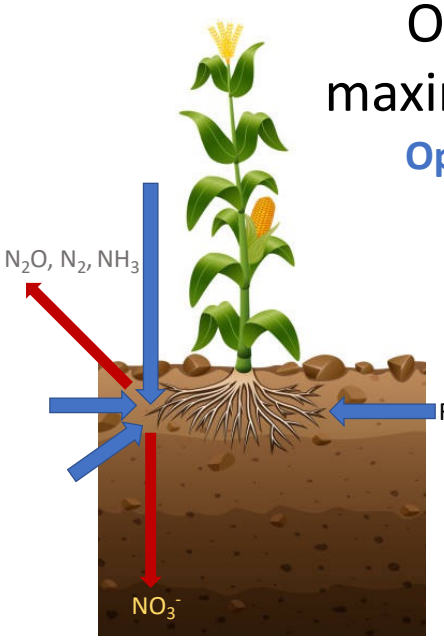
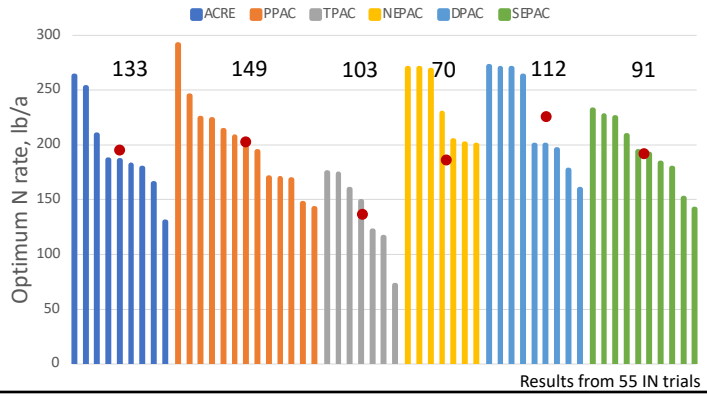
Optimum fertilizer N rate for maximum corn yield in C/S rotation



Optimum fertilizer N rate:

- ±35 to ±75 lb N/a within locations
- varied 138-235 lb N/a among locations



Results from 55 IN trials

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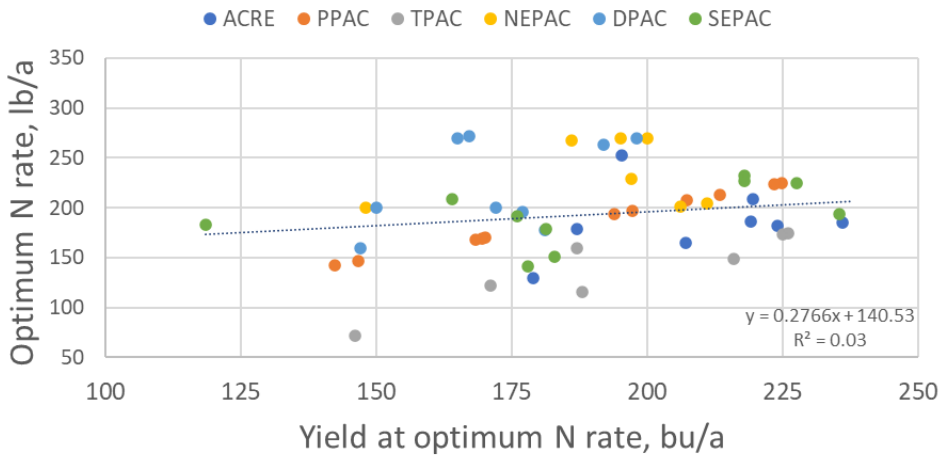
No relationship between maximum yield and N fertilizer rate needed to achieve that yield



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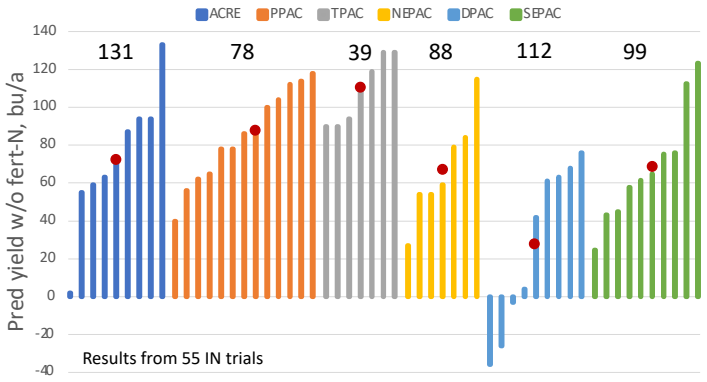
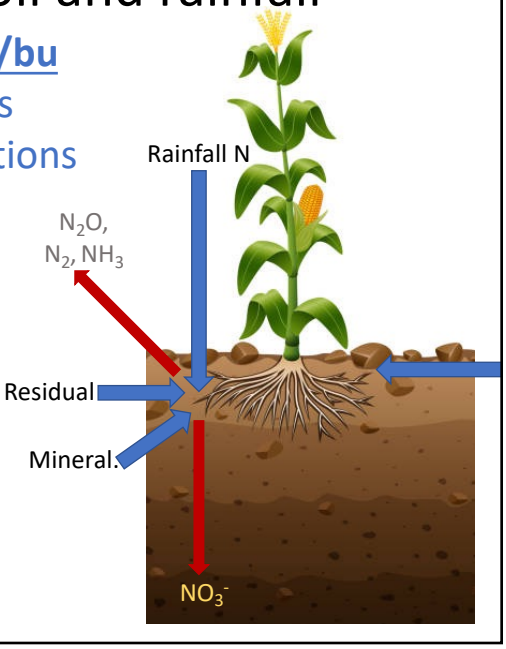
Estimate of N provided by soil and rainfall

