Phosphorus and Potassium Under Pressure

Smart Solutions for Tight Margins

Megan Bourns, Soil Fertility Extension

IN CCA, 12/09/2025

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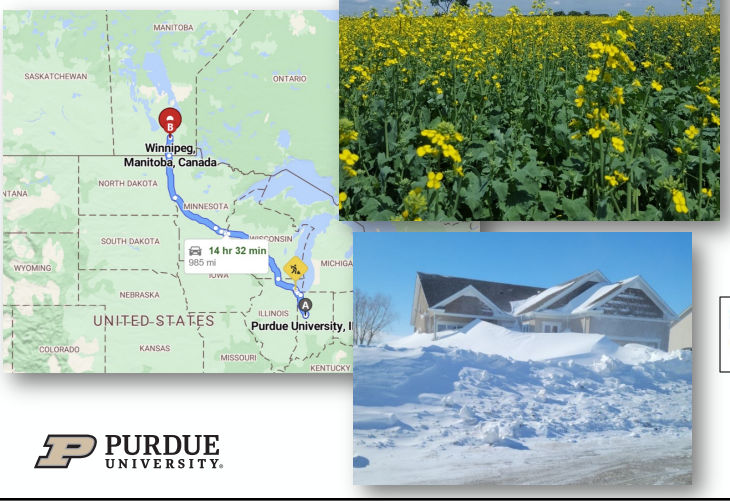
Get to know me

The Origins



University of Manitoba · Manitoba Pulse & Soybean Growers · STATE · FRST Fertilizer Recommendation Support Tool

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2

The Plan for Today

1. Flexibility in P management under tight price conditions
   1. P Cycle
   2. Fertilizer management strategy
2. Flexibility in K management under tight price conditions
3. A valuable tool to inform "alternative" management strategies

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Phosphorus

The role of P

Left: Early season corn showing phosphorus deficiency symptoms (*M. Bourns*)
Top: Soybeans on the right showing phosphorus deficiency symptoms including stunting and small leaflets (*IPNI*)

- Critical role in energy storage and transfer
- Energy that the plant captures from photosynthesis is stored in chemical bonds that involve P
- Tight link to energy → critical for biomass development (above and belowground) and yield

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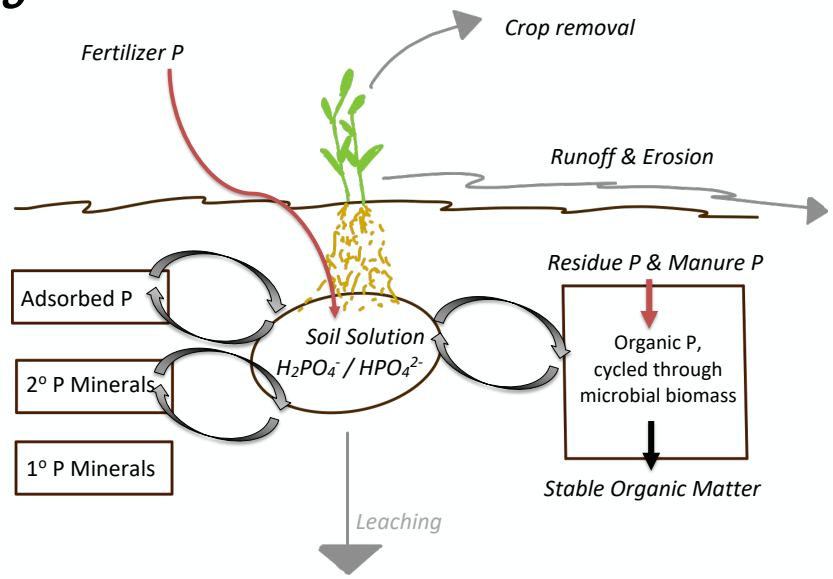
7

Phosphorus

The P Cycle



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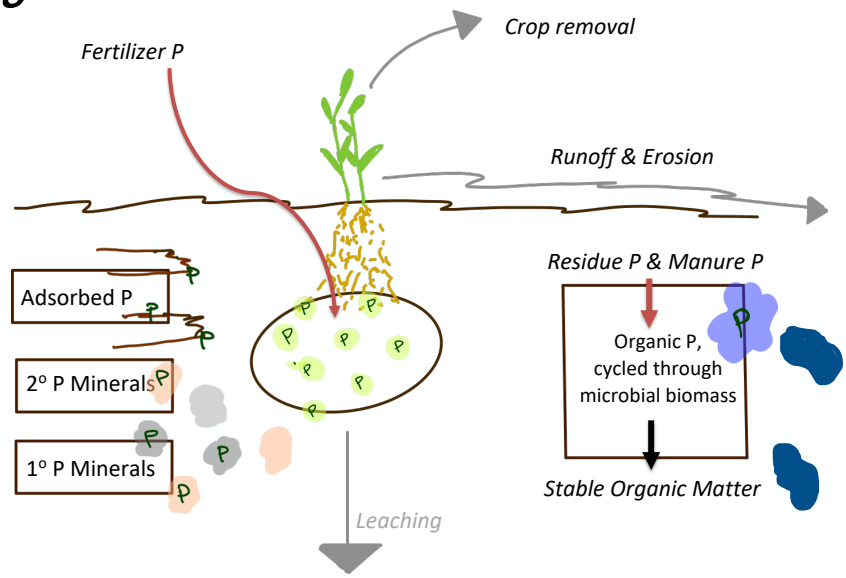
Phosphorus

The P Cycle



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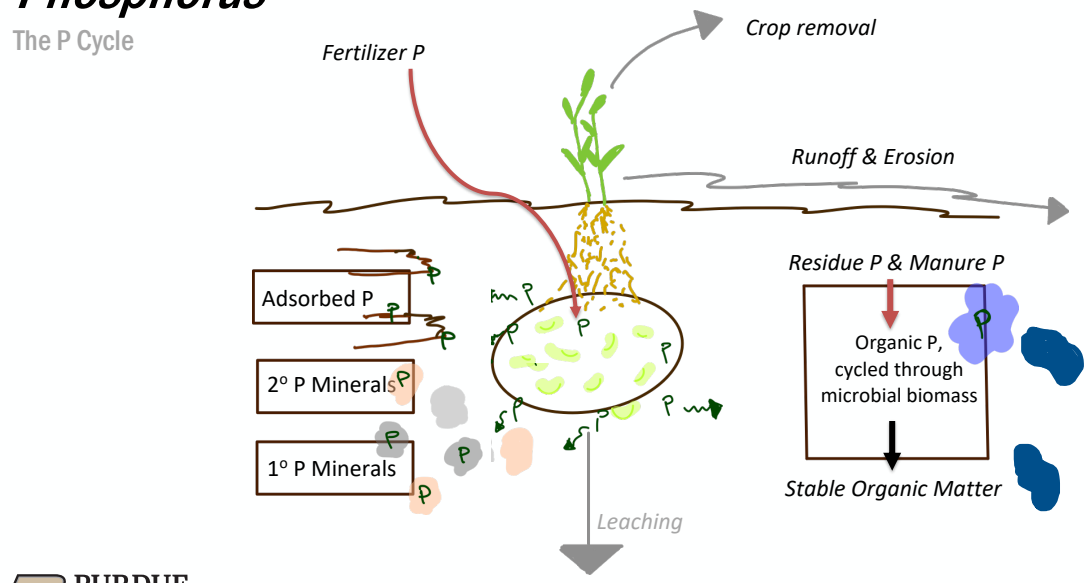
Phosphorus

