Fertilizer Recommendation Support Tool and P & K Management

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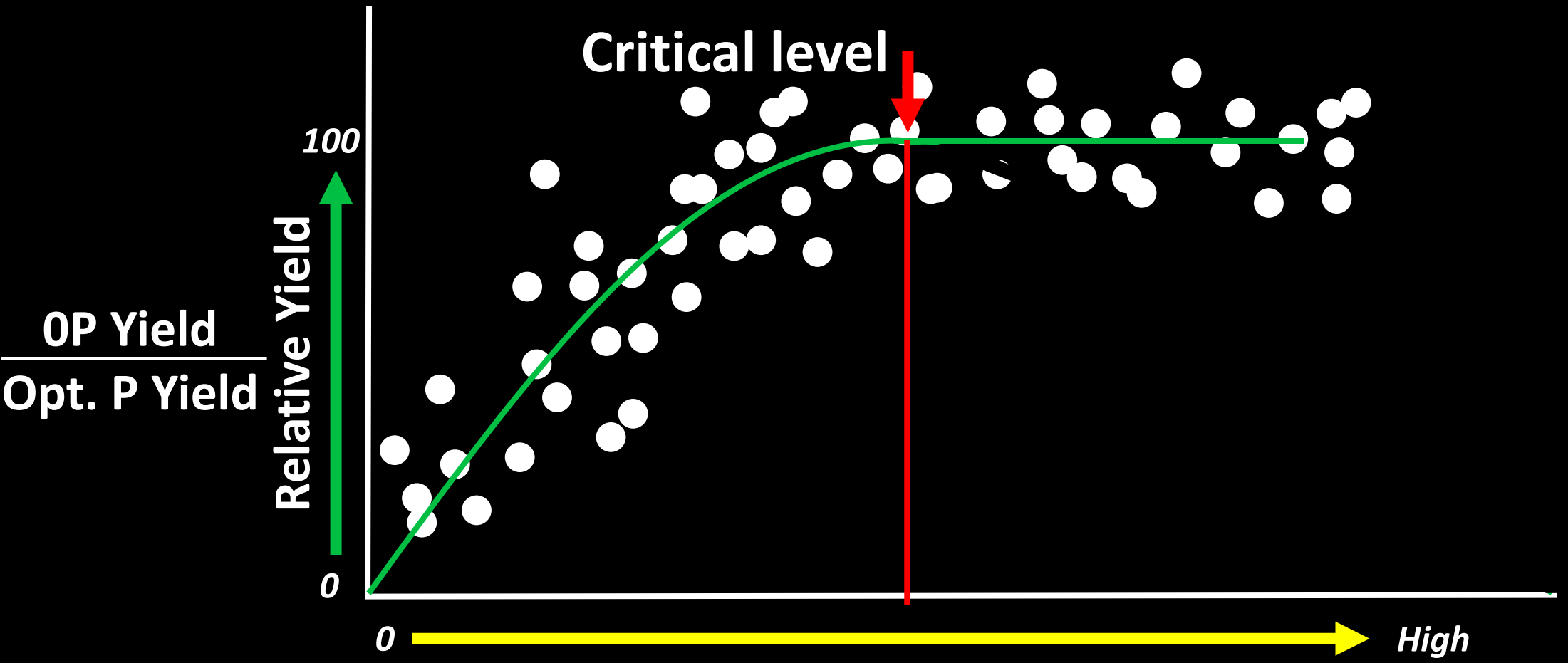
Basis of soil fertility recommendations

- Correlation
  - What soil test levels respond and don’t respond to fertilization
- Calibration
  - What rate of fertilizer should I apply

Correlation analysis:

Olsen-P
Bray-P
Mehlich-3 ICP
Mehlich-3 color

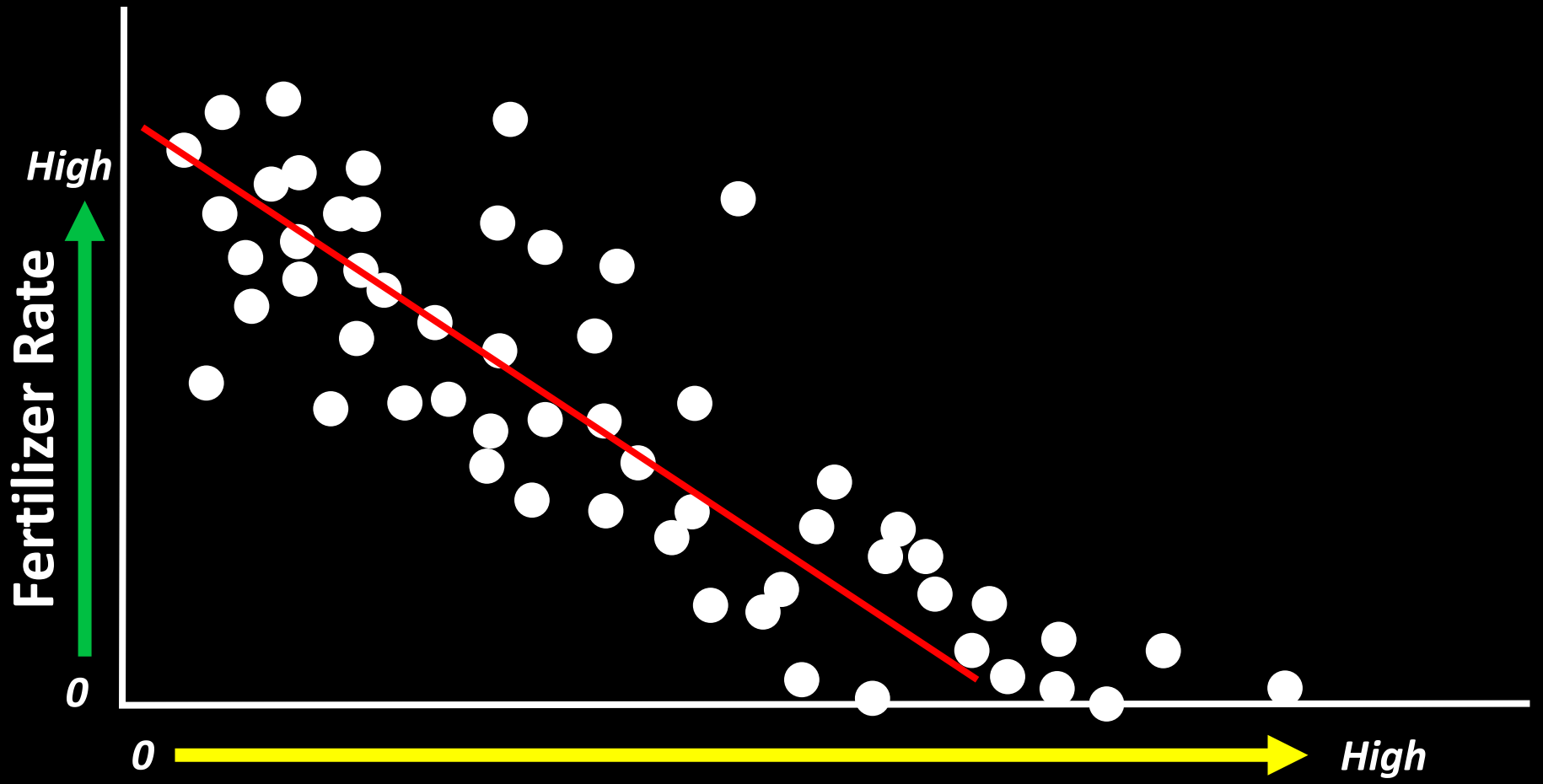
Correlation analysis



Olsen-P Bray-P

Mehlich-3 ICP Mehlich-3 color

Calibration analysis: What rate of P to apply?

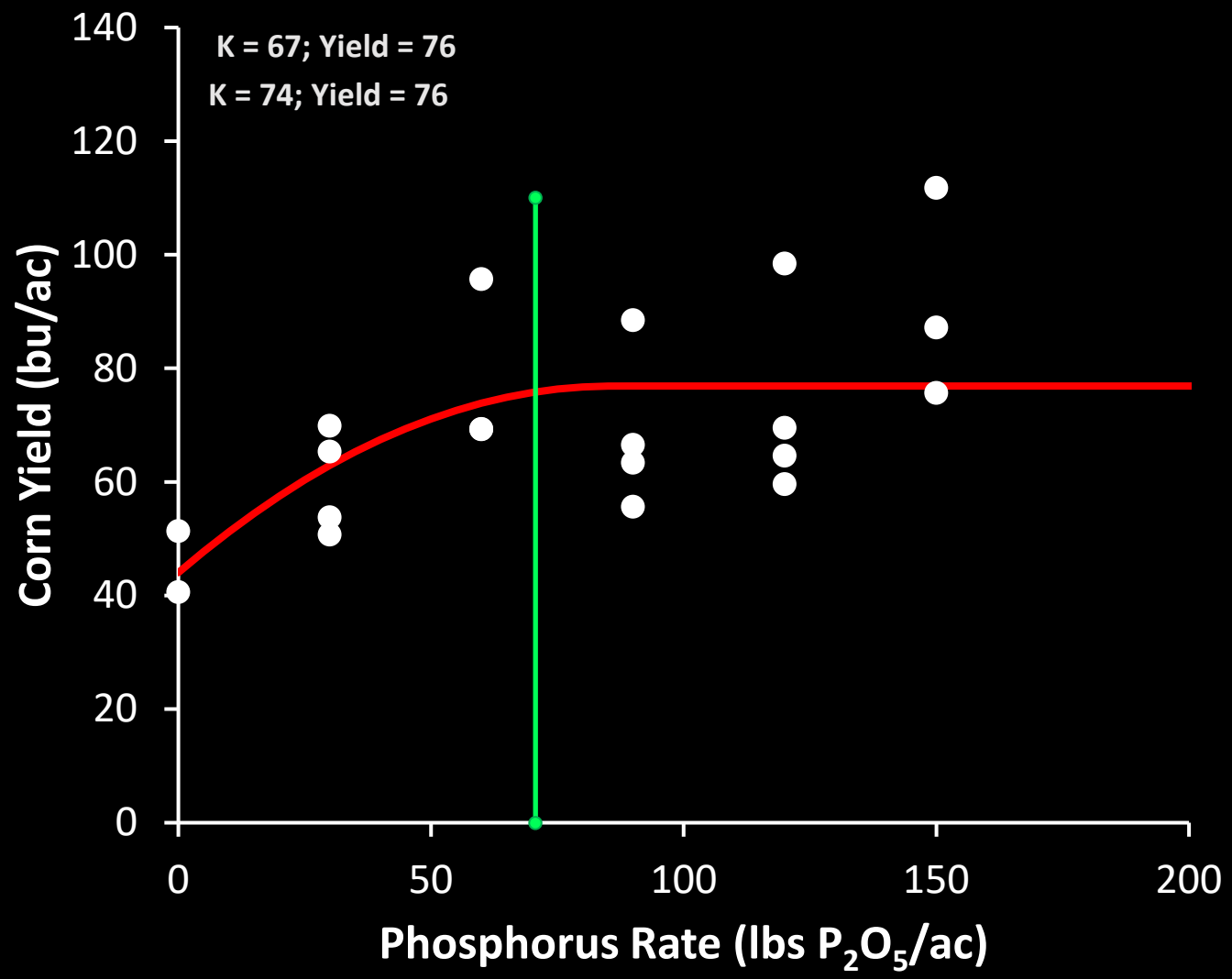


Olsen-P Bray-P

Mehlich-3 ICP Mehlich-3 color

How is the research typically done?

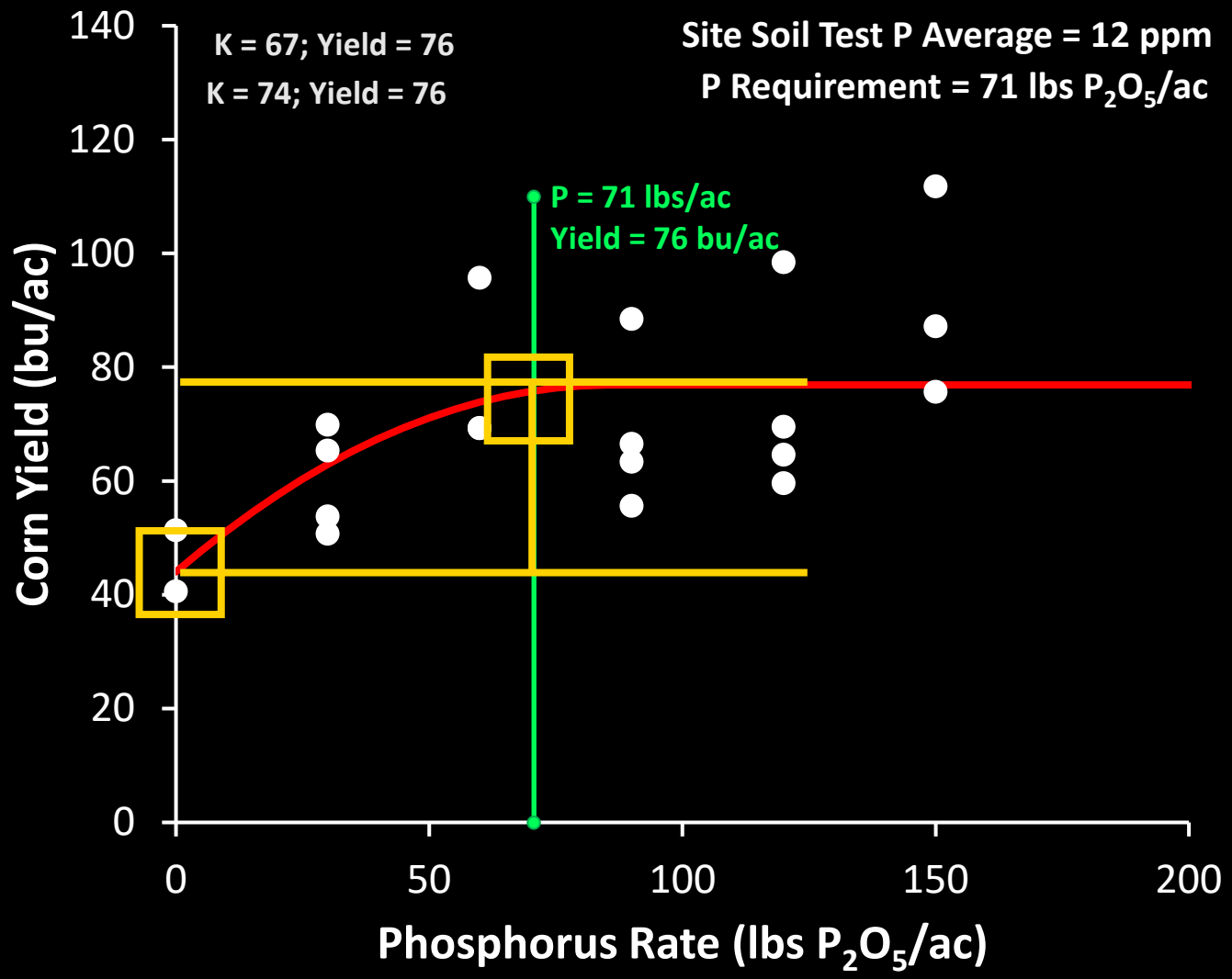
Rep 1	0	30	60	90	120	150
Rep 2						
Rep 3						
Rep 4						