Estimate of soil and rainfall N, ~1 lb N/bu

- ±20 to ±65 lb N/a within locations
- varied 28-109 lb N/a among locations





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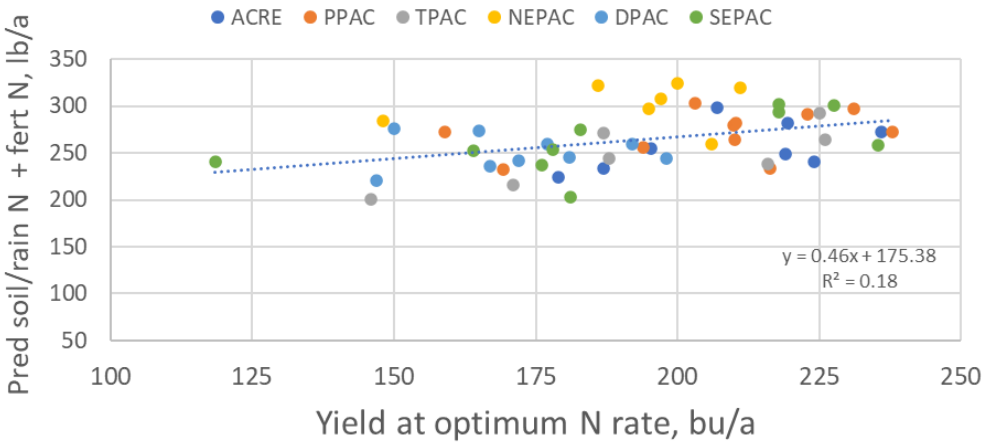
Optimum yield better related to total N than fertilizer N, but only explains **18%** of yield variability



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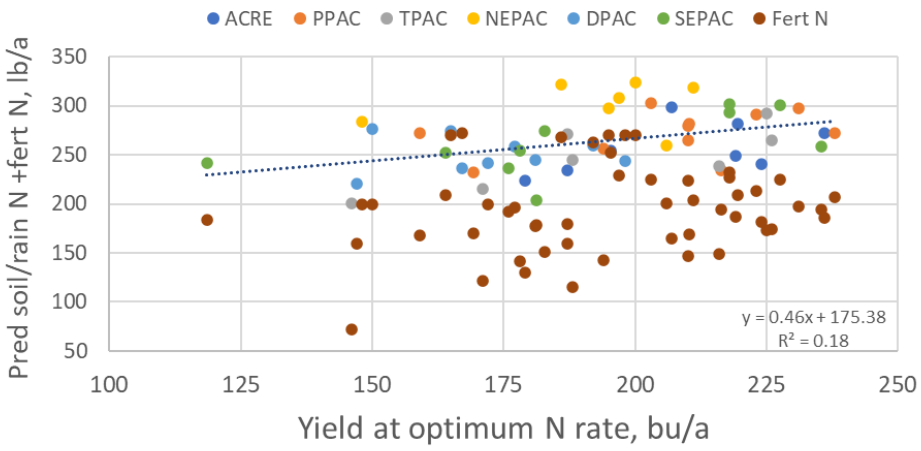
Comparison of optimum yield to fertilizer N and total N, suggests soil N contribution may be important to predicting optimum N rate



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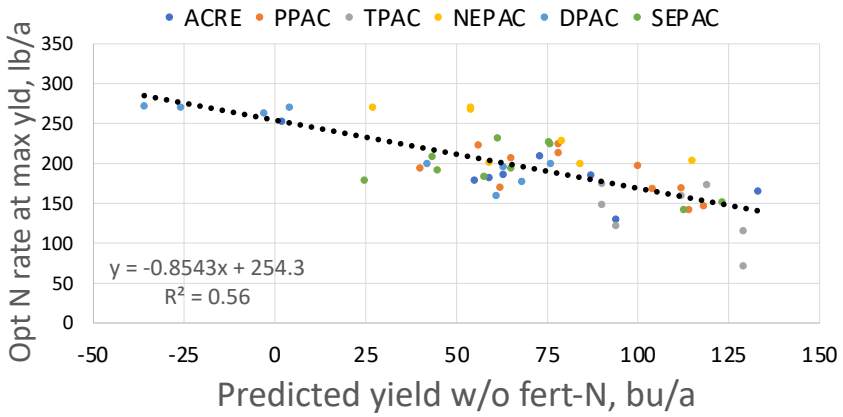
Yield without fertilizer N gives a good indication of fertilizer N needed for opt. yield