The P Cycle



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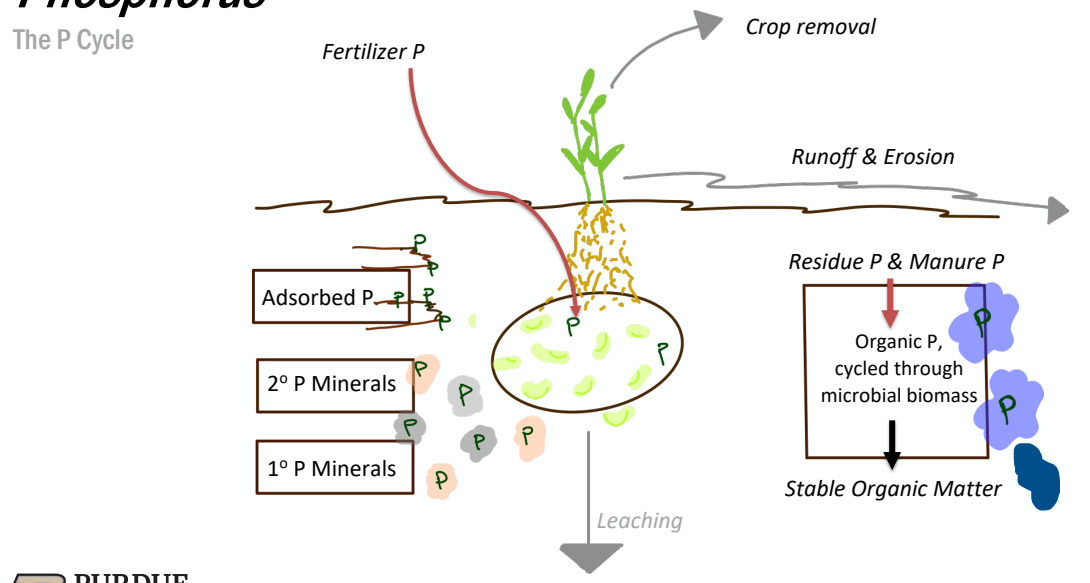
10

Phosphorus

The P Cycle



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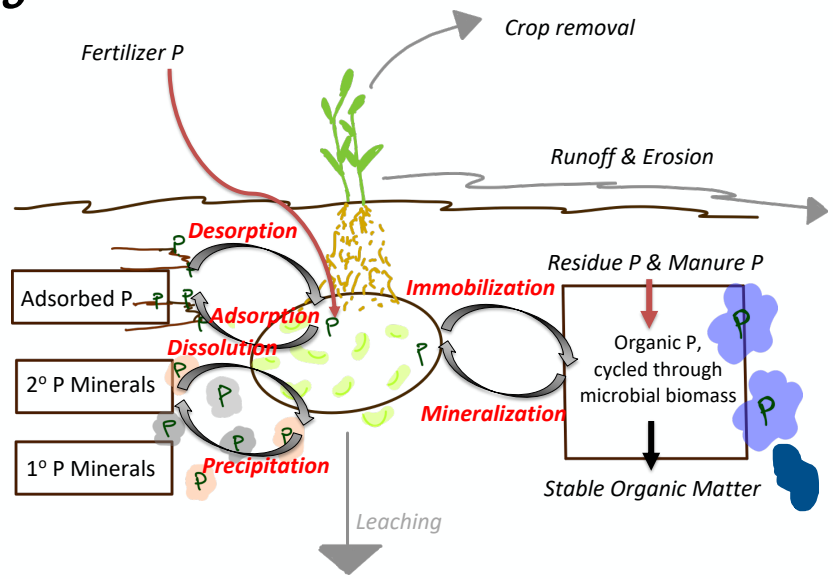
Phosphorus

The P Cycle



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12

Phosphorus

Role of Soil P

- Long-term study in W KS
  - Zero P was applied to the control year over year, since 1961
  - 2-3 ppm Mehlich-3 in the 0P control

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15

Phosphorus

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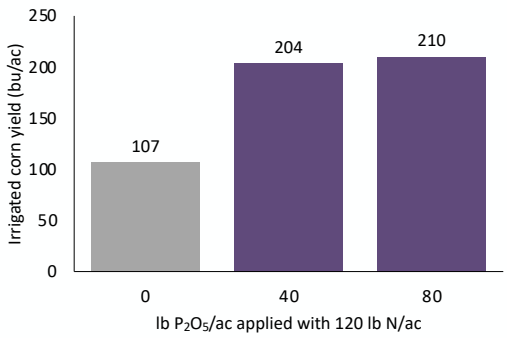

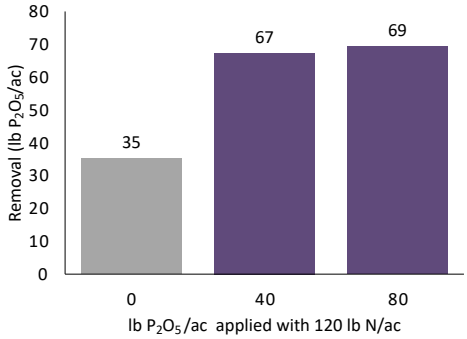

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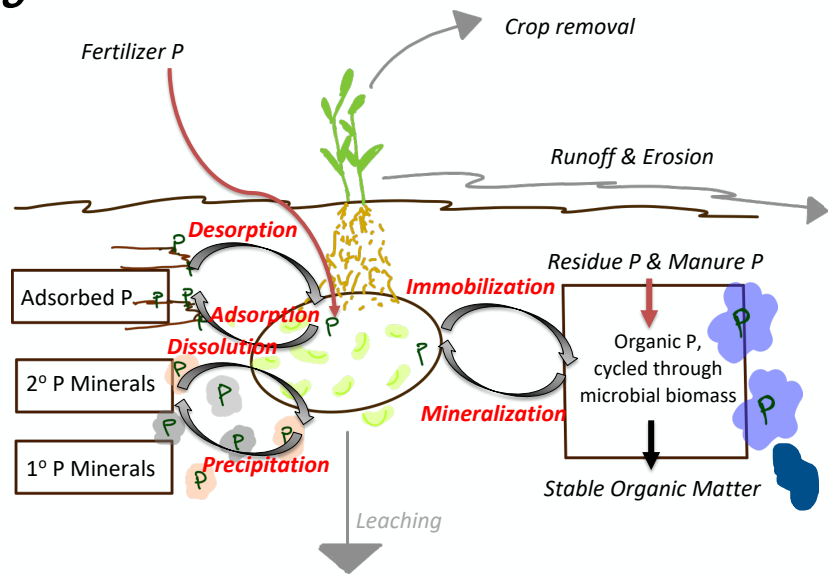
Phosphorus