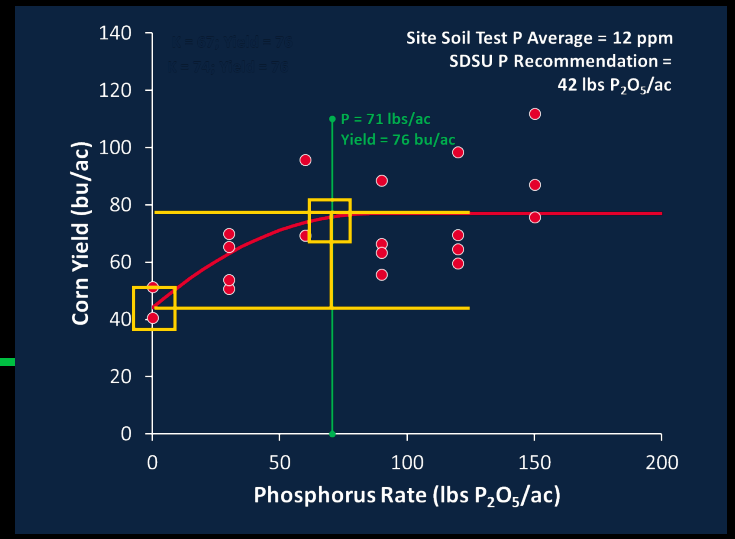
Yield: 0P, optimum P, Relative Yield, Change in Yield

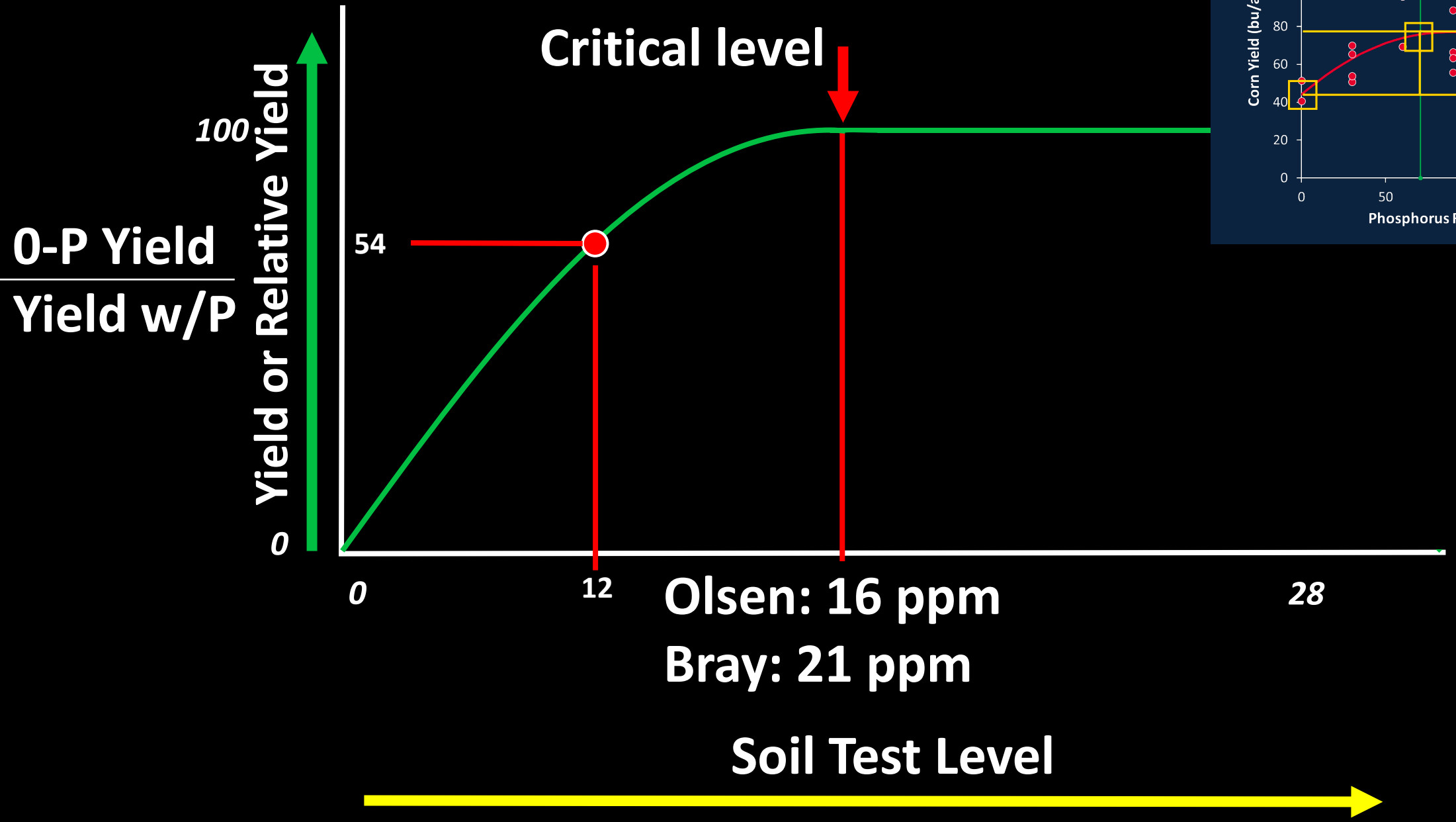
Soil test at 12 ppm:

- Yield at 0 P: 41 bu/ac
- Optimal Yield: 76 bu/ac
- **Relative Yield** = 41/76 = 0.54
- **Change in yield** = 76-41 = 35

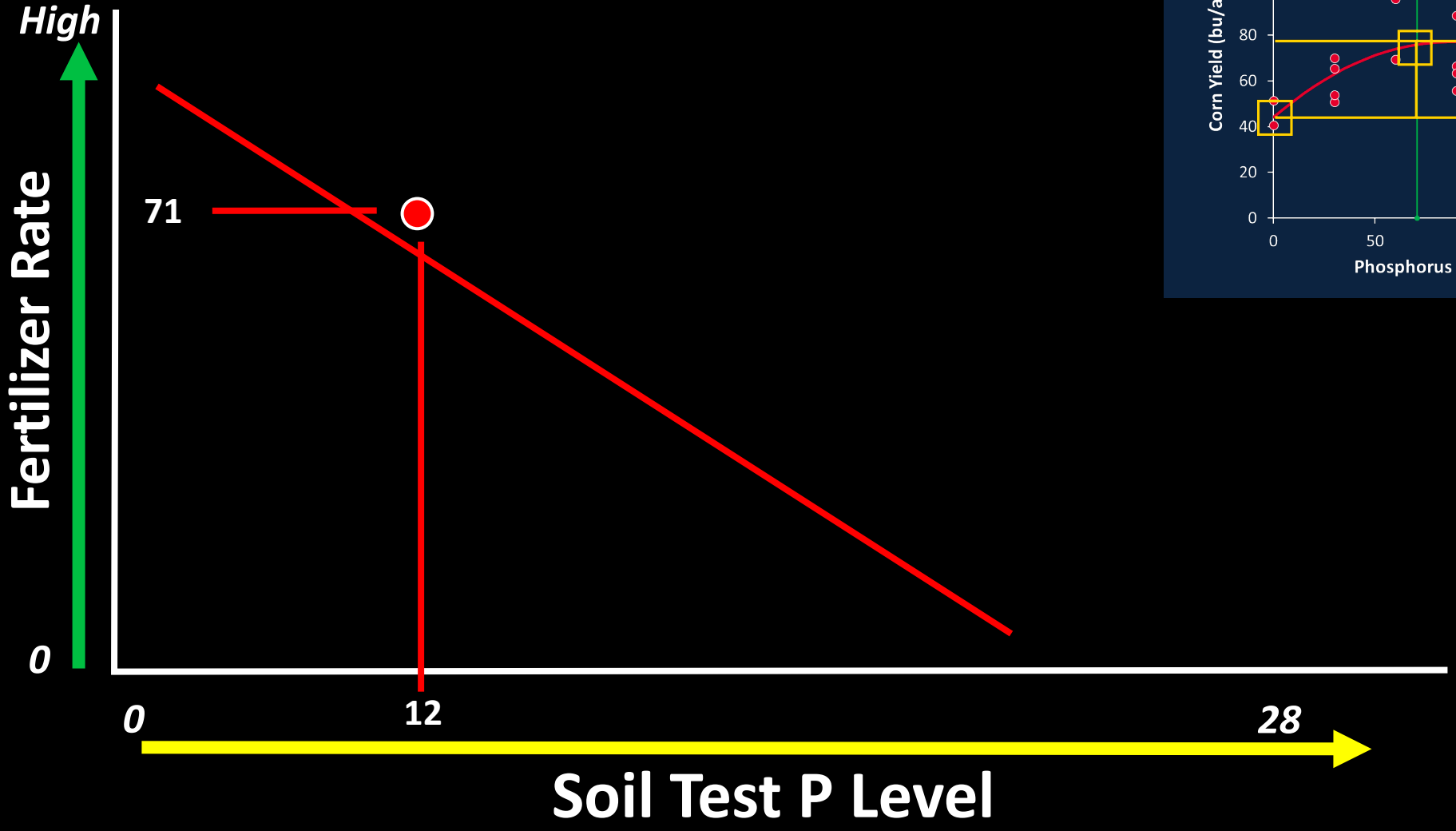


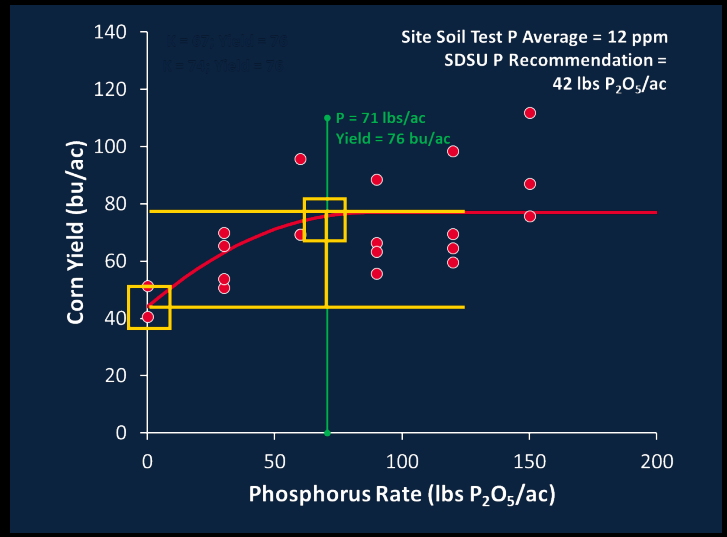
Phosphorus correlation:





Phosphorus calibration:

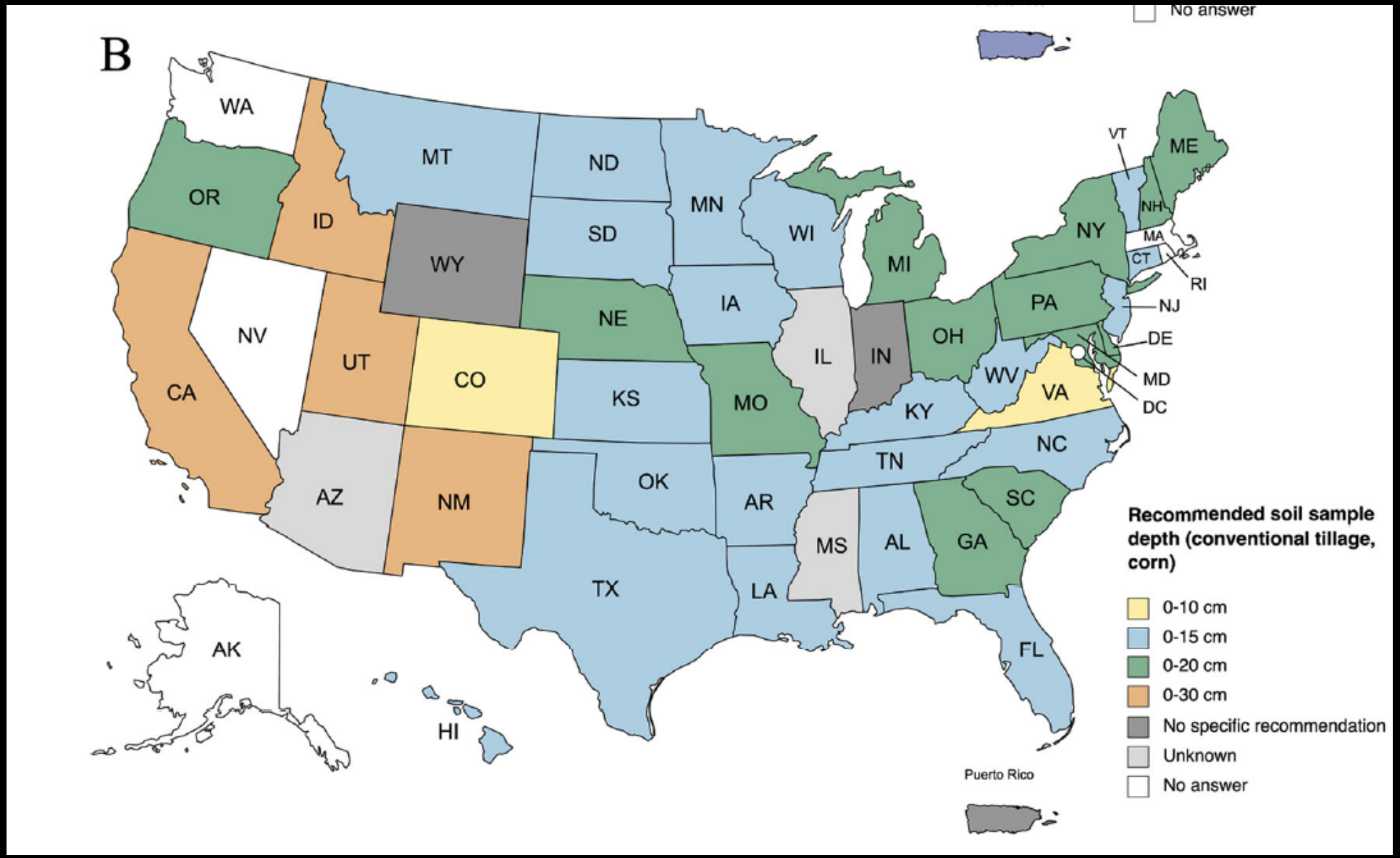




Soil Testing Comparisons

- Depth of soil sampling
- Soil test categories
  - Soil test extractants
- When to fertilize & not
- What rate to fertilize