Yield x 1.0 lb N/bu is estimate of N without fertilization

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We have not yet tried to determine if we can model yield without fertilizer N based on weather and soil properties solely with Indiana data, but we have looked at measures of N mineralization related to these soils

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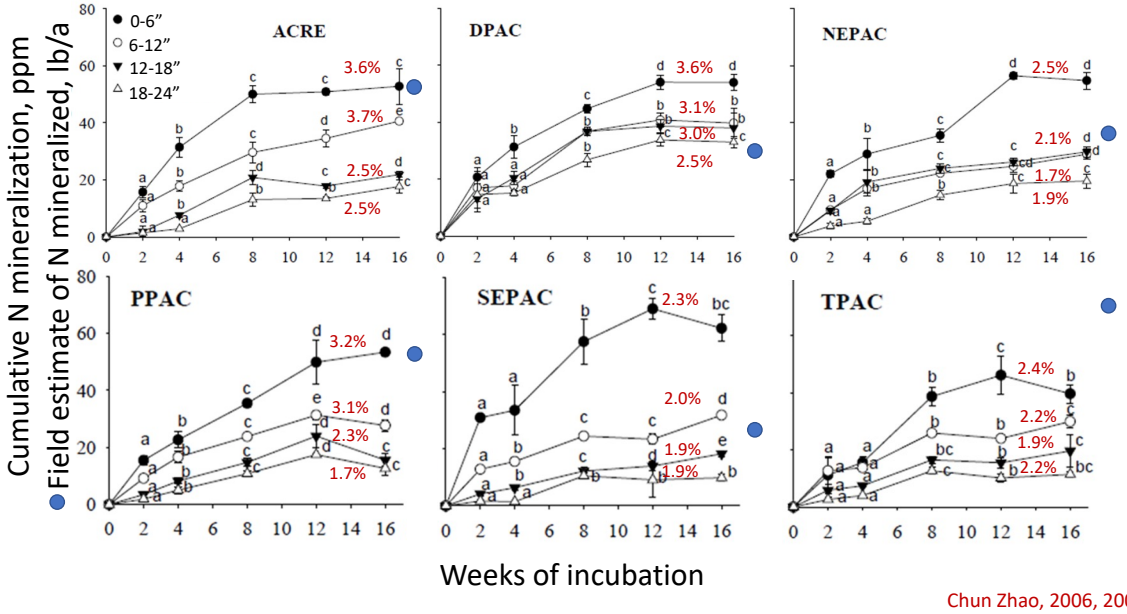
Nitrogen mineralization under ideal conditions



Chun Zhao, 2006, 2008, 2010

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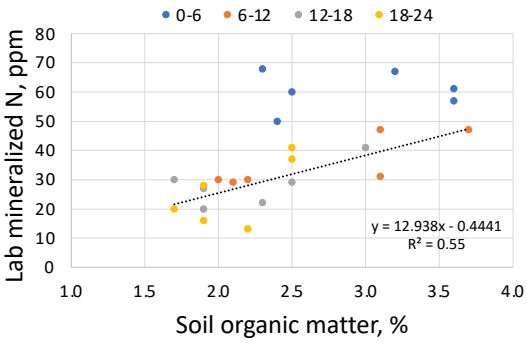
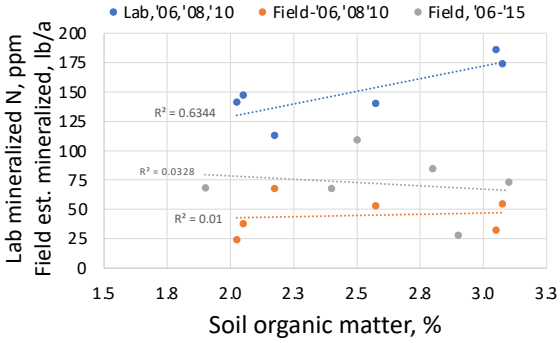
Relationship of soil organic matter to laboratory and field estimates of N mineralization?