The P Cycle



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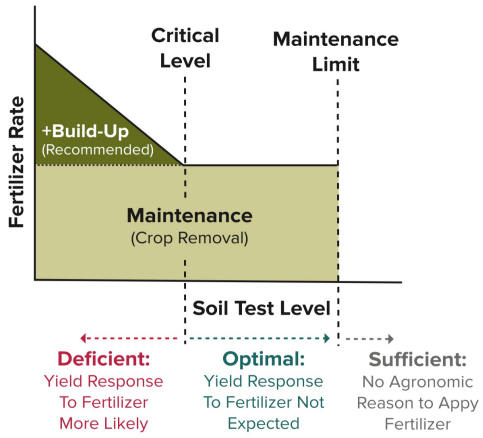
17

Phosphorus Management

Rate Management



- We follow a build and maintain framework for P recommendations in the tri-state
- Increasing soil test P into the optimal range (between the critical level and maintenance limit)
- Continuing to routinely apply P to maintain that optimal soil test level

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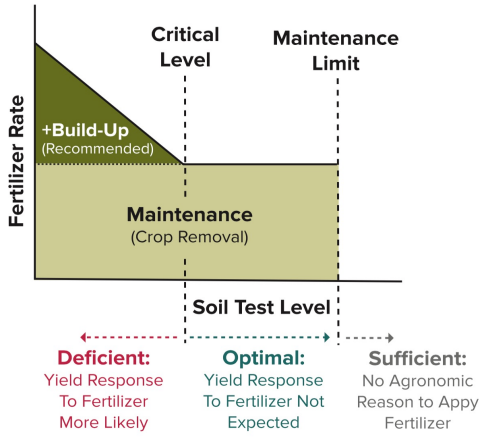
18

Phosphorus Management

Rate Management



Crop	Mehlich-3 Phosphorus Maintenance Range
Corn (grain or forage), Soybean	20–40 ppm
Wheat, Alfalfa	30–50 ppm

Critical Level

Maintenance Limit

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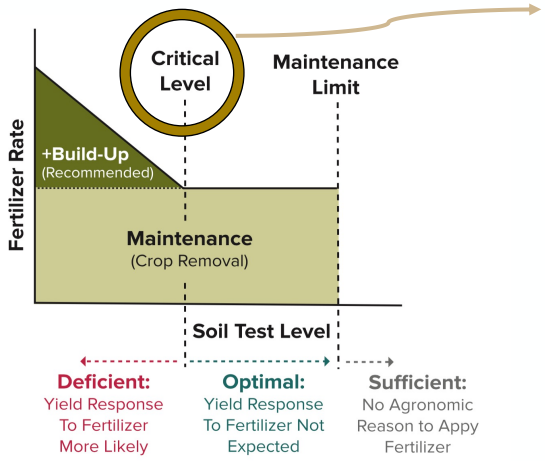
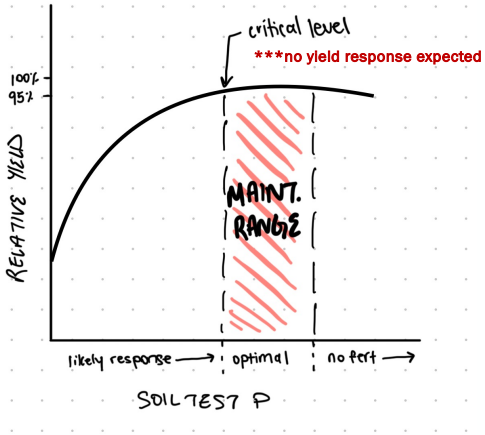
19

Phosphorus Management

Rate Management





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20

Phosphorus Management

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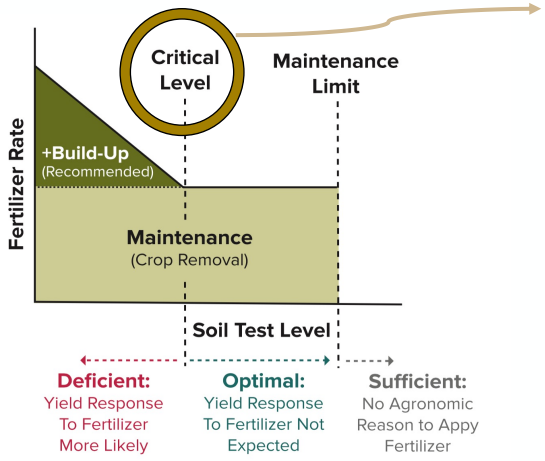

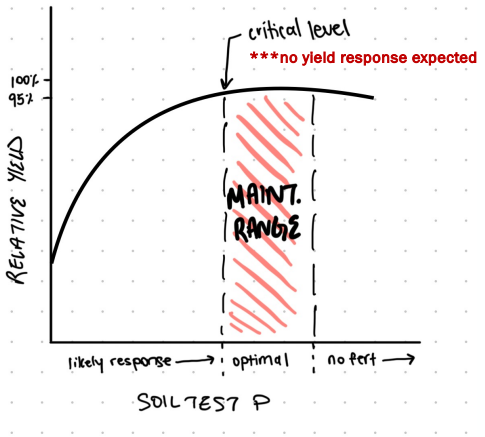

Fertilizing the soil vs. fertilizing the crop

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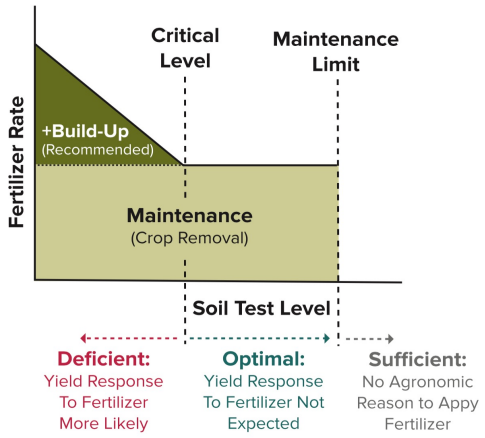
Phosphorus Management

Benefits of Build and Maintain



- Have more P in the system – maybe we can capture years of high yield potential, better
- Flexibility to apply maintenance rates every other year/rotationally
- Can pull back in years when price conditions are not favorable

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Phosphorus Management

Is Pulling Back "Safe"?