Soil sampling depth



- 0-4”
- 0-6”
- 0-8”
- 0-12”
- None/Unknown

Comparison between SD, MN, IA P & K recs

Soil Testing Categories

MN
Very low
Low
Medium
High
Very High

Comparison between SD, MN, IA P & K recs

Soil Testing Categories

Phosphorus Bray-P

Cat.	MN
VL	0-5
L	6-10
M/O	11-15
H	16-20
VH	21+

Phosphorus Olsen-P (pH >7.4)

Comparison between SD, MN, IA P & K recs

Soil Testing Categories

Phosphorus Mehlich-3 color

Cat.	MN*	Iowa
VL		0-9
L		10-17
M/O		18-25
H		26-34
VH		35+

***Mehlich-3 not suggested for MN or SD. However, if pH < 7.4 follow Bray result guidelines. pH > 7.4 not likely related to Olsen P**

Phosphorus Mehlich-3 ICP

Comparison between SD, MN, IA P & K recs

Soil Testing Categories (dry soil)

Potassium: Ammonium acetate

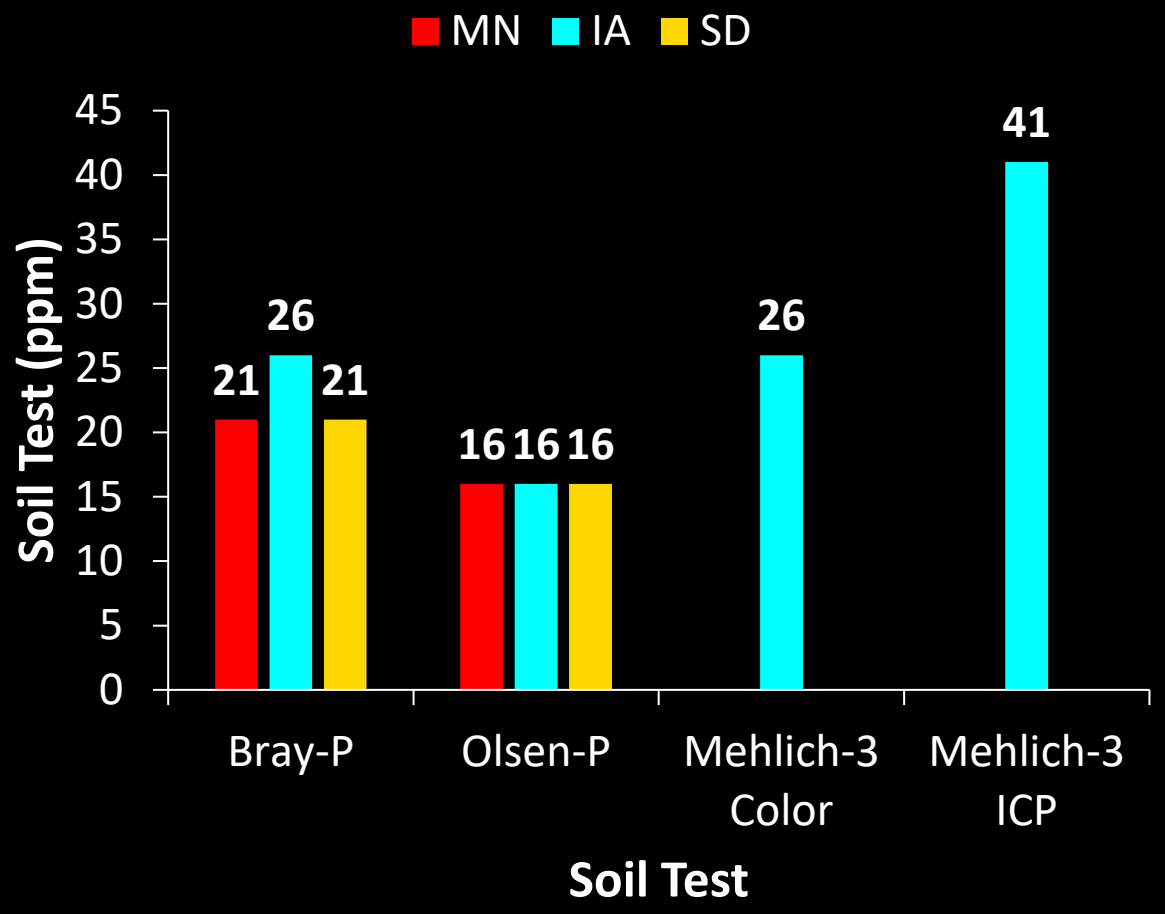
Potassium Mehlich-3

Cat.	MN
VL	0-50
L	51-100
M/O	101-150
H	151-200
VH	201+

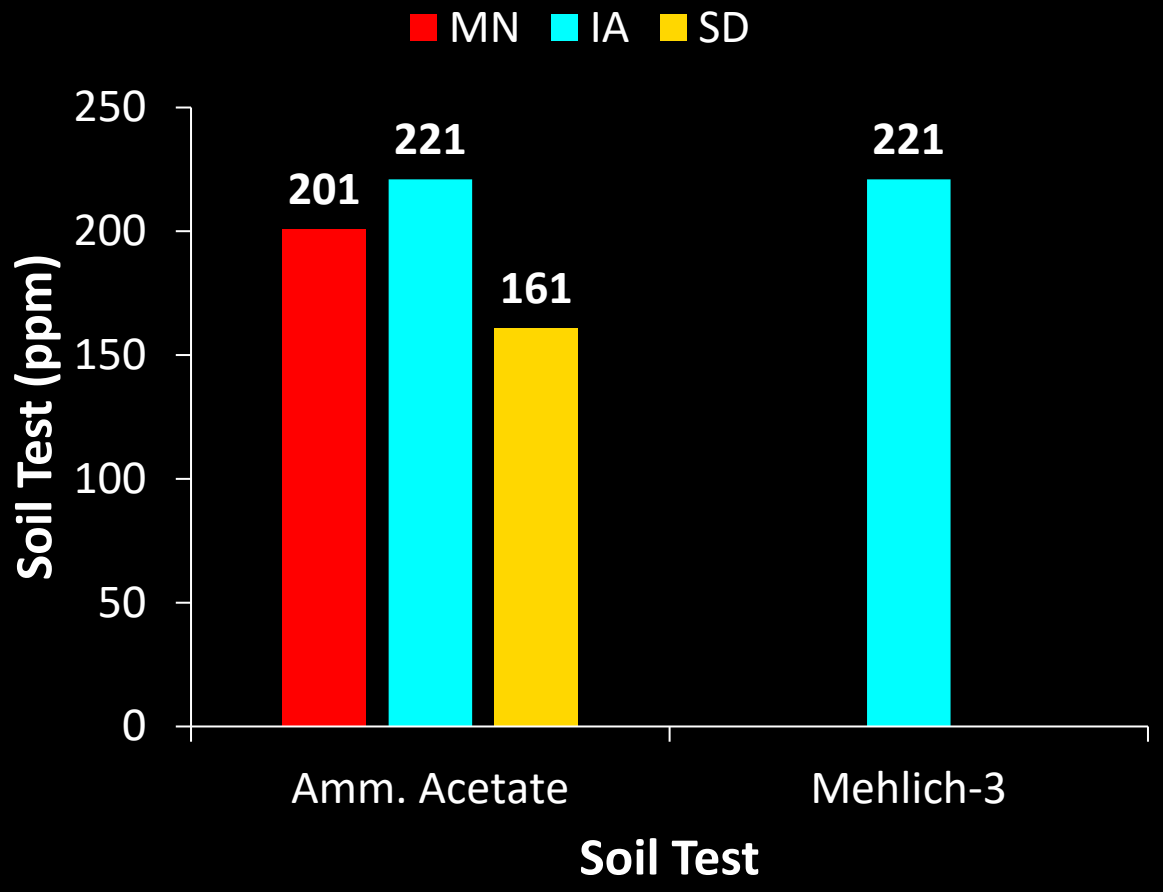
Comparison between SD, MN, IA P & K recs