N mineralized in a 16-week lab incubation was correlated with OM% at soil depths of 6-24" but not at 0-6"



N mineralized in the lab was correlated with OM% across fields, but not when compared to field estimates of N mineralization

16 week aerobic incubation, LOI

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Additional recent efforts to improve N recommendation tools

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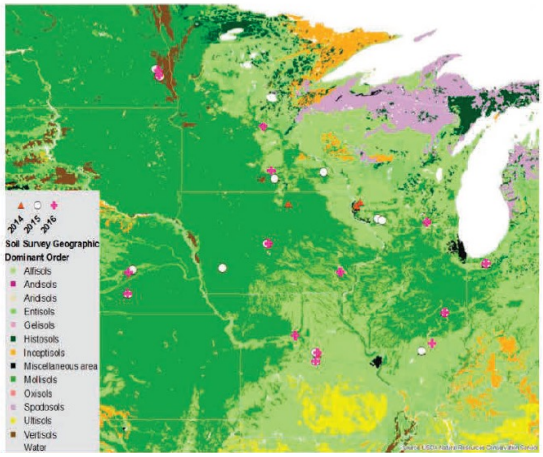
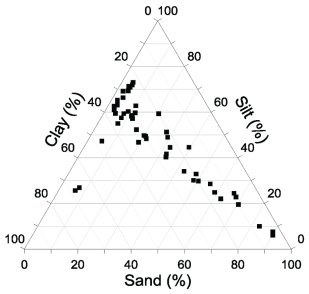
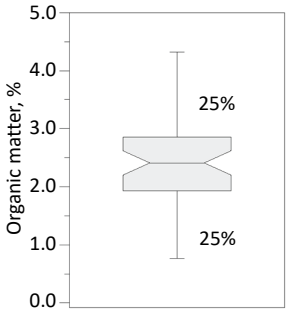
Corn Belt wide N response trials – 2014-2016, 49 site-years







- N rates – 0-280 lb N/a in 40 lb N/a increments
- all at-planting or 40 lb N/a AP and remainder sidedress (V10)

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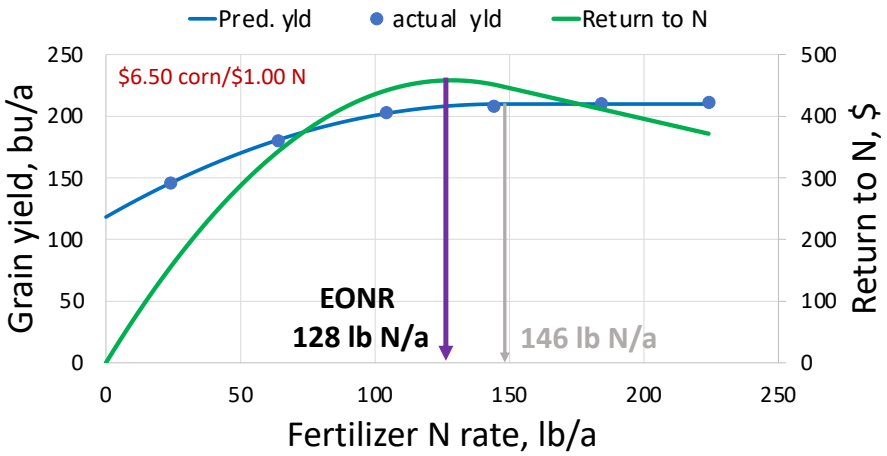
Economic optimum N rate



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Maximum return to N approach

- Aggregation of multiple return to N curves to find the maximum return to N across multiple sites
  - biases the recommendation to more responsive sites more than taking the arithmetic average of economic optimum N rates

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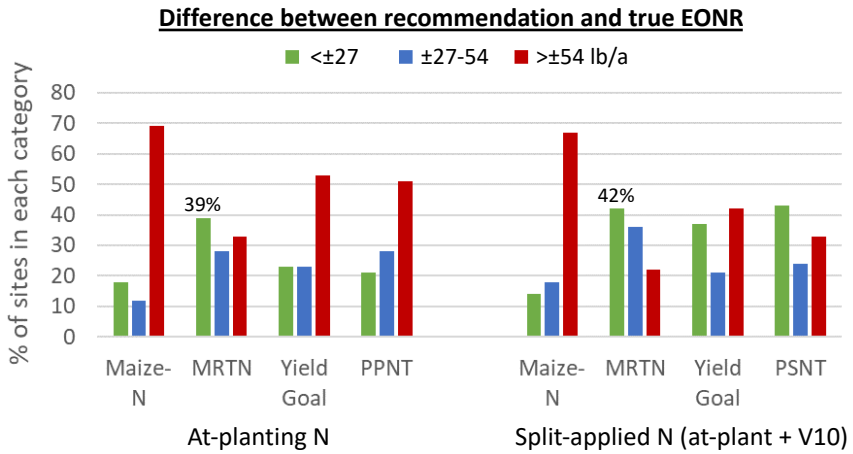
MRTN was one of the best N recommendation tools across up to 49 site-years in 8 Midwest states

Tests Evaluated

- Maize-N crop growth model
- MRTN
- Yield goal
- Pre-plant and pre-sidedress soil NO_3 tests
- Canopy reflectance sensing



Ransom et al. 2019; AJ DOI: 10.1002/agj2.20035

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Machine learning improved N recommendations