- Two main things we'd be worried about:
  1. Not having enough P to meet this year's crop needs
  2. The effect on soil test P levels

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Phosphorus Management

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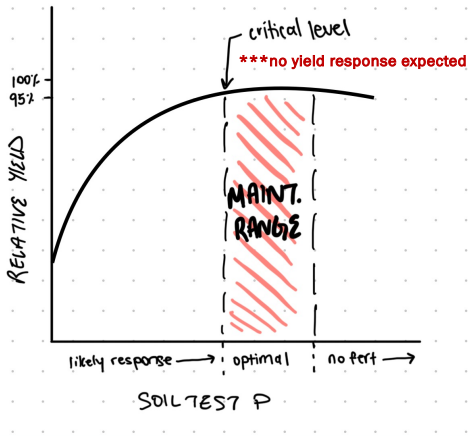

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Phosphorus Management

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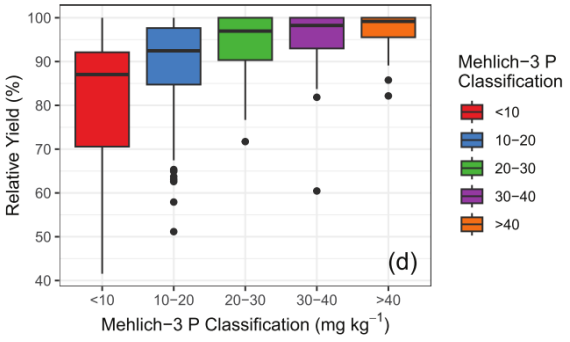

(Culman et al., 2023)

- Data from on-farm trials in Ohio (439 sites worth of data summarized here)
- Corn and soybean
- As soon as we are over the critical threshold for yield response, we're achieving >95% relative yield on average
  - This is what we would expect, based on how our recs were developed

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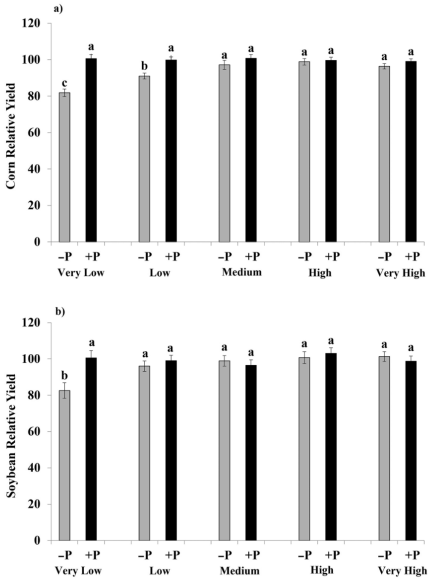
26

Phosphorus Management

Is Pulling Back "Safe"?

- Data from small plot trials in MN
- Range of soil test P values from very low to very high (Bray-P)
  - Very low: <5
  - Low: 6-10
  - Medium: 11-15
  - High: 16-20
  - Very high: >20
- Looked at with and without P fertilizer at a non-yield limiting rate for each soil test category (they did 1.5x MN recommended rate)



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(Kaiser et al., 2025)

Phosphorus Management

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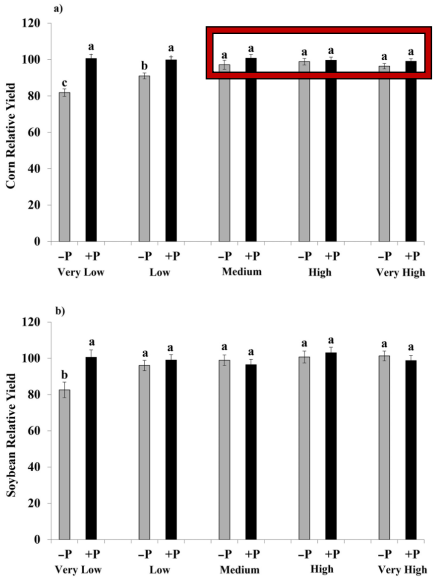
- CORN: once soil test P is at/above 11-15 Bray (~16-20 Mehlich-3), no benefit to fertilizer P



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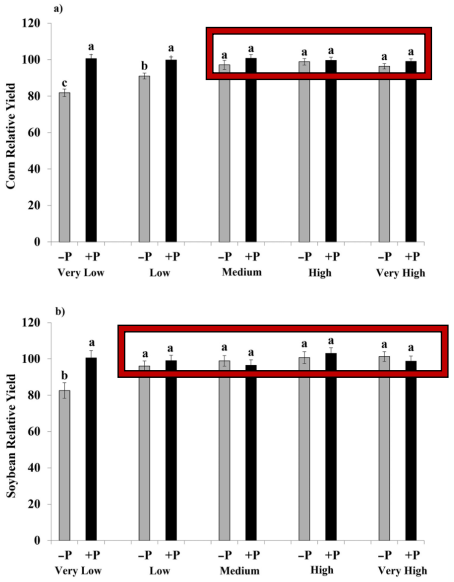
- CORN: once soil test P is over 11-15 Bray (~16-20 Mehlich-3), no benefit to fertilizer P
- SOYBEAN: once soil test P is over 6-10 Bray (~11-15 Mehlich), no benefit to fertilizer P



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Phosphorus Management

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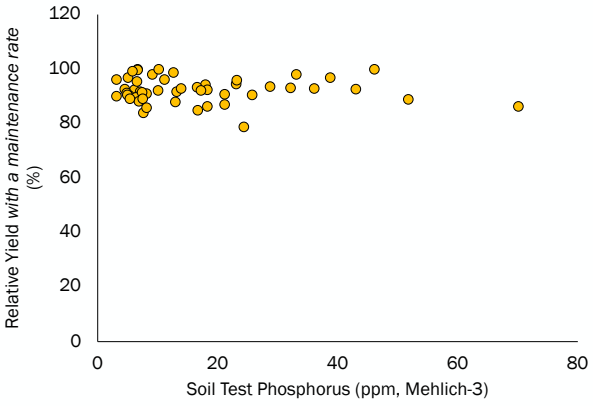

- Higher soil test P did not increase corn or soybean yield when a maintenance rate of P fertilizer was applied

(Bourns et al., 2024)

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Phosphorus Management

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- Two main things we'd be worried about:
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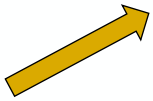

Recent work in this area indicates we very likely have enough P to meet this crop's demand, if soil test P is above the critical level

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31

Phosphorus Management

Is Pulling Back "Safe"?

Removal	
Crop	P_2O_5 (lb)/bu
Corn	0.35
Soybeans	0.80
Wheat	0.50

- Rule of thumb:
  - *Every 20 lb P_2O_5/ac removed = -1 ppm soil test P*
- 200 bu corn, 45 ppm Mehlich-3 P, no P fertilizer added
  - Removed ~70 lb P_2O_5/ac
  - Estimate our soil test P to be down about 3.5 ppm

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32

Phosphorus Management

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- Do we need to be concerned about that drop in soil test P??