When not to fertilize

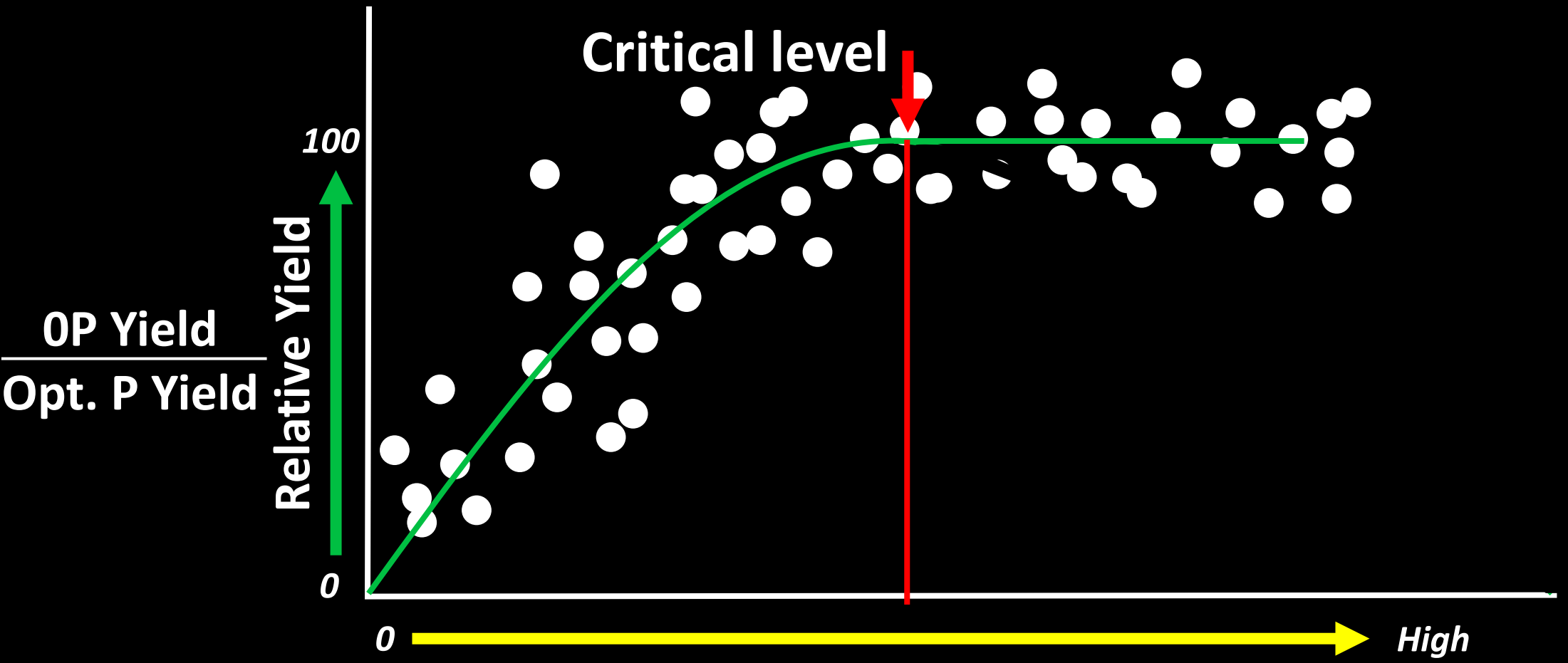
Phosphorus



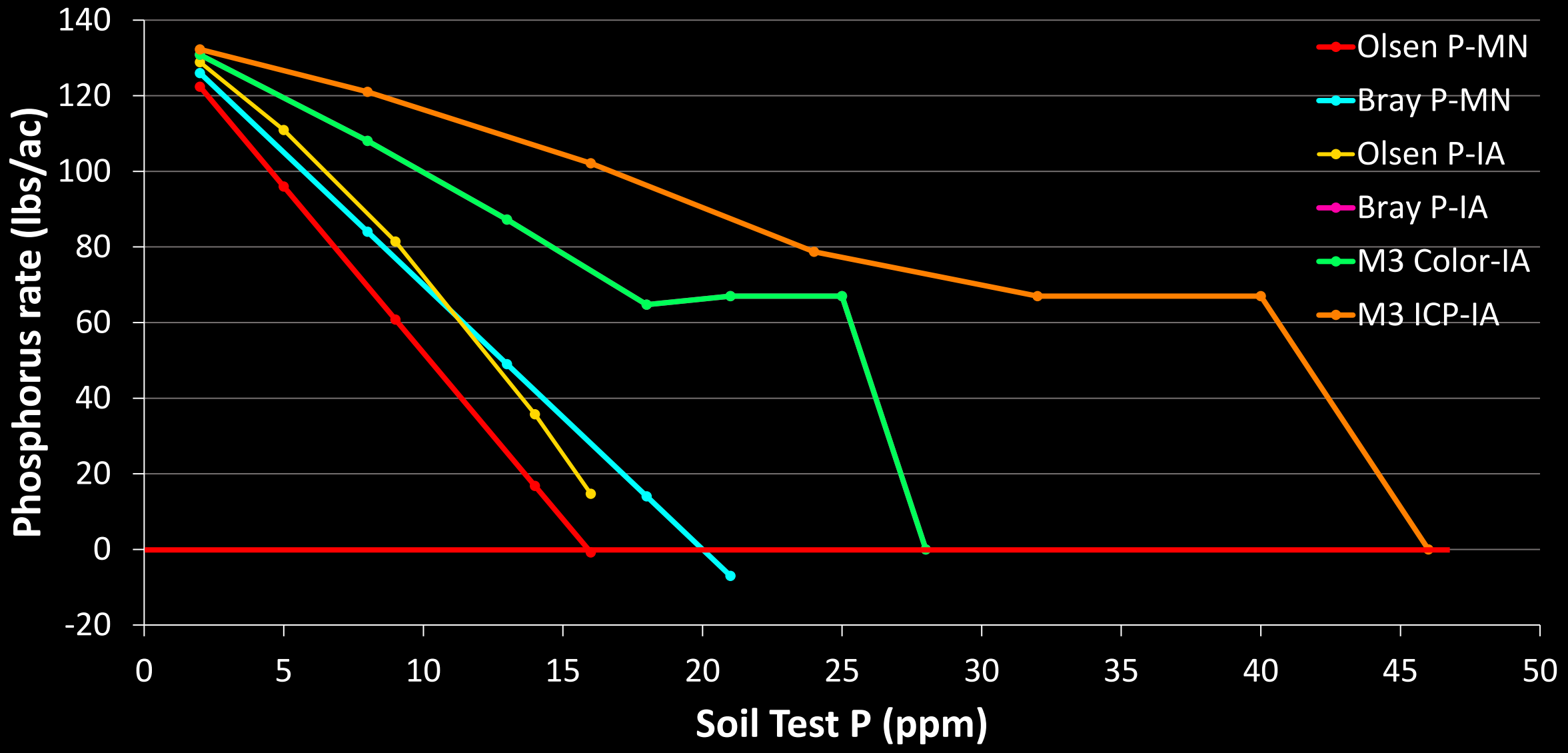
Potassium



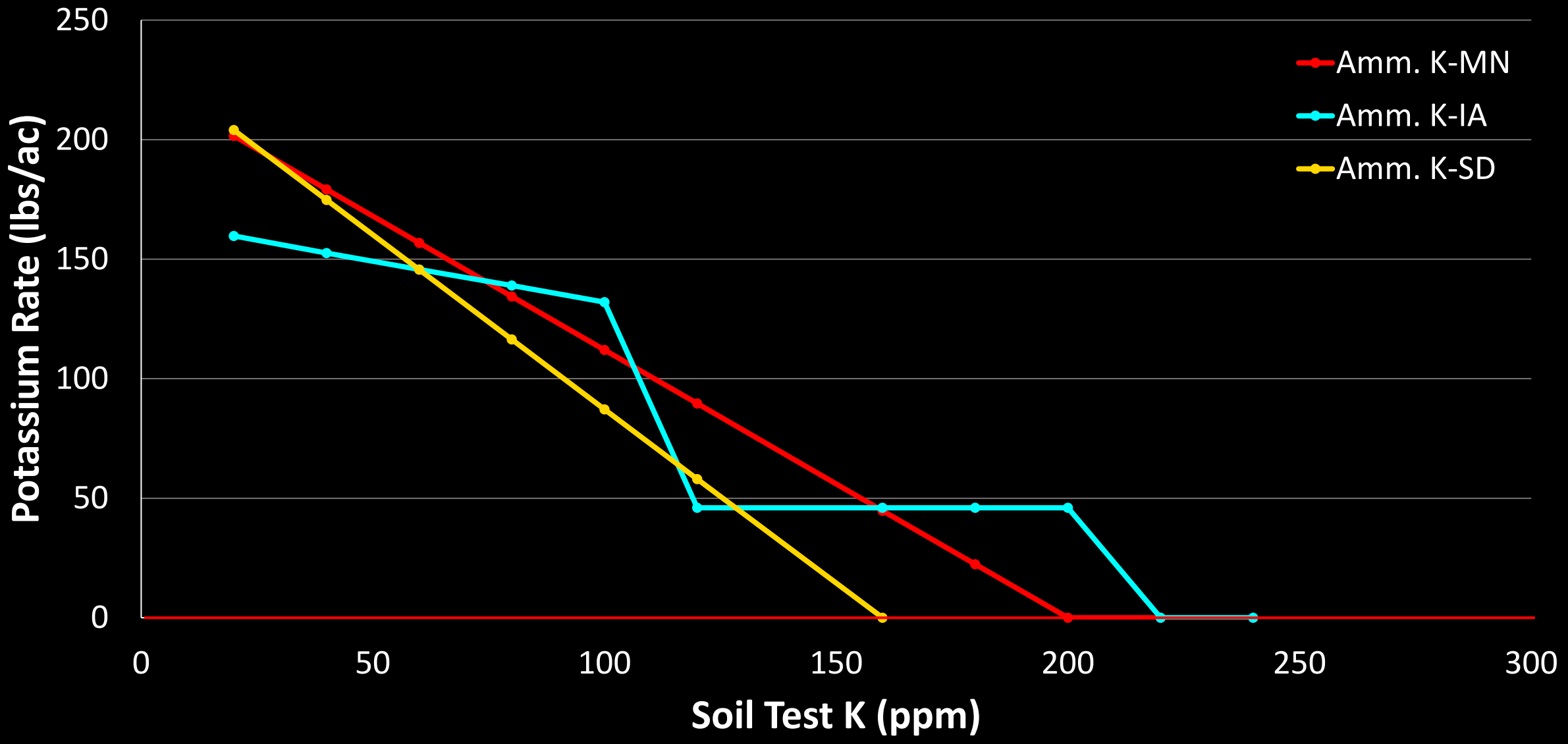
Correlation analysis



Fertilizer Rate Comparisons: Phosphorus



Fertilizer Rate Comparisons: Potassium



Other Fertilizer Recommendation Discrepancies

State	Soil Test	Soil Test Level					Phosphorus Fertilizer	
		Level I	Level II	Level III	Level IV	Level V	Min Rate	Max Rate
							lb P_2O_5/acre	
A	Bray-1	0-5						
B	Bray-1	0-7						
C	Bray-1	0-9						
D	Bray-1	0-9						
E	Bray-1	0-25		26-35	>35			
Color Key		Below CSTV		CSTV-FCOV	>FCOV (no fertilizer recommended)			

Comparison between SD, MN, IA P & K recs

- Depth of soil sampling
- Soil test categories
  - Soil test extractants
- When to fertilize & not
- What rate to fertilize

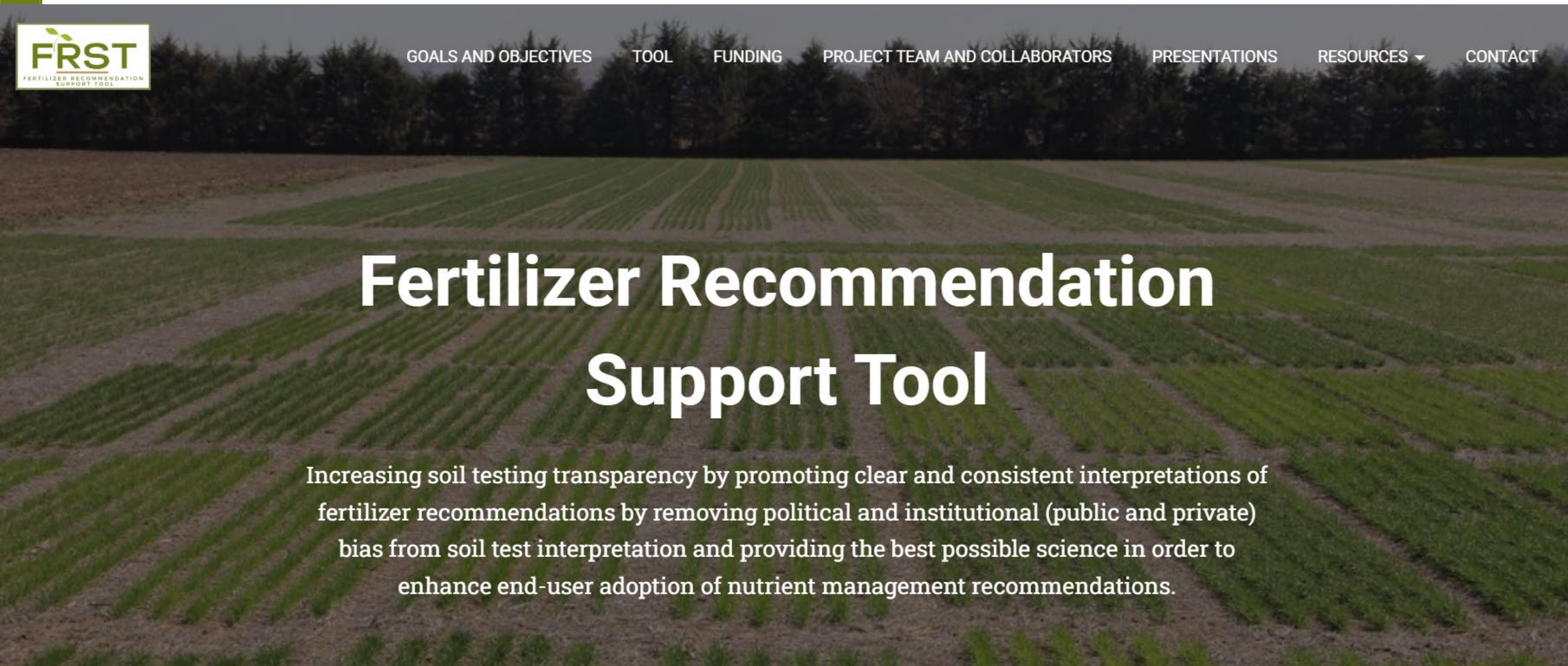
SOME SIMILAR AND SOME VERY DIFFERENT

Problems

- Retirement
  - Often don’t know how the work was done or have the data
- People likely have different methods used
  - Relative yield calculation
  - Model to determine when to no longer fertilize
  - Model to determine what rate to fertilize
    - Do we apply enough for yield that year
    - Do we include crop removal in it
    - Do we work to build the soil test level
- Potential Solution
  - National collaborative effort: FRST

Fertilizer Recommendation Support Tool (FRST)

https://soiltestfrst.org/objectives/



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The Ohio State University

UConn University of Connecticut

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University of Nevada, Reno

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UofA Division of Agriculture Research & Extension University of Arkansas System

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FFAR

FAR Foundation for Agronomic Research

Rock River Laboratory, Inc. Agricultural Analysis

UF University of Florida

NM State

Arizona

LSU Louisiana State University

ALP Agricultural Laboratory Proficiency Program

Plant Nutrition Canada

University of Guelph

UPR Recinto Universitario de Mayagüez

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Nathan Slaton	University of Arkansas
Joao Souza	Montana State University
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Jim Wang	Louisiana State University
Charles White	Penn State
Stephen Wood	The Nature Conservancy
Frank Yin	University of Tennessee
Matt Yost	Utah State University

Fertilizer Recommendation Support Tool (FRST)

SOILTESTFRST.ORG

Increasing soil testing transparency by promoting clear and consistent interpretations of Fertilizer recommendations by removing political and institutional (public and private) bias from soil test interpretation and providing the best possible science in order to enhance end-user adoption of nutrient management recommendations.