At-planting N

ML adjust	N recommendation tool		
	MRTN	Yield Goal	PPNT
	% sites within 27 lb N/acre true EONR		
Unadjusted	39	23	21
Elastic-net	50	33	30
Decision-tree	36	37	34

MRTN: ↑ adequate and well-distributed rainfall/30d prior to plant, ↓ pH
YG: ↓ OM% 0-1'
PPNT: ↑ 36 lb N/a

Split-applied N (at-plant + V10)

ML adjust	N recommendation tool		
	MRTN	Yield Goal	PSNT
	% sites within 27 lb N/acre true EONR		
Unadjusted	42	37	43
Elastic-net	44	40	41
Decision-tree	44	35	39

MRTN: ↑ well-distributed rainfall/plant-SD, ↓ pH
YG: ↑ well-distributed rainfall/plant-SD, ↓ OM% 0-3'

pH: 5.5 – 7.8; OM% 0-1': 0.8 – 5.2; OM% 0-3': 0.5 – 4.3

Ransom et al. 2021; AJ DOI: 10.1002/agj2.20627

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Another approach to making N recommendations

- Hydrologic soil groups and drainage class (PD and WD)
- Weather – uniformity of rainfall, GDD, precipitation, abundant and well-distributed rainfall
- Measured soil properties – clay, PAWC, SOM, organic C, pH, soil respiration
- SSURGO-based values - clay, PAWC, SOM

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Hydrologic soil group delineations and soil properties to make N recommendations

Hydrologic group	Water transmission	Saturated hydraulic conductivity	Clay	Sand	Depth to water table	Depth to impermeable layer
		inches/hour	%		inches	
A	Unrestricted	>5.67	<10	>90	>20	>24
B	Unrestricted	1.42 – 5.67	10-20	50-90	>20	>24
C	Somewhat restricted	0.14 – 1.42	20-40	<50	>20	>24
D	Very restricted	<0.14	>40	<50	<20	<24

https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba

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Machine learning identified variables important to N recommendations that were specific to hydrologic soil groups – (49 site year data)

- **At-planting N appl.**
  - B-WD – OM% 0-1' ⬇
  - B-PD – water holding cap. x OM% 0-2' ⬆
  - C-WD – clay% 0-1' x OM% 0-1' ⬆
  - C-PD – total carbon ⬇
- **Sidedress N appl.**
  - A and D – rain dist. (SDI) ⬆ plant to sidedress
  - B-WD – soil resp. ⬇
  - B-PD – SDI x clay% 0-2' ⬆
  - C-WD – SDI x clay% 0-1' ⬆
  - C-PD – SDI x water holding cap. 0-2' ⬆

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Summary

- In B-WD soils %OM and respiration, which are likely related to N mineralization, reduce optimum fertilizer N rate
- In the other soils frequent rainfall and soil variables that relate to wetness and C availability increase optimum fertilizer N rate

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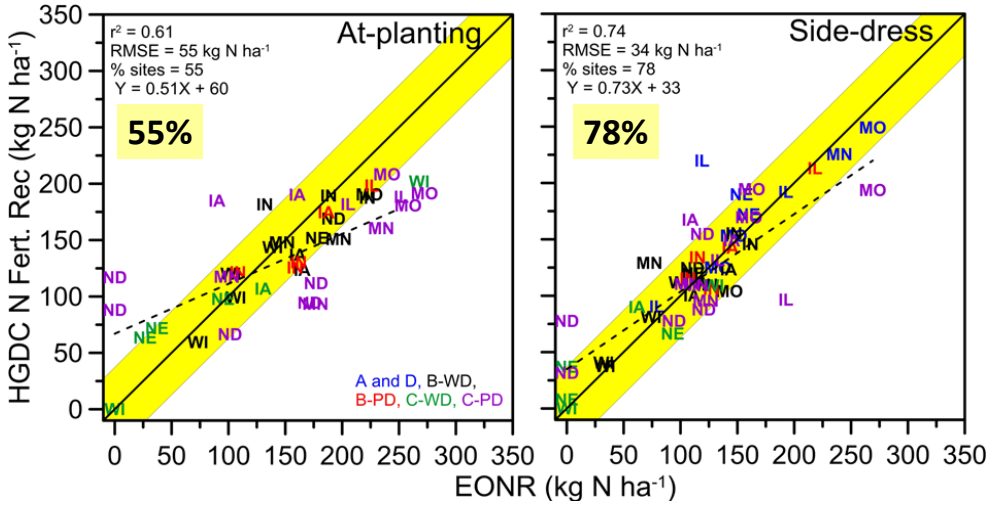
55% and 78% of sites within 30 lb N/a of true EONR