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33

Phosphorus Management

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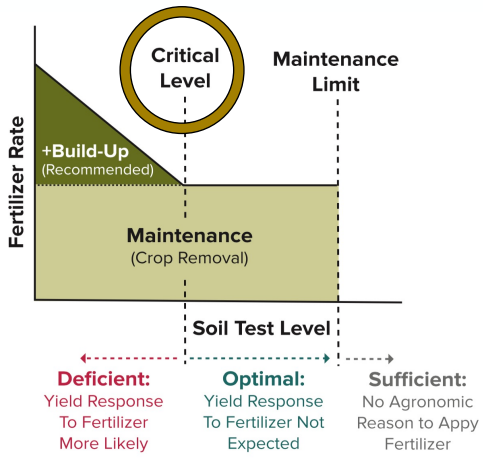

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- Do we need to be concerned about that drop in soil test P??
  - 20 ppm (Mehlich-3) critical level for corn/soy
  - 30 pm (Mehlich-3) critical level for wheat/alfalfa

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Phosphorus Management

Is Pulling Back "Safe"?

- Two main things we'd be worried about:
  1. Not having enough P to meet this year's crop needs
  2. The effect on soil test P levels

Recent work in this area indicates we very likely have enough P to meet this crop's demand, if soil test P is above the critical level

Be mindful of our soil test P levels with respect to critical levels. If well above critical level, likely not a major concern to utilize flexibility under tight price conditions.

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Phosphorus Management

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Soil test every 2-4 years !

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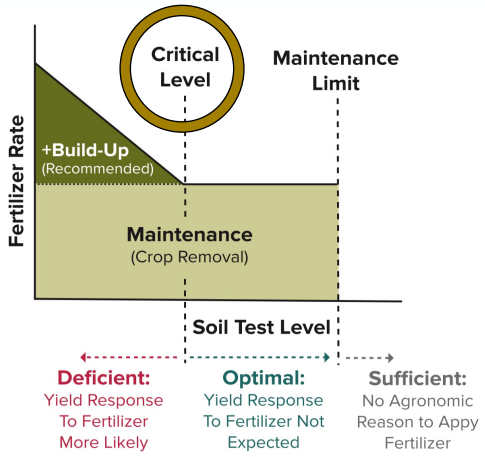
Phosphorus Management

Is Pulling Back "Safe"? What if I am below the critical level?



- If you are in the crop responsive range of soil test P, there is a higher likelihood you will see yield loss if you do not apply P fertilizer
- Consider:
  - Plan A: a maintenance rate only (no build)
  - Plan B: less than maintenance rate as your risk tolerance allows and depending on how tight cash flow is

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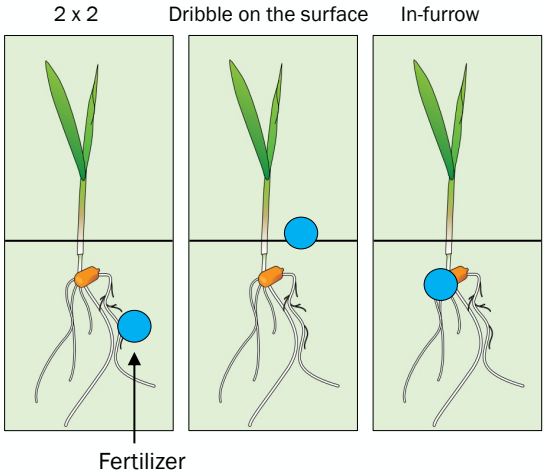
37

Phosphorus Management

Rapid Fire "Other" Considerations



- Timing:
  - closer to plant uptake = better (e.g., spring over fall, if possible)
- Placement:
  - Sub-surface = less loss
  - Banded = less interaction with bulk soil (not super critical in maintenance)
- Source:
  - Any of your standard P sources that fit your system (DAP, MAP, TSP, APP)
- Starter:

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38

Phosphorus Management

Rapid Fire "Other" Considerations

No starter in center, corn is not yet tasseling. Starter applied to the left and right of the center strip, corn is tasseling. (Camberato and Nielsen, 2023)

- Starter:
  - Can have pop-up/improve early season vigor, generally not reliably increasing yield
- Jim Camberato and Bob Nielsen did a number of starter trials across the state (55) with N and P in starter
  - Almost always saw more rapid vegetative development
  - Can lead to faster dry down, even when there's no yield response
  - Yield response was not consistent
  - Attributed most of responses they saw to N, not P

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39

Potassium

The role of K

- K is heavily involved in metabolic processes in the plant
  - Synthesis of ATP
  - Activity of enzymes in the plant
  - Adsorption of CO_2
- K is necessary for plants to capture energy from the sun and turn it into useful energy for the plant
  - E.g., K is essential for photosynthesis

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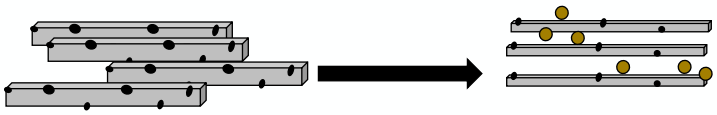
Potassium

K in Soil Components



Soil minerals can contain >95% of the total soil K. In primary (relatively unweathered) minerals, the K is not exchangeable.

Example: feldspars

As primary minerals weather into secondary, layered minerals, structural K becomes more exchangeable.

Example: mica or vermiculite

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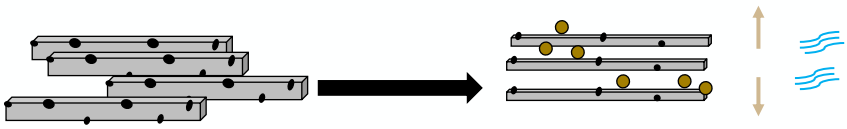
41

Potassium

K in Soil Components



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Potassium

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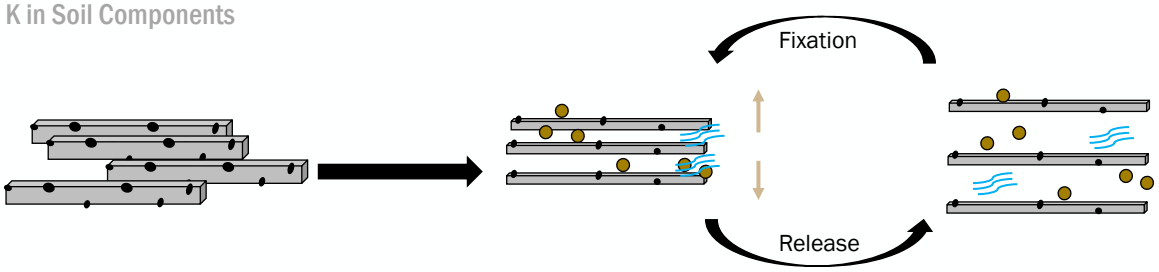

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Example: mica or vermiculite

As water moves in and out, the availability of K changes.