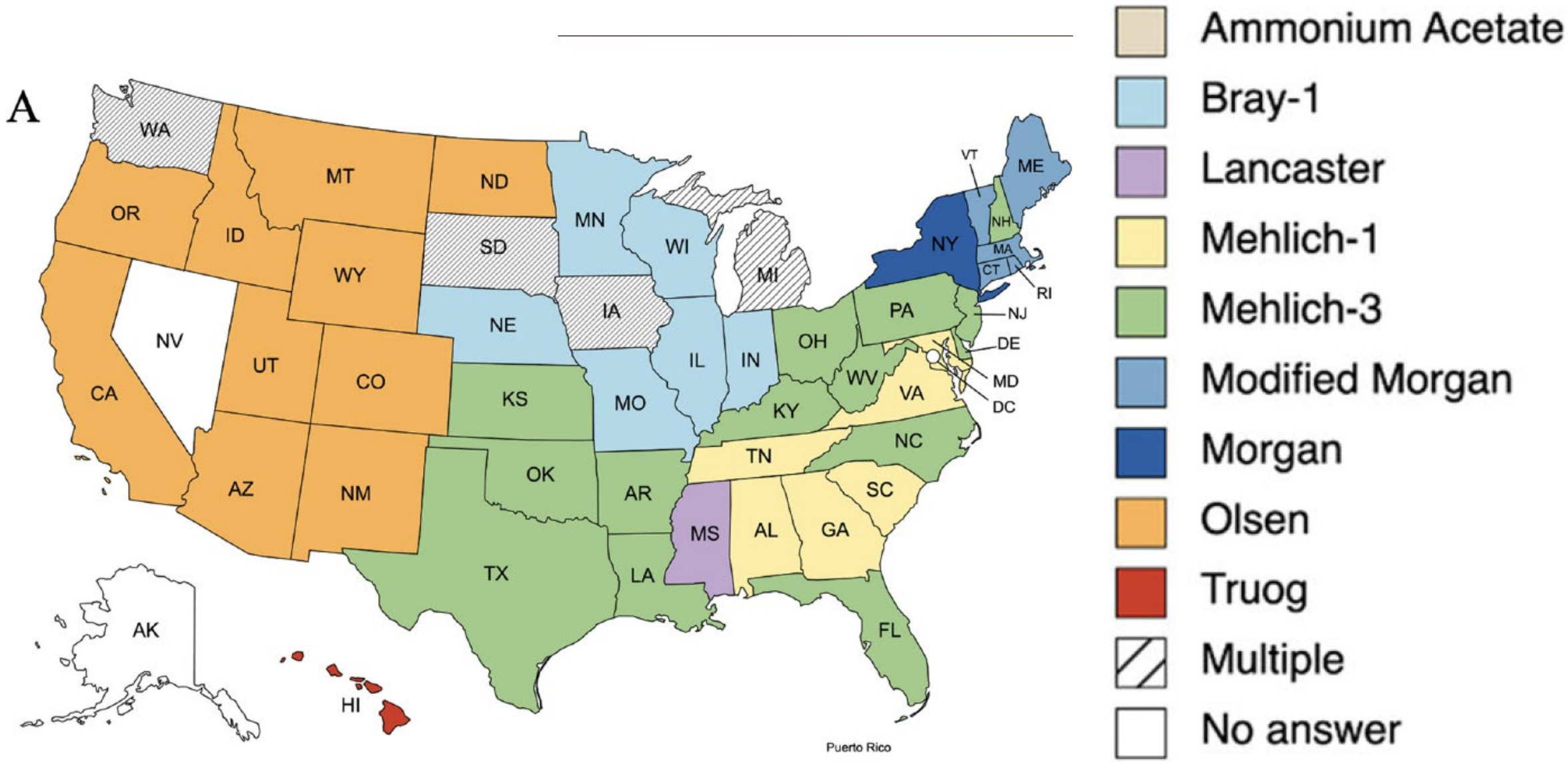
FRST
FERTILIZER RECOMMENDATION SUPPORT TOOL

FRST Goals

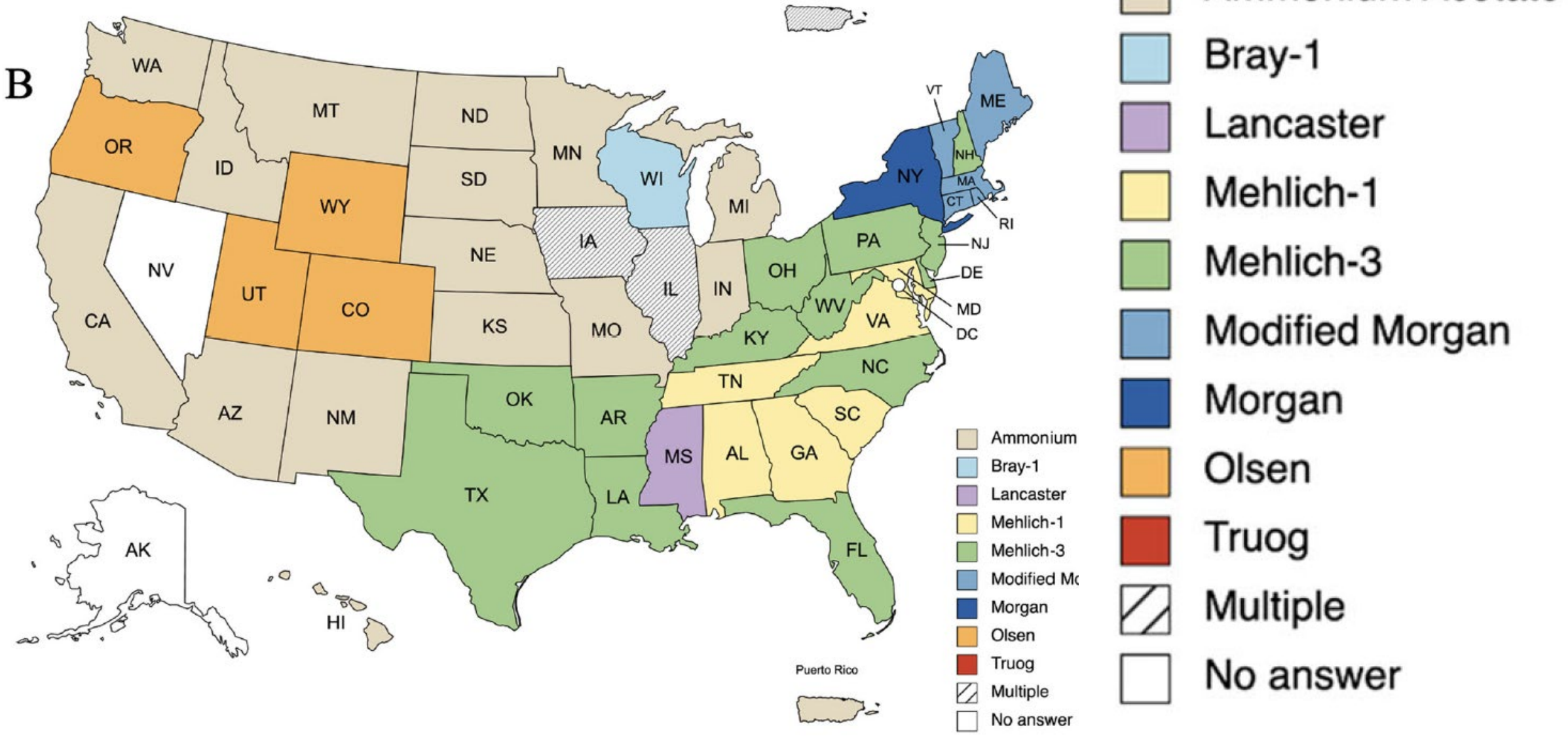
- Transparency of soil test evaluation
  - Remove political and institutional bias from soil test interpretation
- Develop a decision aid to store and manage crop soil fertility data that assists in the advancement of soil testing science
- Enhance end-user awareness, confidence, and adoption of soil-test-based crop nutrient management recommendations
- Provide a collaborative environment for discussing and communicating the issues, needs, and science of soil-test-based nutrient recommendations to catalyze innovation in soil fertility assessment
- *Provide information that can be used to augment existing state recommendation systems*

Survey

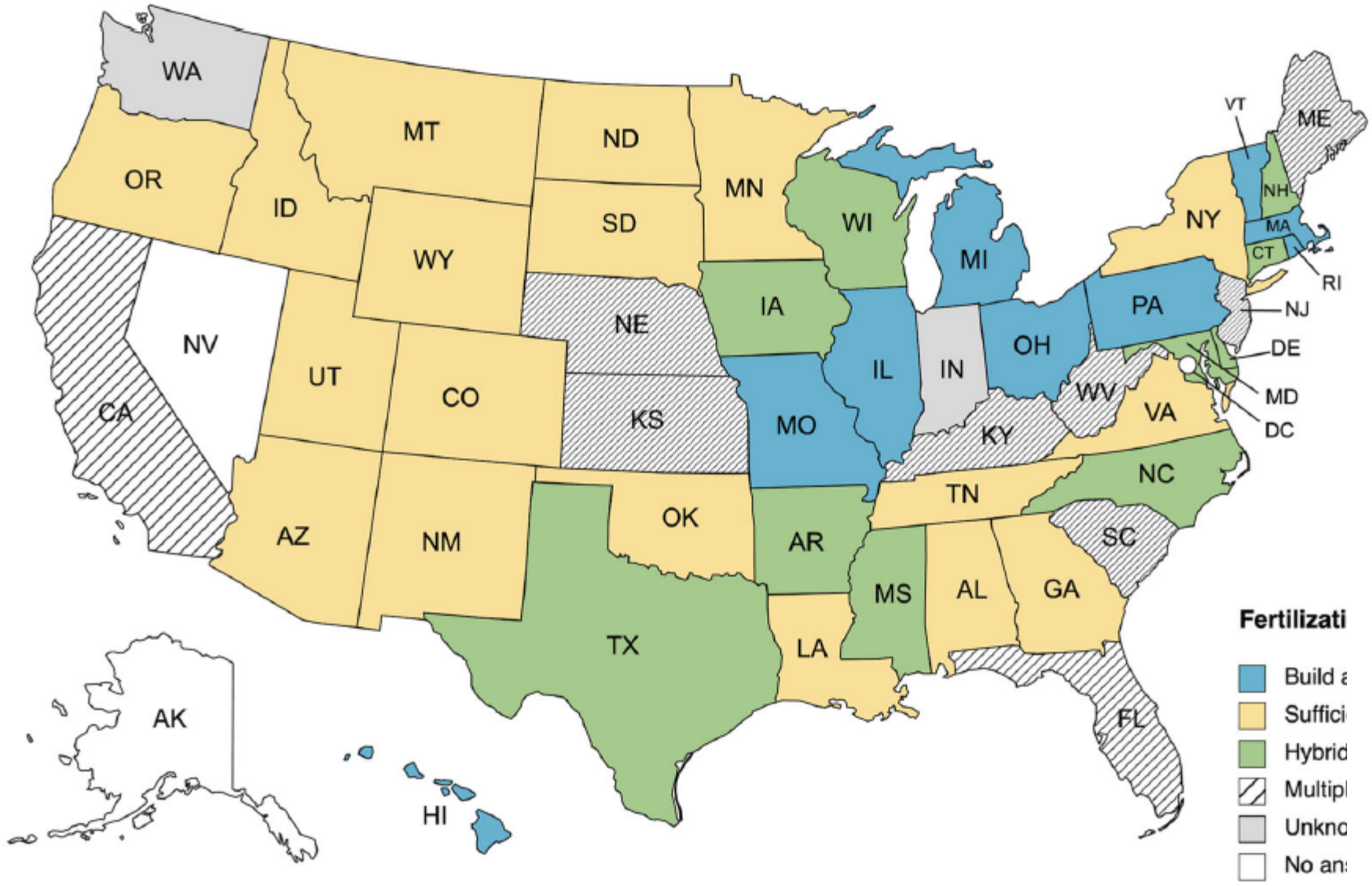
Soil test P extraction methods



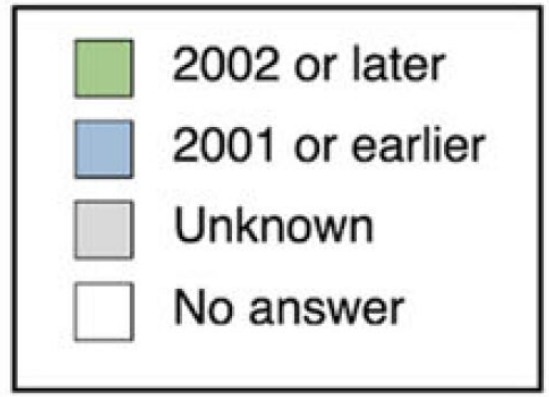
Soil test K extraction methods



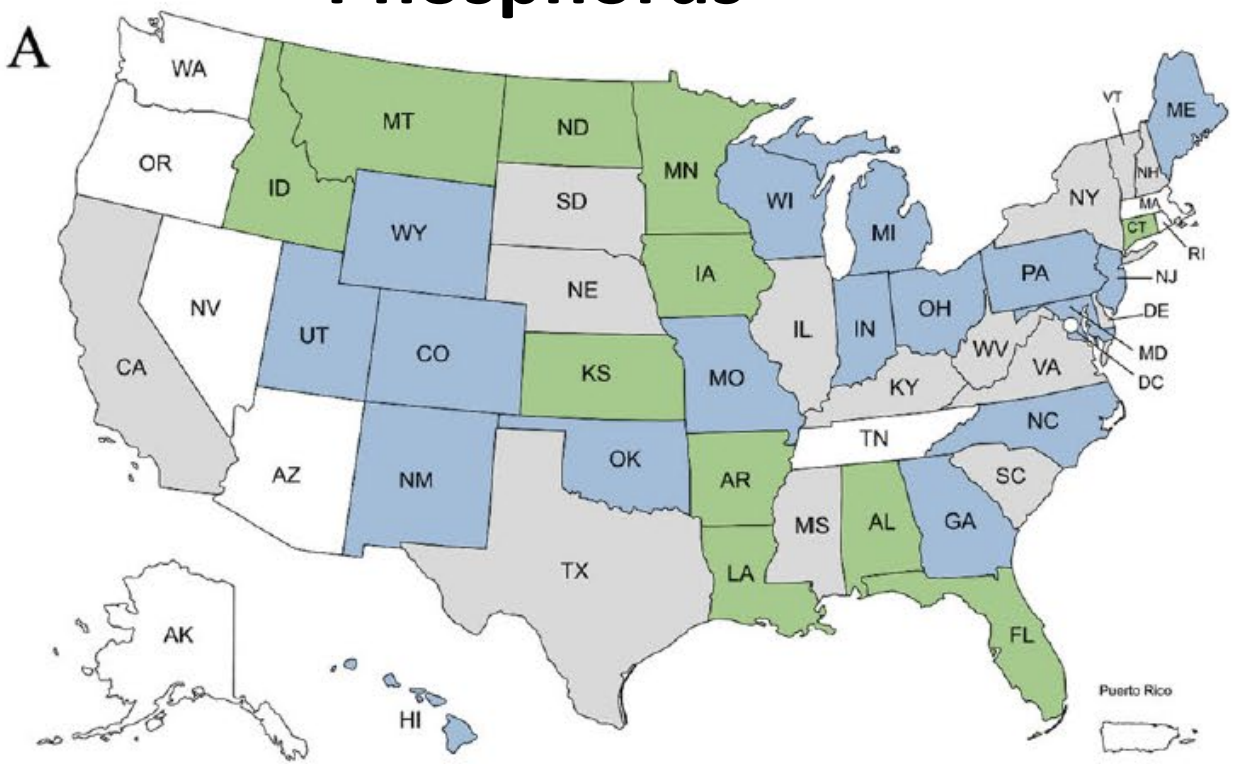
Philosophy: Build & Maintain or Sufficiency