Bean et al. 2021; AJ DOI: 10.1002/agj2.20888

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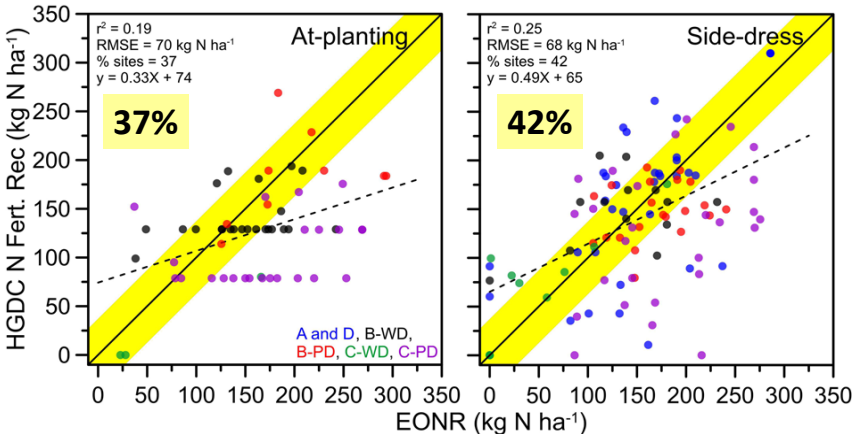
Validation of models on 165 site years (IA, IN, MO, ND, NE, WI) unrelated to model building



% sites within 30 lb N/a

Group	At-plant	Sidedress
A and D	--------	49%
B-WD	46%	39%
B-PD	44%	52%
C-WD	66%	70%
C-PD	37%	15%

41% site-years from IN

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SUMMARY

- A riddle wrapped in a mystery inside an enigma
- Recommendations are a good starting point for N recommendations
- Incorporating hydrologic group/drainage, clay, OM, pH, and rainfall can be used to modify recommendations *(not attempted yet)*
- Can historical and/or forecast weather be used to improve recommendations beyond the time at which fertilizer decisions are made *(statistical modeling)*

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What would consultants and farmers be happy with?

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2022 response to S

Location	+S
ACRE C/S	+7
ACRE C/C	+8
DPAC	+3
PPAC	+34
SWPAC	+10
TPAC	+3

Location	+S
Noble	0 (2)
Blackford	+11
Franklin	+6
Shelby	0

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Corn response to S fertilization in the previous and current year

2021 S	2022 S	Blackford	Jay	Whitley	Jennings	Knox
S applied, lb/ac		---------- bu/acre ----------				
0	0	197	225	217	234	205
0	15	213	226	225	237	213
20	0	213	227	222	236	203
20	15	214	226	229	237	216
	CV	1.2	3.1	2.4	1.1	3.1
	Pr>F	**<0.0001**	0.98	**0.0003**	0.15	**0.06**
	LSD.10	2.4	ns	4.1	ns	8.4
	Contrast					
	0/0 vs rest	**<0.0001**	0.78	**0.0003**	**0.004**	0.75
	0/15 vs 20/0	0.94	0.83	0.17	0.31	0.23
	20/0 vs 20/15	0.23	0.75	**0.004**	0.65	0.73

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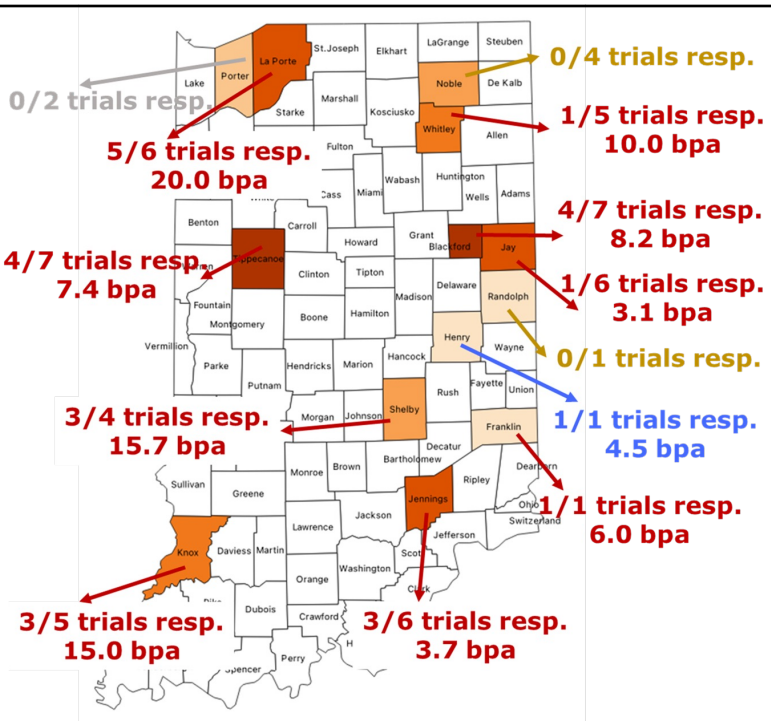