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Potassium

The role of K

- Potassium availability depends on:
  - Mineralogy
  - Growing season conditions
  - K fertility program

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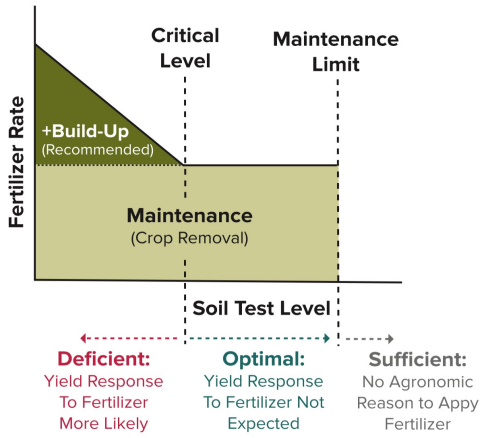
44

Potassium Management

Rapid Fire



Crop	Potassium (Mehlich-3 K)	
	Sandy soils (CEC <5 meq/ 100g)	Loam and clay soils (CEC >5 meq/ 100g)
Corn, Soybean	100–130 ppm	120–170 ppm
Wheat, Alfalfa	100–130 ppm	120–170 ppm

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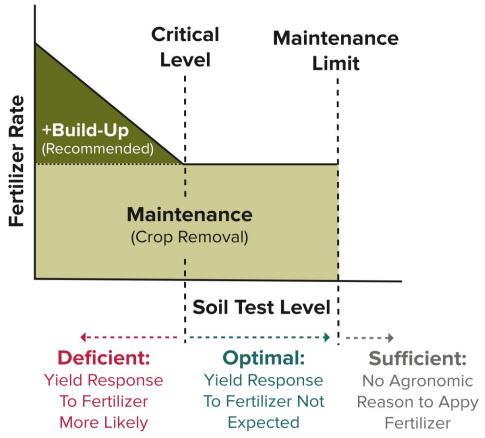
Potassium Management

Rapid Fire



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Dominated by minerals without much exchange capacity, or capacity to expand to release K

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Potassium Management

Rapid Fire

- Very similar takeaways to P management
- If > than critical threshold, can likely cut back this year
- BUT – be careful if you have low CEC, inherently lower fertility soil
  - Not as much K supply from the soil

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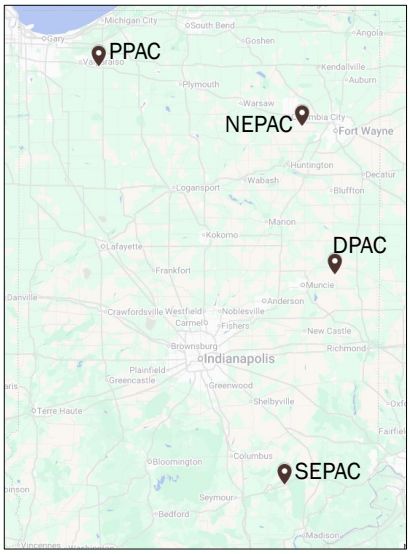
Ongoing K Fertility Work in IN

- Long-term trials that were set up back in 1997
- Different K fertility-related questions since they started
- Recently looked at effect of residual K applications
- Working on summarizing this data
  - Look for winter extension publication/communication on this



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48

48

Ongoing K Fertility Work in IN

NxK Interaction in Corn, Dan Quinn with Nutrien

Agronomy Center for Research and Education (ACRE):

- Located in West Lafayette, IN
- Generally highly productive soils
- Field site had average of 104 ppm K (spring), CEC of 17

Pinney Purdue Agricultural Center (PPAC):

- Located in Wanatah, IN
- Mix of loamy, sandy, and muck soils across the research farm
- Field site had average of 45 ppm K (spring), CEC of 4.8

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49

Ongoing K Fertility Work in IN

NxK Interaction in Corn, Dan Quinn and Nutrien

Four K rates: 0, 60, 120, 180 lb K_2O/ac

Six N rates: 0, 50, 100, 150, 200, 250 lb N/ac

- K was applied as potash, pre-plant, broadcast and incorporated at both sites
- N was applied at V3 as UAN
- 20 lb S/ac was applied across both sites as AMS (AMS provided additional 18 lb N/ac across all treatments)

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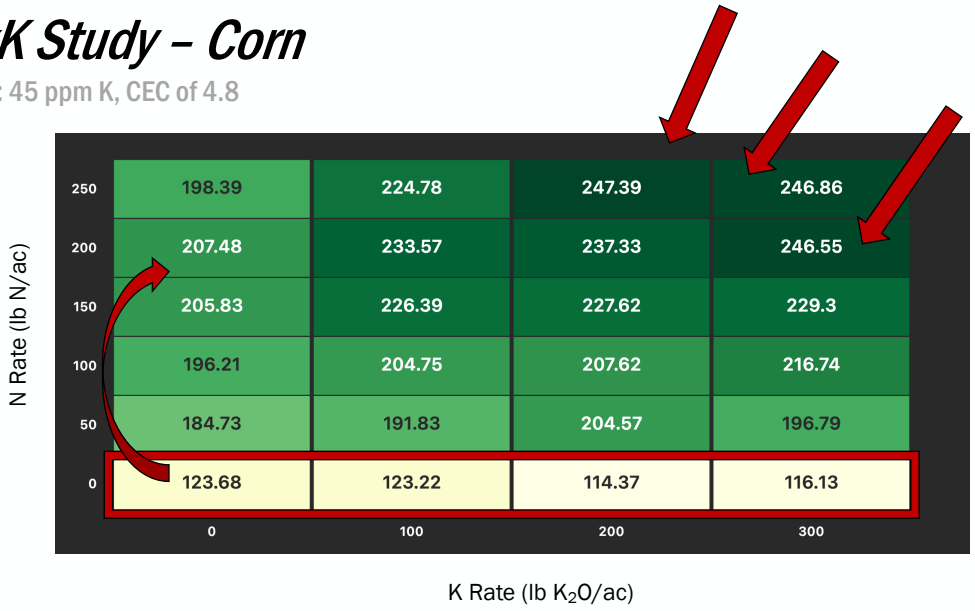
NxK Study – Corn

PPAC: 45 ppm K, CEC of 4.8



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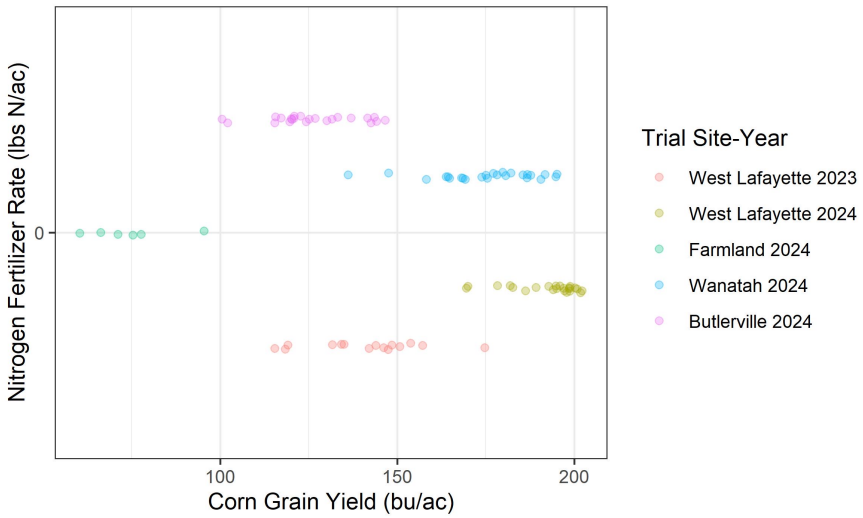
Nitrogen Management