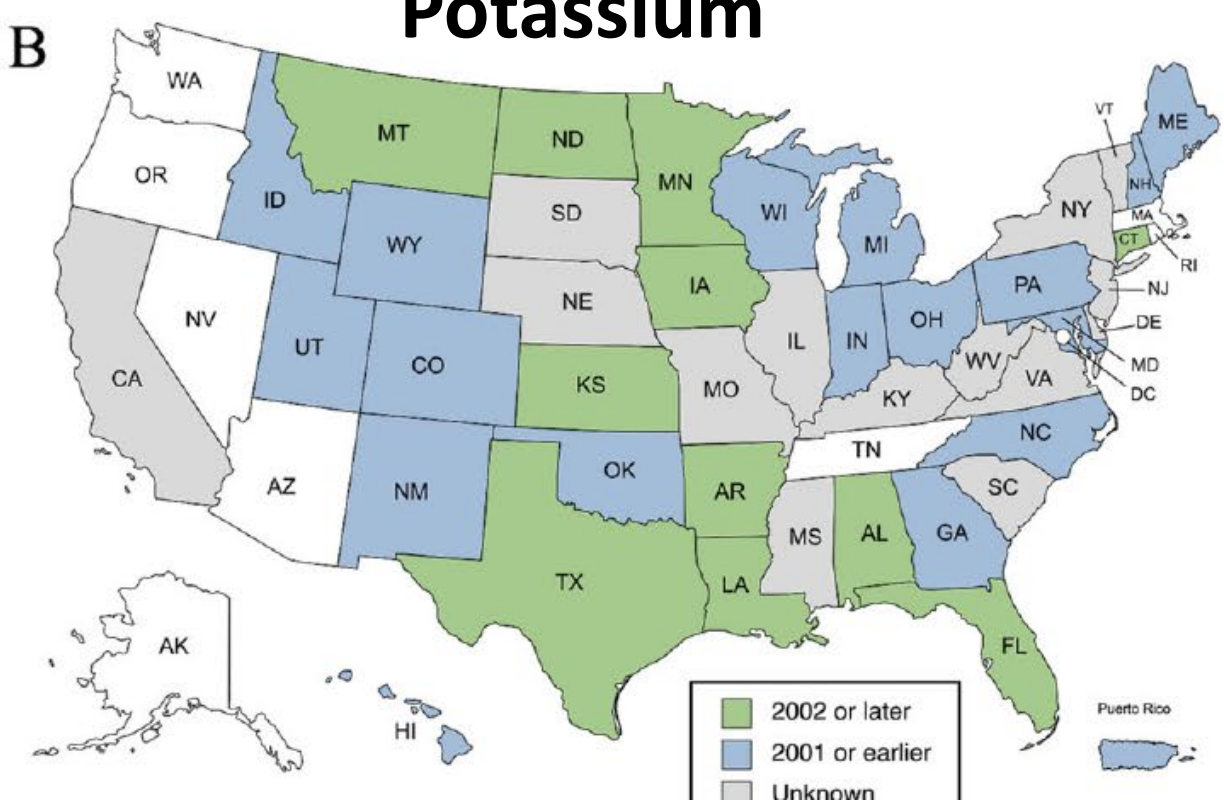
Last correlation update/validation



Phosphorus



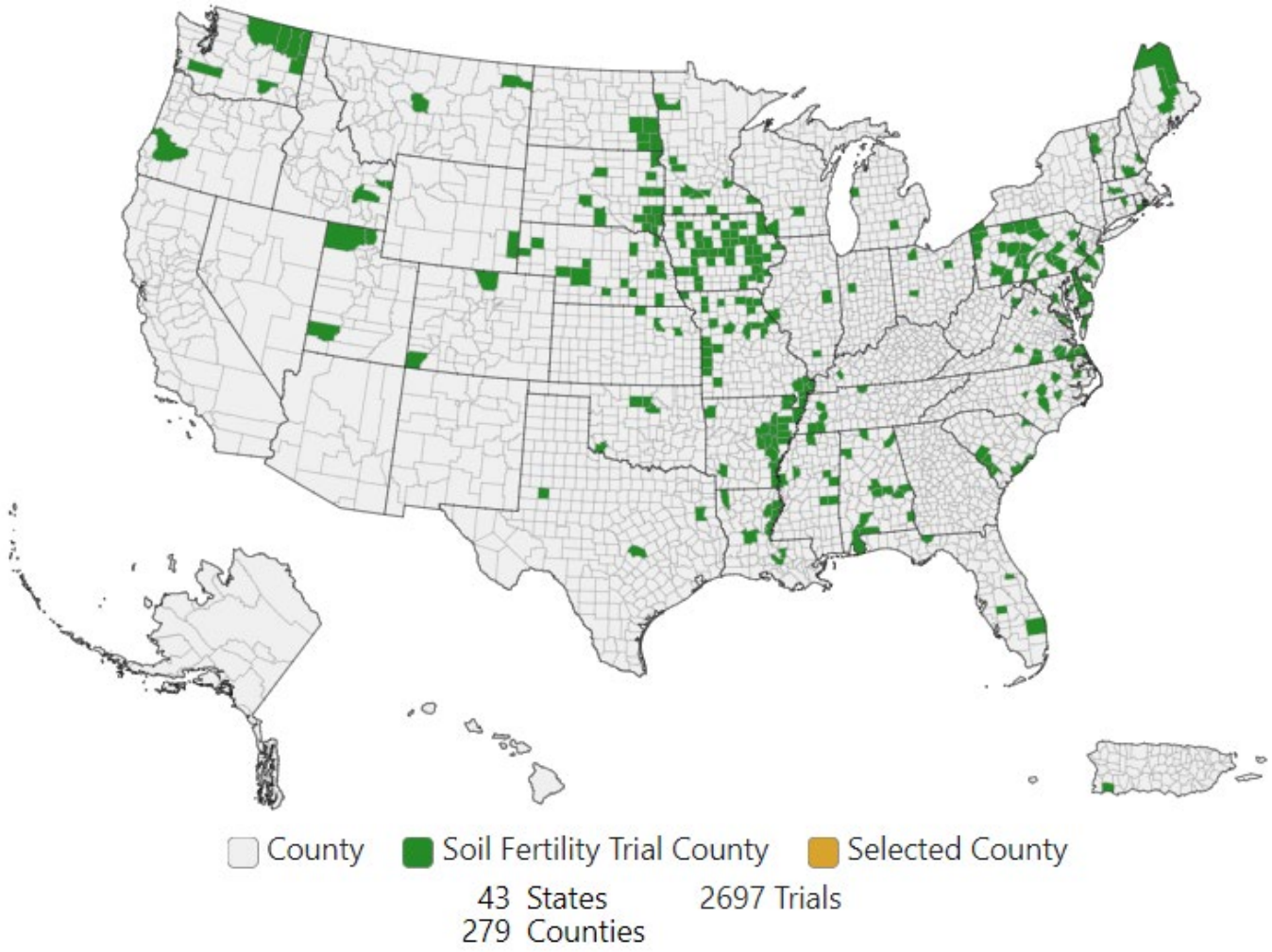
Potassium



Database: legacy and new data

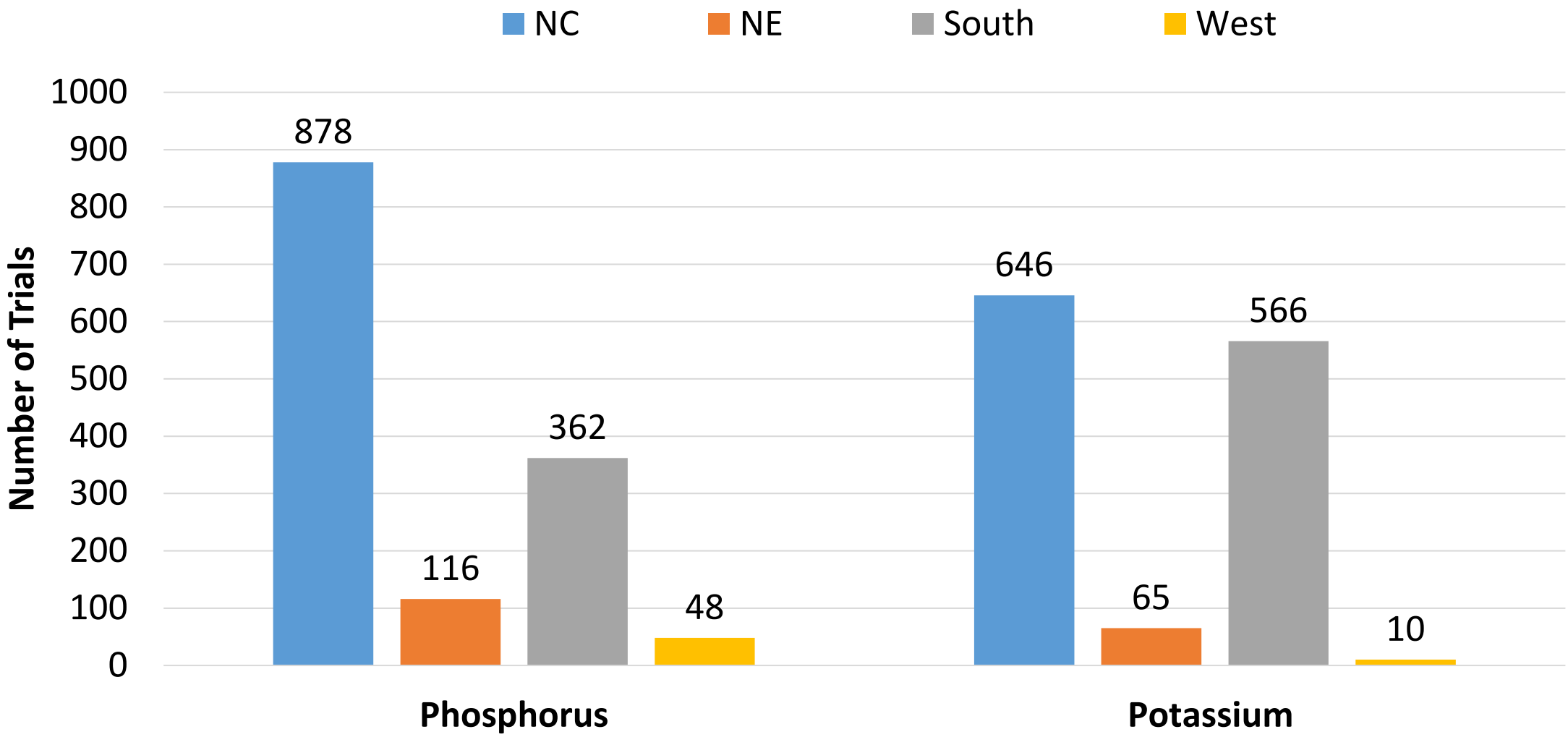
FRST, Fertilizer Recommendation Support Tool

- **P database, 1404 observations**
  - 39 states represented
  - Corn data, 25 states
  - Soybean data, 15 states
  - 83% of data from corn & soybea
- **K database, 1293 observations**
  - 30 states represented
  - Corn data, 22 states
  - Soybean data, 17 states
  - 76% of data from corn & soybea



Database information from October 2(

Geography of Soil-Test Correlation Database

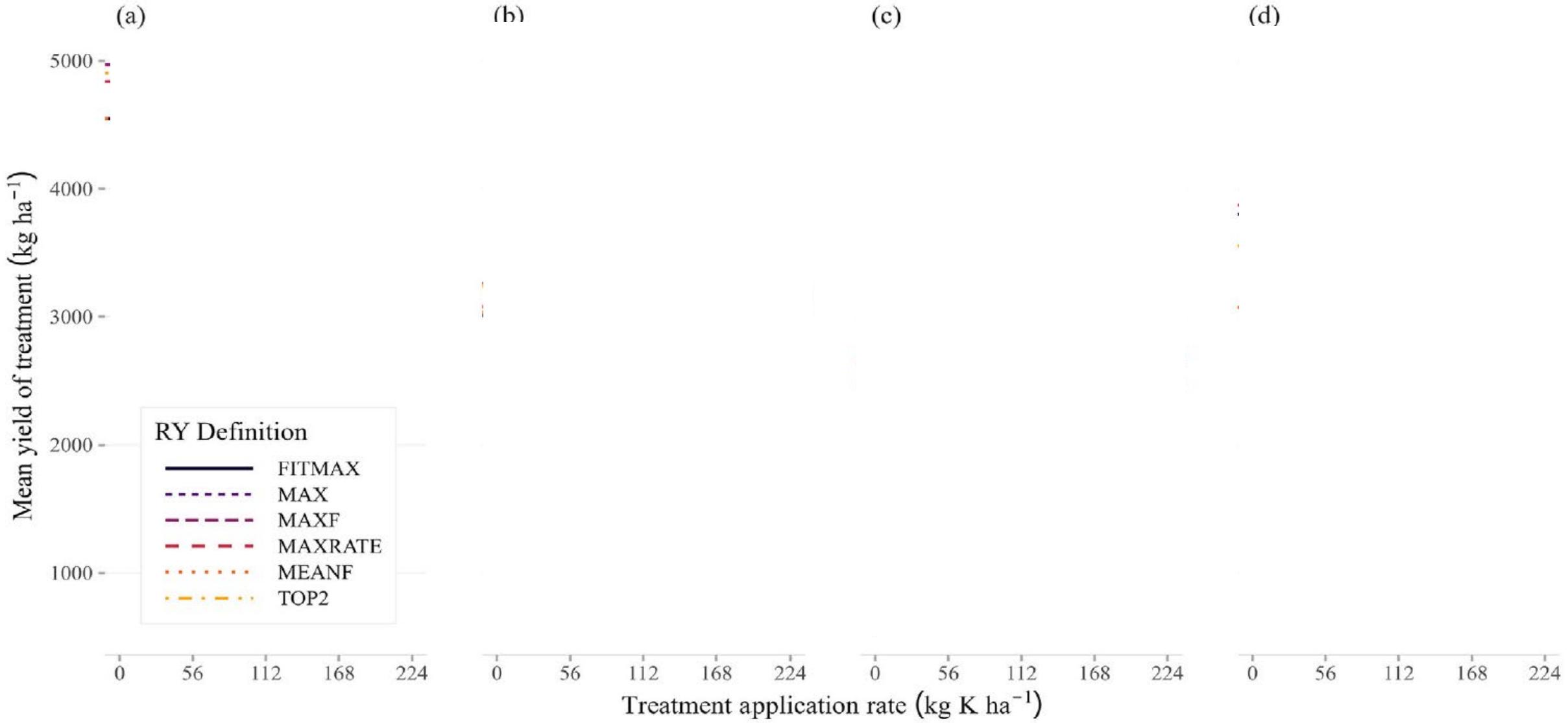


Data as of 10.12.2024

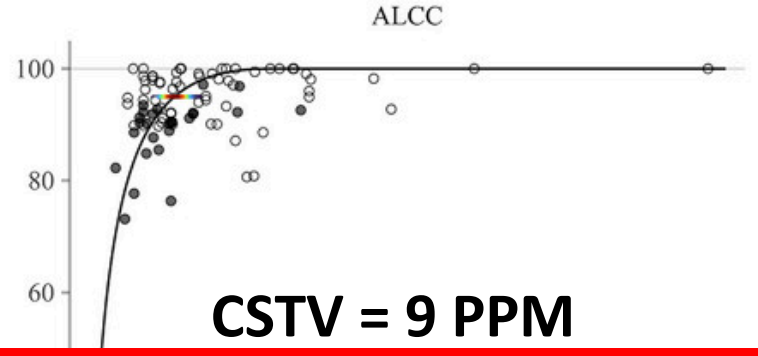
Develop common language and approach to fertilizer recommendations

- Correlation analysis
  - Defining relative yield
  - Determine common model

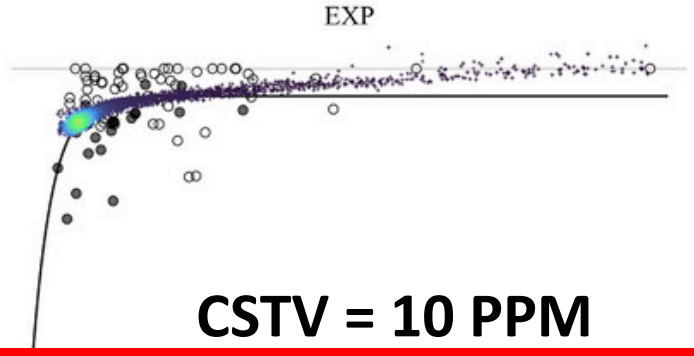
Defining relative yield: Tested 6 methods