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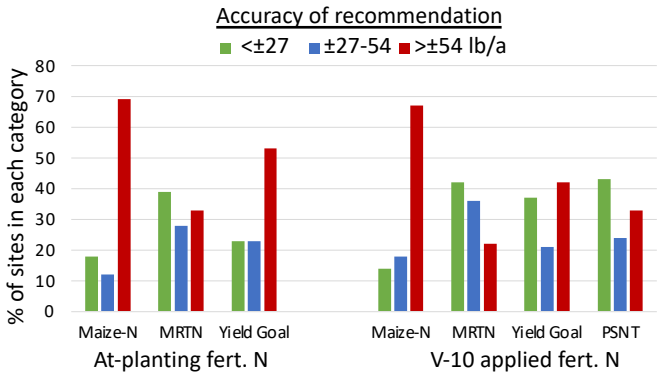

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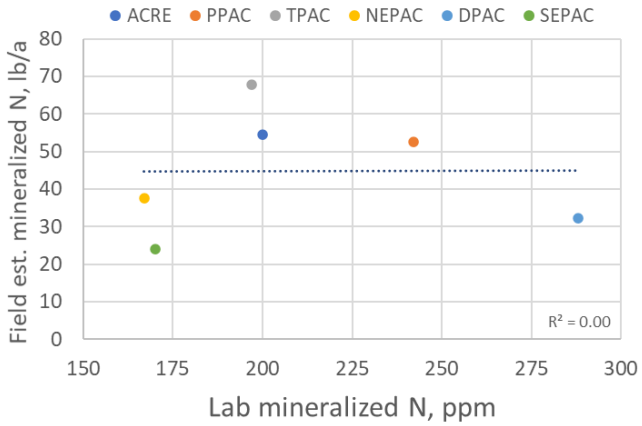
Can soil organic matter or a laboratory measure estimate N mineralization?



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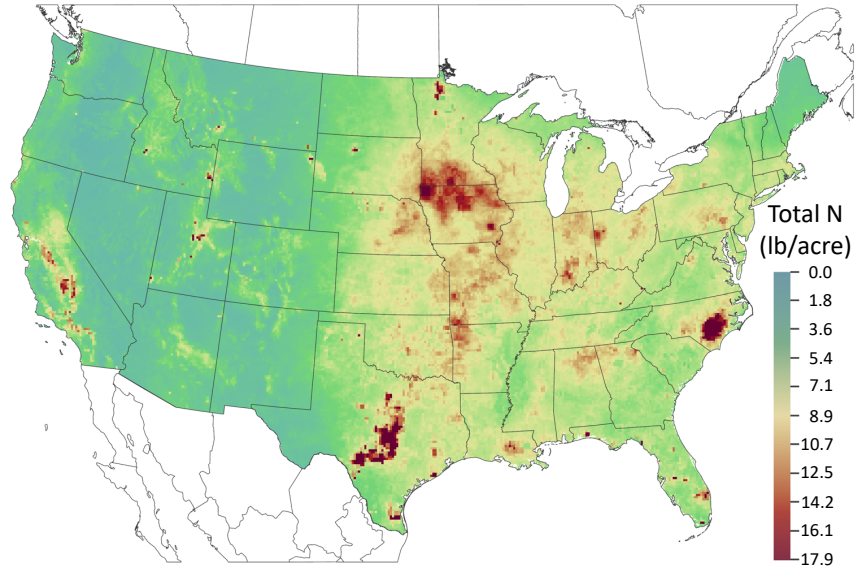
Total N
(lb/acre)
0.0
1.8
3.6
5.4
7.1
8.9
10.7
12.5
14.2
16.1
17.9
Total deposition of nitrogen 2021
Source: v2022.1, data: CASTNET/CMAQ/NADP
USEPA 11/21/22

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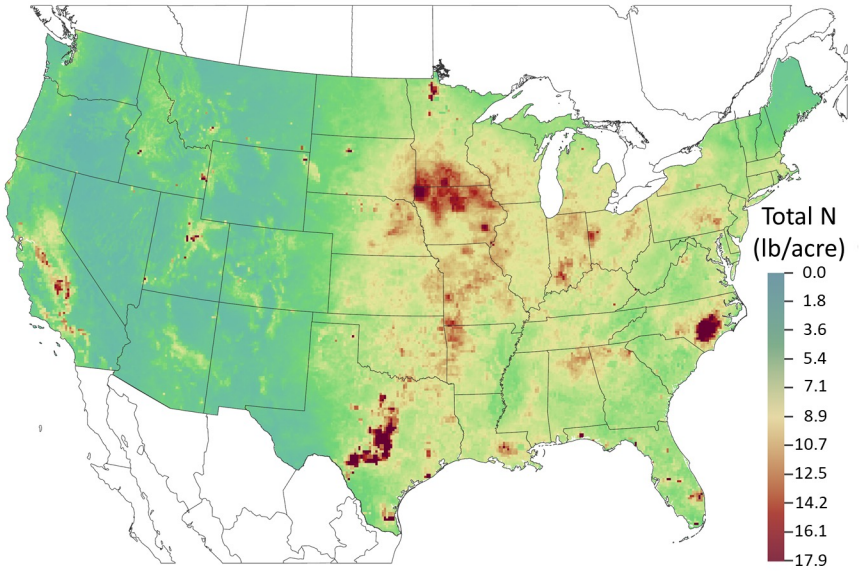
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Total deposition of nitrogen 2021
Source: v2022.1, data: CASTNET/CMAQ/NADP
USEPA 11/21/22