Rapid Fire

- Figure from Dan Quinn
- Highly variable soil supply of N, with no N fertilizer applied
- Hard to predict, hard to rely on



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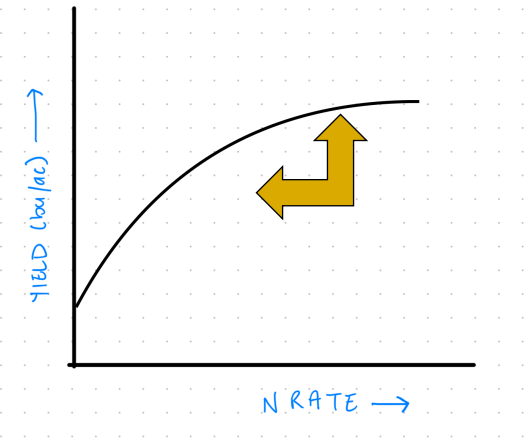
Nitrogen Management

Rapid Fire

- Also, shape of N response curve comes into play
- Tend to see much larger drop off in yield with under-fertilization for N, compared to P or K
- Continue to stive for EONR
- Use good 4R principles to protect N you've paid for
  - Timing & Placement



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Sulfur Management

Rapid Fire

Dan Quinn

- Majority of S (not applied as fertilizer) comes from mineralization of soil organic matter
- Every 1% of organic matter in top 6-8" of soil contains *about* 100 lb S/ac BUT, needs to be mineralized to be plant available
  - 2-6 lb S/ac per year that become available
- Conditions that affect soil-S availability will then be those that affect mineralization
  - More S deficiency in cool soils
  - More S deficiency in excessively wet or excessively dry soils

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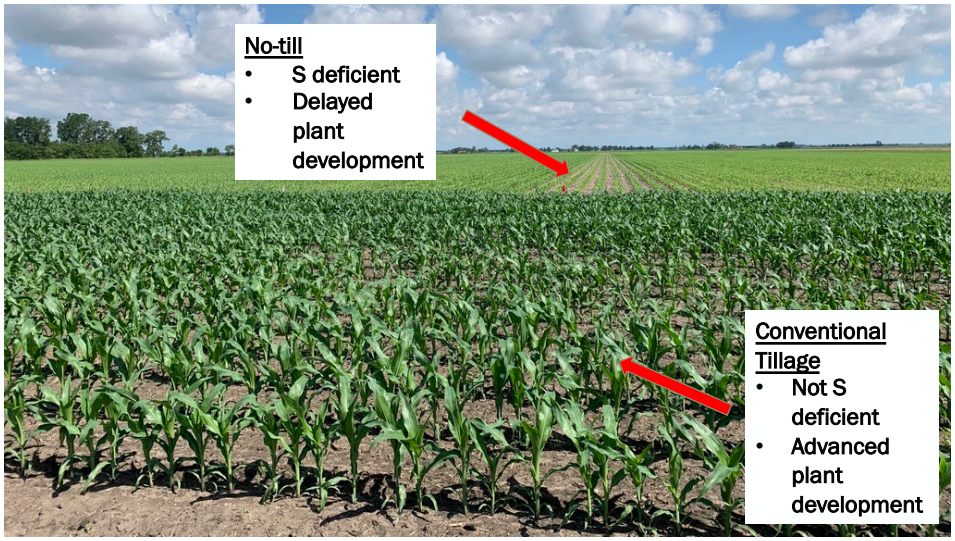
Sulfur Management

Rapid Fire

Image: J. Camberato, Purdue University



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Sulfur Management

Rapid Fire

Dan Quinn

- Can see responses to S in corn and soybean in Indiana
  - Response is variable and can be inconsistent
- Soil and early season weather conditions matter
  - Sandy, low organic matter soils – higher likelihood of response
  - Less mineralization = less soil S supply
- If you already know S is a beneficial part of your fertility program, stay the course

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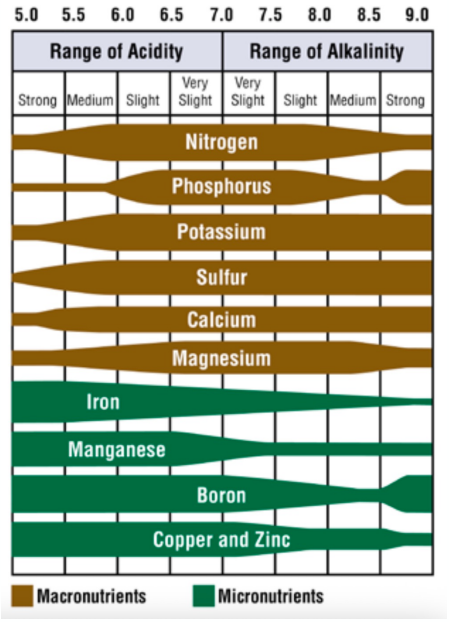
pH Management

- If it's time for a lime application, exercise caution if you're considering holding off
  - Look at soil pH and make a decision
- pH is critical for nutrient availability, particularly when it comes to P



Brady and Weil, 2007

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57

Key Takeaways

- If you've followed a build and maintain program, you've afforded yourself some flexibility for high price years

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Key Takeaways

- If you've followed a build and maintain program, you've afforded yourself some flexibility for high price years
- Soil test P/K >> critical threshold, safe to cut back rate or forgo application for a year
- Soil test P/K @ critical threshold, use caution when looking to reduce rates but could still be a viable option
- Soil test P/K < critical threshold, recommend applying at a maintenance rate (forgo build rate to save $)

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59

Key Takeaways

- If you've followed a build and maintain program, you've afforded yourself some flexibility for high price years
- Soil test P/K >> critical threshold, safe to cut back rate or forgo application for a year
- Soil test P/K @ critical threshold, use caution when looking to reduce rates but could still be a viable option
- Soil test P/K < critical threshold, recommend applying at a maintenance rate (forgo build rate to save $)
- N: stick to an EONR model for determining rates
- S: if you already know you need it, stay the course

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Making Decisions with Homegrown Data

On-Farm Research

- On-farm research can help inform changes in management **with data from your fields, under your management and growing season conditions**
- We can work with you to set up a trial if you have a specific question