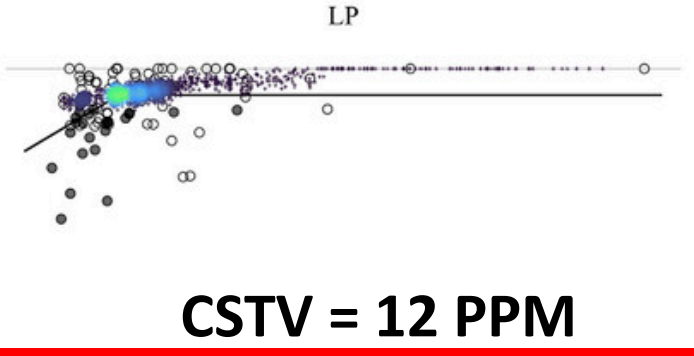
Correlation modeling: Tested 5 models/methods



CSTV = 9 PPM

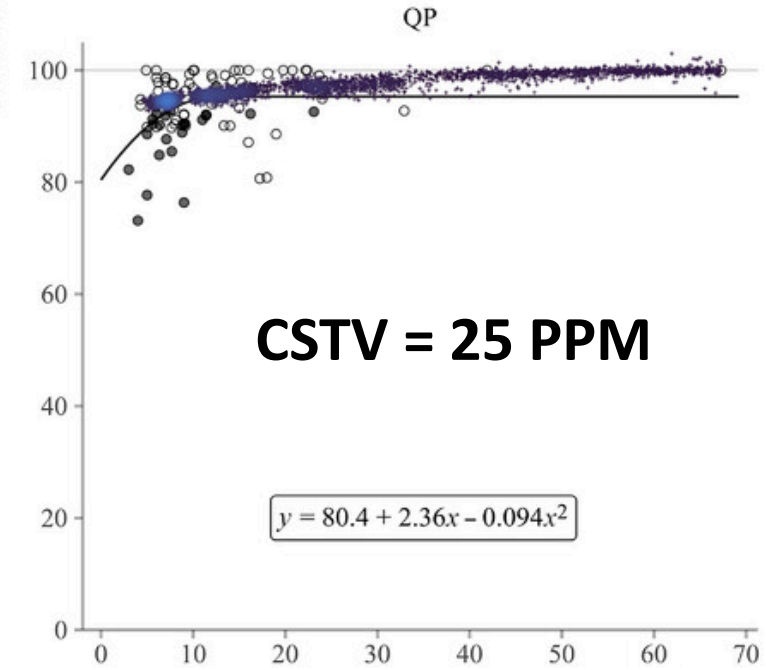


CSTV = 10 PPM

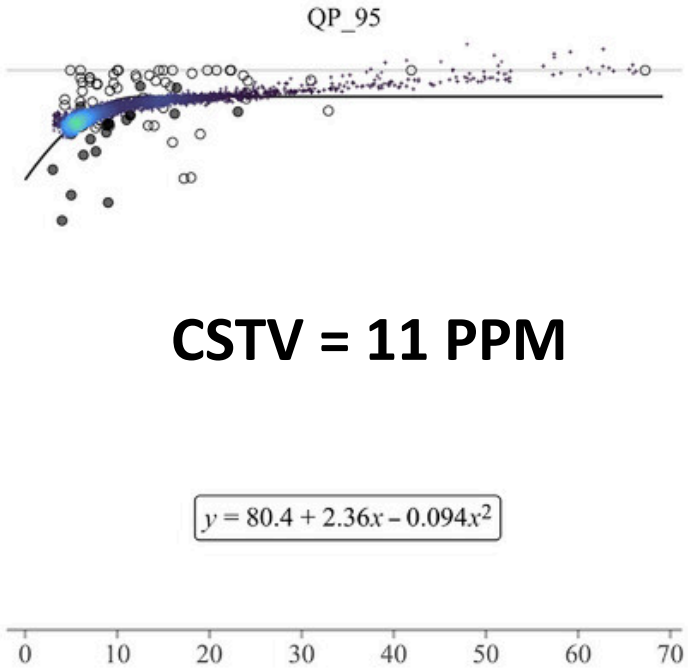


CSTV = 12 PPM

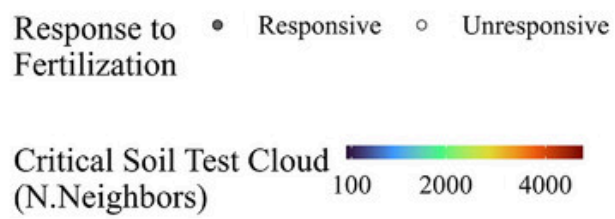
How long does it take a group of scientists to make this decision?



CSTV = 25 PPM



CSTV = 11 PPM



CSTV Modeling Journey

20 months

Models and sufficiency interpretation for estimating critical soil test values for the Fertilizer Recommendation Support Tool

N. A. Slaton, A. Pearce, L. Gatiboni, D. Osmond, C. Bolster, F. Miquez, J. Clark, J. Dhillon, B. Farmaha, D. Kaiser, S. Lyons, A. Margenot, A. Moore, D. Ruiz Diaz, D. Sotomayor, J. Spackman, J. Spargo, M. Yost

First published: 08 June 2024 | https://doi.org/10.1002/saj2.20704

18-member CSTV Modeling Committee Formed

February 2022

April 2022

1st Committee Meeting

Manuscript draft introduced to committee

September 2022

October 2022

Committee rejected manuscript draft with recommendation for ALCC model

CSTV modeling options refined Cate-Nelson model dropped & Model Averaging added

December 2022

April 2023

Collaborators surveyed on modeling decisions/preferences

Manuscript draft to committee

Sept-Oct 2023

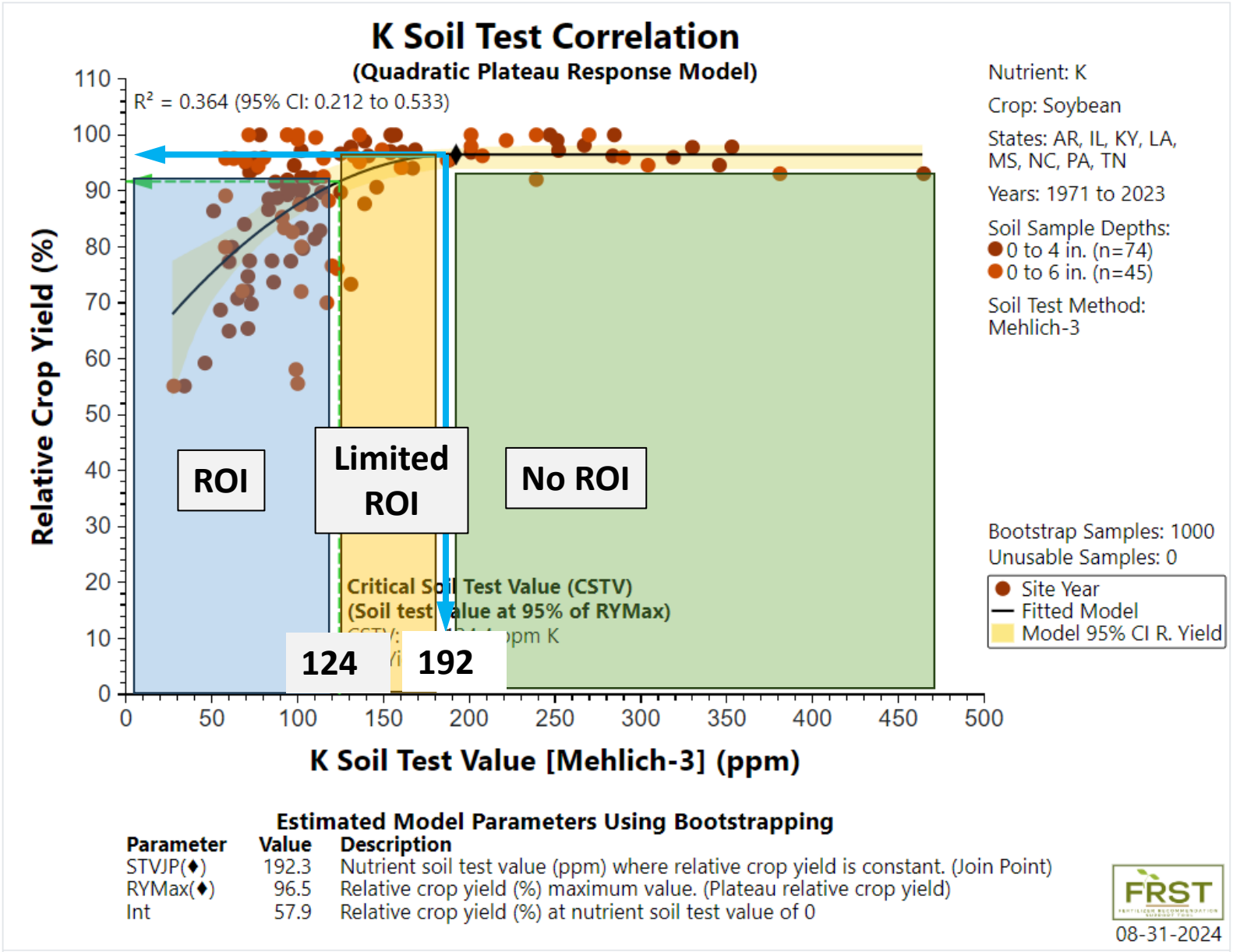
November 2023

Manuscript Submitted

Manuscript Accepted

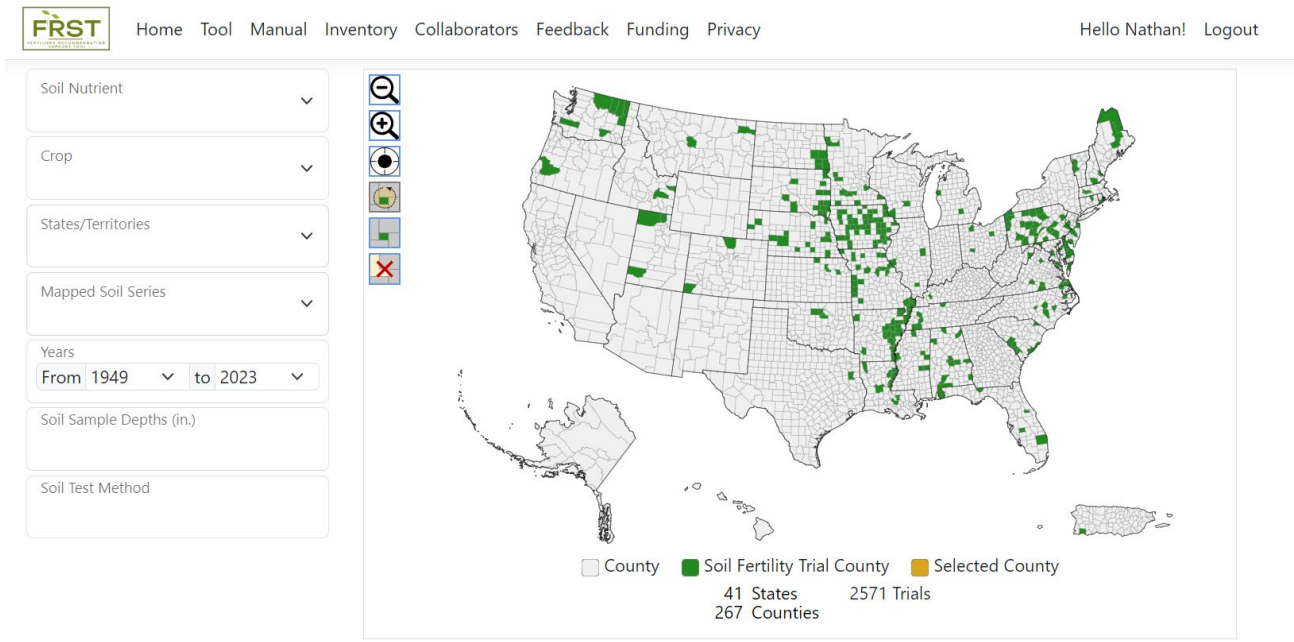
May 2024

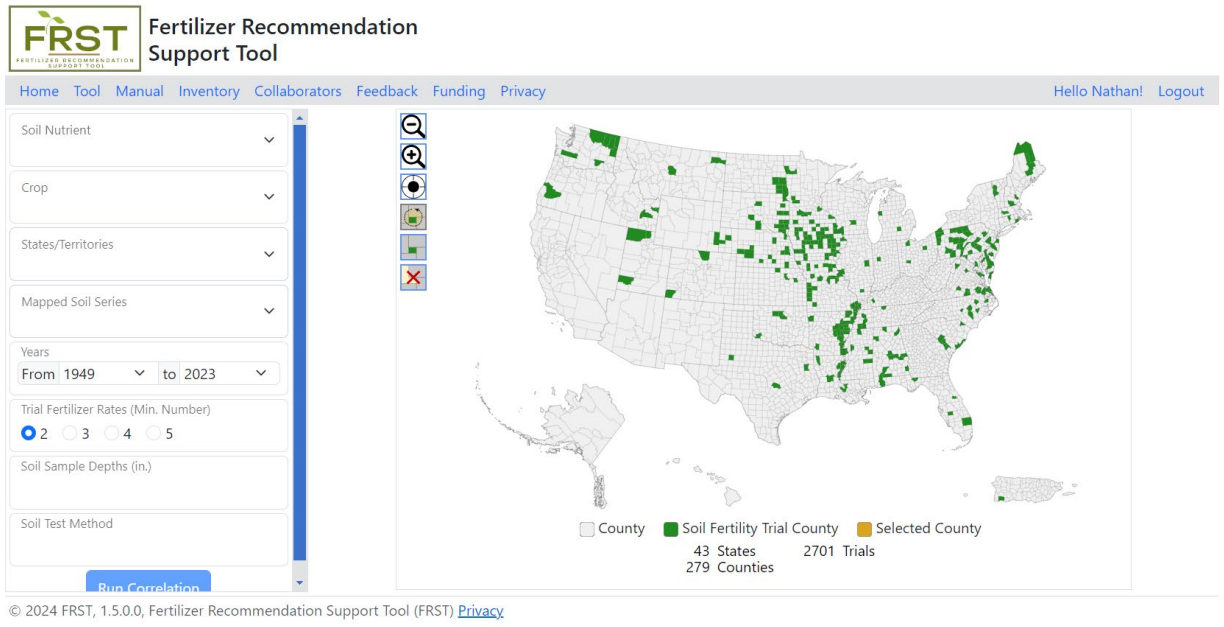
Soil Testing and ROI



FRST Decision Aid Launch

- Release date 8 April 2024
  - Beta Version
  - V1.0 Launch (8 April 2024) publicized with press releases
  - V1.5 (10 October 2024)
- Features
  - ~2500 trials in database
  - Manual
  - Registered User Login
- Continue to grow database and add features to FRST