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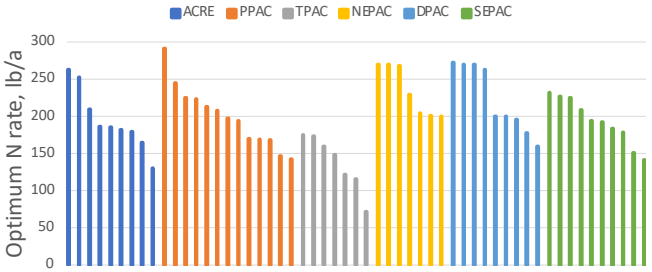
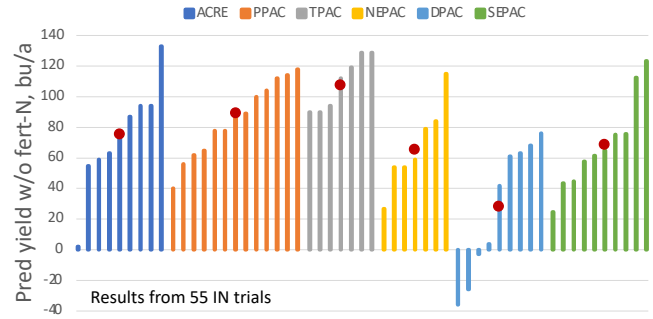
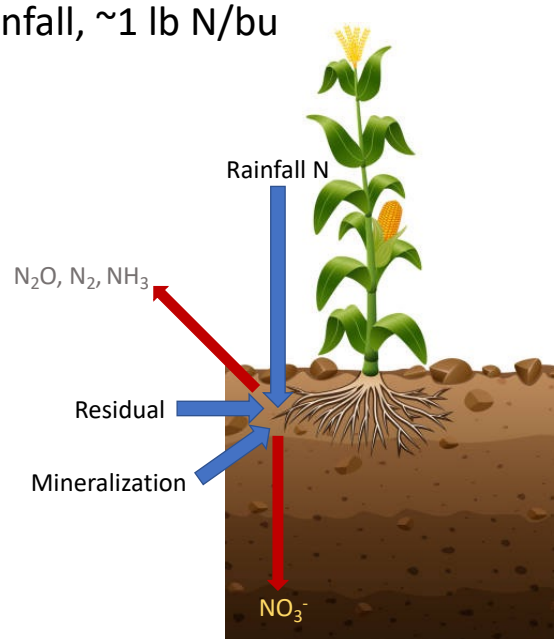
Estimate of N provided by soil and rainfall, ~1 lb N/bu







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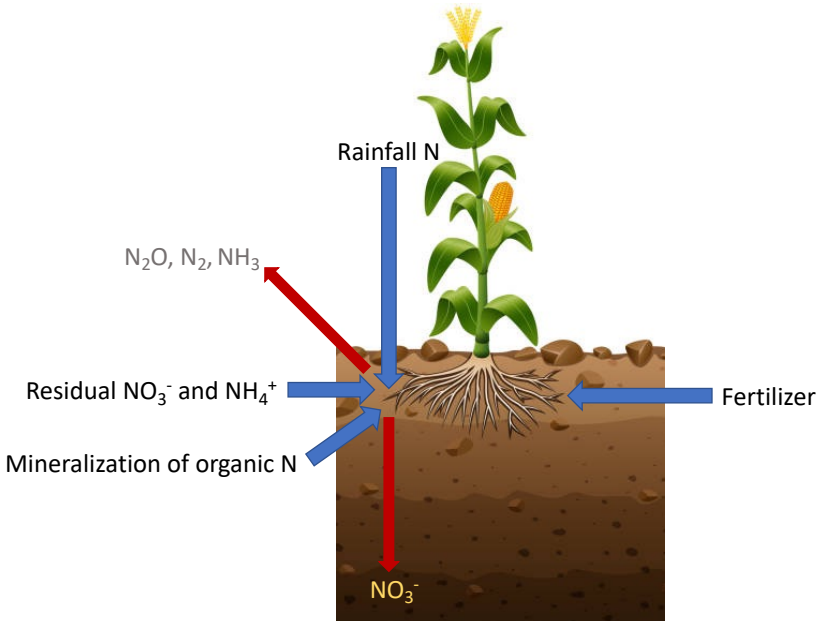

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