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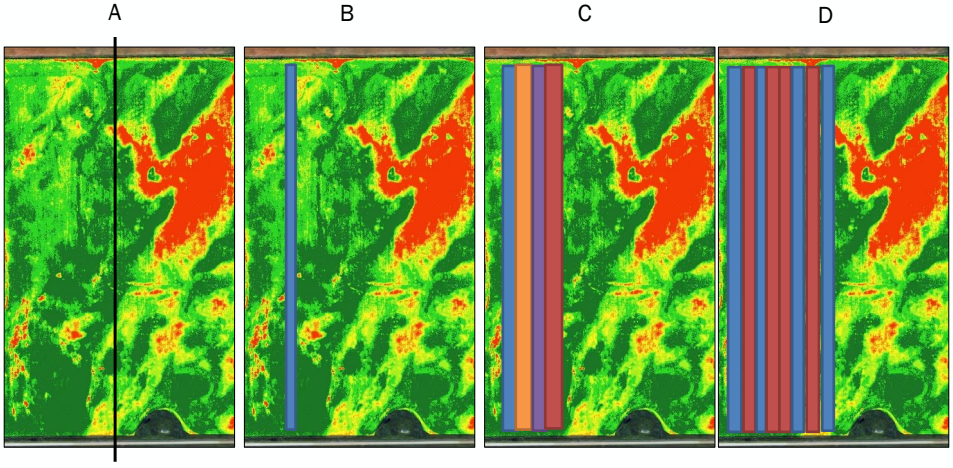
61

61

Making Decisions with Homegrown Data

On-Farm Research



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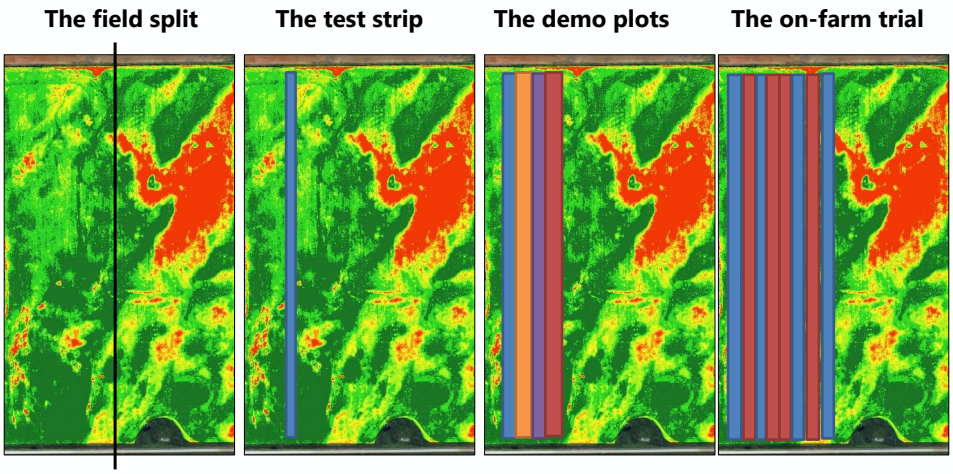
Making Decisions with Homegrown Data

On-Farm Research



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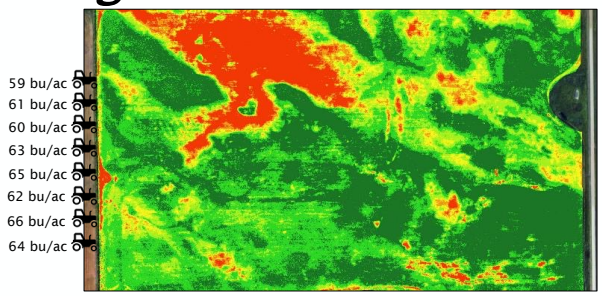
Making Decisions with Homegrown Data

On-Farm Research

8 Passes, 8 different yields



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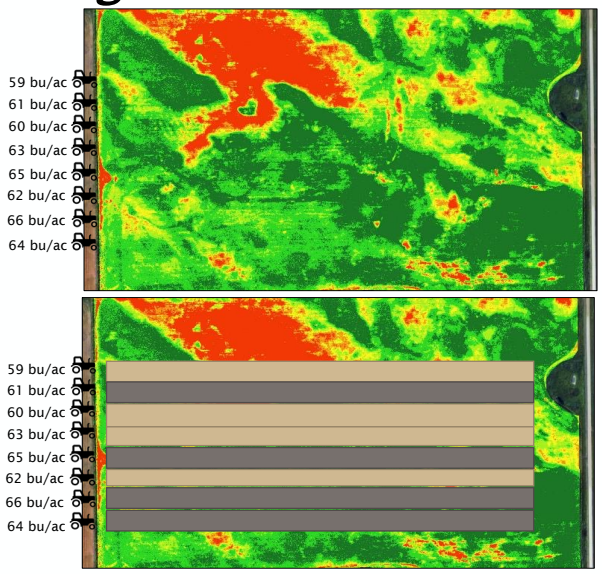
Making Decisions with Homegrown Data

On-Farm Research

8 Passes, 8 different yields



8 Passes, 8 different yields
and <u>why</u> they are different

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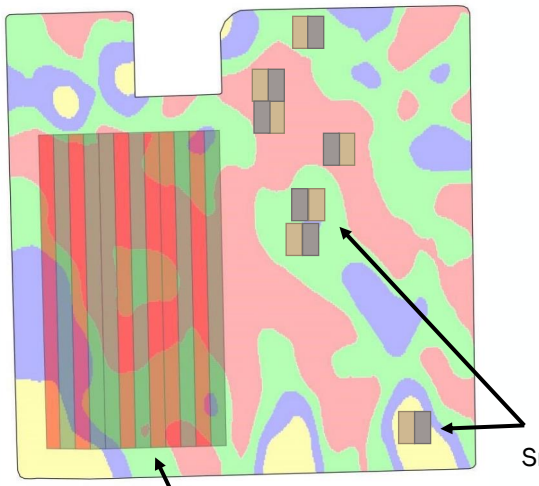
Making Decisions with Homegrown Data

On-Farm Research

The scale of the question should reflect **the scale of management decisions**

How is field variability managed?



Smaller-scale plots

Strip trials

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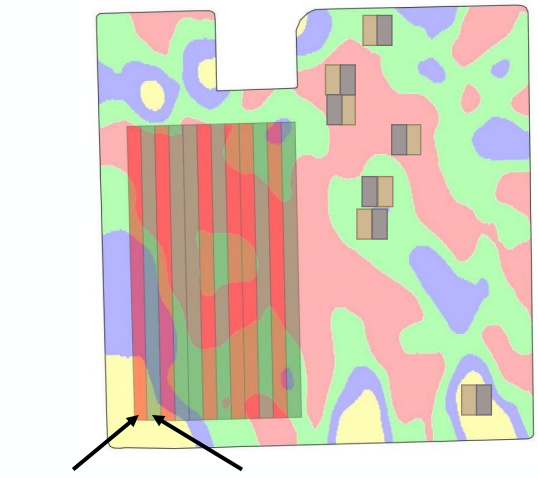
Making Decisions with Homegrown Data

On-Farm Research

- We can work with you to set up a trial if you have a specific question
- I am more than happy to help
- Reducing fertilizer rates this year
  - P
  - K
- Another related fertility question (or any agronomic question you might have)



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67

Questions?

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74