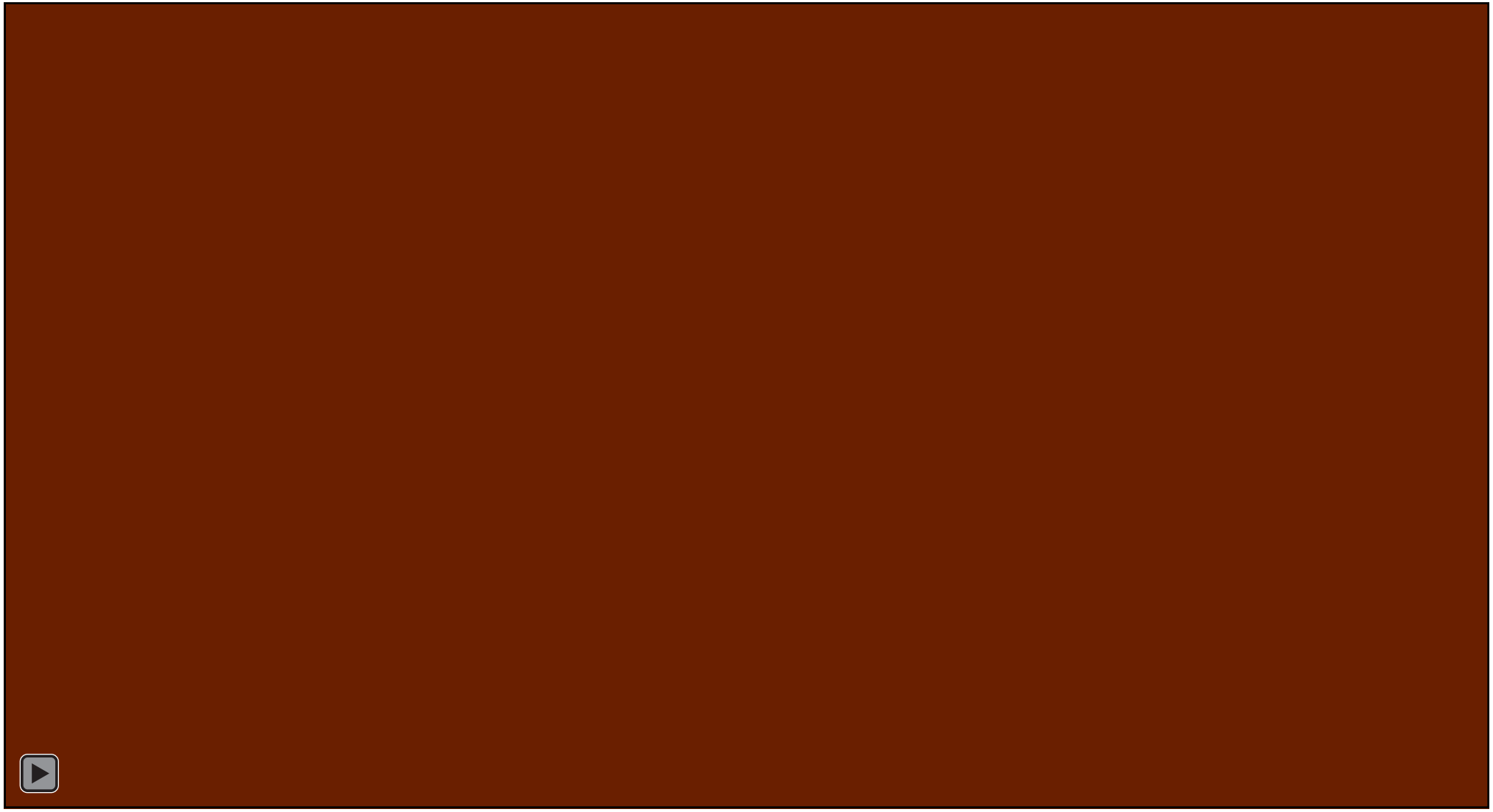




Online tool demonstration

- Soiltestfrst.org

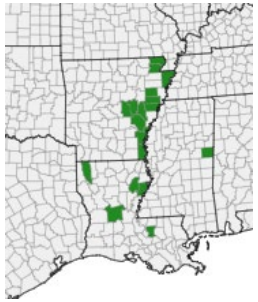
Video: 8:30



Augmenting Crop Fertilization Decisions using the FRST Decision Aid

https://soiltestfrst.org/

FRST Decision Aid Use with Soil Test Results



Field A

Test	Method	Results	SOIL TEST RATINGS (Very Low / Low / Medium / Optimum / Very High)
Soil pH	1:1	4.6	
Buffer pH	BPH	7.65	
Phosphorus (P)	M3	86 LB/ACRE	
Potassium (K)	M3	280 LB/ACRE	
Calcium (Ca)	M3	622 LB/ACRE	
Magnesium (Mg)	M3	78 LB/ACRE	
Sulfur (S)	M3	18 LB/ACRE	
Boron (B)	M3	0.2 LB/ACRE	
Copper (Cu)	M3	0.4 LB/ACRE	
Iron (Fe)	M3	238 LB/ACRE	
Manganese (Mn)	M3	94 LB/ACRE	
Zinc (Zn)	M3	3.0 LB/ACRE	
Sodium (Na)	M3	82 LB/ACRE	
Soluble Salts			
Organic Matter	LOI	1.1 % ENR 66	
Nitrate Nitrogen			

Calculated Cation Exchange Capacity: 5.2 meq/100g

%Saturation

	%sat	meq
K	6.9	0.4
Ca	29.9	1.6
Mg	6.3	0.3
H	53.8	2.8
Na	3.4	0.2

K/Mg Ratio: 1.10

Ca/Mg Ratio: 4.75

SOIL FERTILITY GUIDELINES

Crop : Corn Yield Goal : 150 bu/acre Rec Units: LB/ACRE

(lbs) LIME (tons)	N	P_2O_5	K_2O	Mg	S	B	Cu	Mn	Zn	Fe
4500 2.3	183	56	68	21	11	1.5	1.0	0	3.0	

Lab Number : 27915 Field Id : Tillar Sample Id : Shen CP

Field B

Test	Method	Results	SOIL TEST RATINGS (Very Low / Low / Medium / Optimum / Very High)
Soil pH	1:1	5.7	
Buffer pH	BPH	7.80	
Phosphorus (P)	M3	44 LB/ACRE	
Potassium (K)	M3	176 LB/ACRE	
Calcium (Ca)	M3	1564 LB/ACRE	
Magnesium (Mg)	M3	94 LB/ACRE	
Sulfur (S)	M3	12 LB/ACRE	
Boron (B)	M3	0.6 LB/ACRE	
Copper (Cu)	M3	1.2 LB/ACRE	
Iron (Fe)	M3	432 LB/ACRE	
Manganese (Mn)	M3	80 LB/ACRE	
Zinc (Zn)	M3	4.6 LB/ACRE	
Sodium (Na)	M3	136 LB/ACRE	
Soluble Salts			
Organic Matter	LOI	1.9 % ENR 82	
Nitrate Nitrogen			

Calculated Cation Exchange Capacity: 6.1 meq/100g

%Saturation

	%sat	meq
K	3.7	0.2
Ca	64.1	3.9
Mg	6.4	0.4
H	21.3	1.3
Na	4.8	0.3

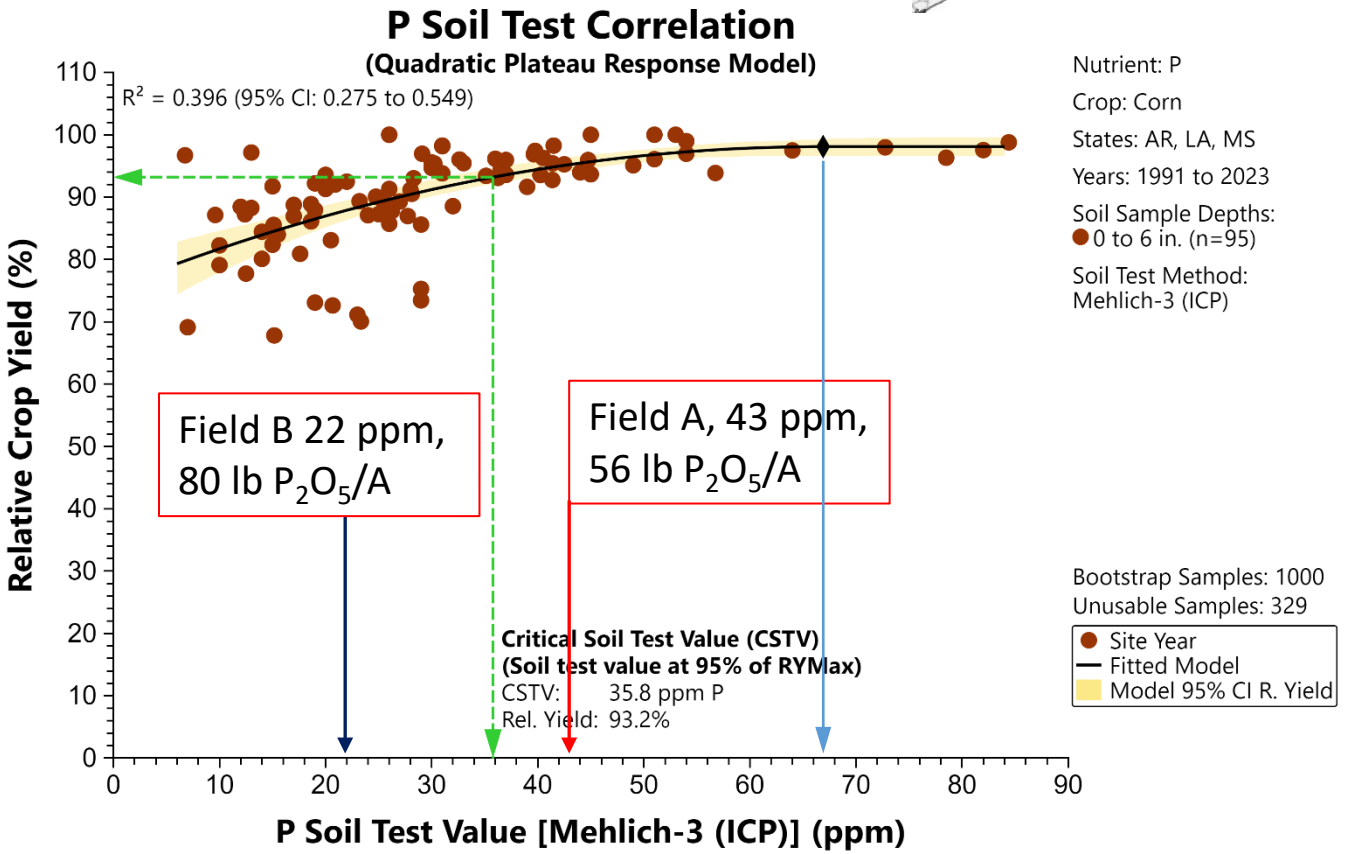
K/Mg Ratio: 0.58

Ca/Mg Ratio: 10.02

SOIL FERTILITY GUIDELINES

Crop : Corn Yield Goal : 150 bu/acre Rec Units: LB/ACRE

(lbs) LIME (tons)	N	P_2O_5	K_2O	Mg	S	B	Cu	Mn	Zn	Fe
1500 0.8	183	80	106	16	14	1.4	1.0	2	2.2	

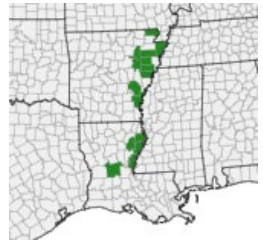


Estimated Model Parameters Using Bootstrapping

Parameter	Value	Description
STVJP(♦)	66.9	Nutrient soil test value (ppm) where relative crop yield is constant. (Join Point)
RYMax(♦)	98.1	Relative crop yield (%) maximum value. (Plateau relative crop yield)
Int	75.4	Relative crop yield (%) at nutrient soil test value of 0

05-17-2024

FRST Decision Aid Use with Soil Test Results



Field A

Mehlich III Nutrient	Units ppm	Units lbs/acre	Soil Test Level: Very Low	Low	Medium	Optimum	Above Optimum
Phosphorus (P)	19	38	< 16 ppm	16 - 25 ppm	26 - 35 ppm	36 - 50 ppm	> 50 ppm
Potassium (K)	175	350	< 61	61 – 90	91 – 130	131 – 175	> 175
Zinc (Zn)	1.5	3.0	< 1.6	1.6 – 2.5	2.6 – 4.0	4.1 – 8.0	> 8.0

Mehlich III Nutrient	ppm	lbs/acre
Sulfate-S (SO4-S)	10	20
Calcium (Ca)	1235	2470
Magnesium (Mg)	132	264
Iron (Fe)	137	274
Manganese (Mn)	70	140
Copper (Cu)	0.7	1.4
Boron (B)	0.3	0.6
Nitrate (NO3-N)		

Other Soil Properties				Units
Electrical Conductivity (EC)				µmhos/cm
Estimated CEC (ECEC)			11	cmolc/kg
Organic Matter				%
Estimated Soil Texture	Silt Loam - Silty Clay Loam			
Base Saturation	69	Ca	54.9	% of ECEC
		Mg	9.8	% of ECEC
		K	4.0	% of ECEC
		Na	0.3	% of ECEC

Methods: Soil pH and EC in 1:2 soil-water volume mixture; nutrients other than NO3-N extracted with Mehlich-3 determined by ICAP; Nitrate extracted with Al2(SO4)3 and determined by electrode; ECEC by cation summation; organic matter by weight loss on ignition.

Comments: Unit of lbs/acre assumes the sample depth represents a plow layer weighing 2 million pounds.

Code	Name	N	P_2O_5	K_2O	SO_4-S	Zn	B	Lime	
14	Soybean - Full-Season	0	50	50	0	0	0	0	lb/acre

Field B

Mehlich III Nutrient	Units ppm	Units lbs/acre	Soil Test Level: Very Low	Low	Medium	Optimum	Above Optimum
Phosphorus (P)	37	74	< 16 ppm	16 - 25 ppm	26 - 35 ppm	36 - 50 ppm	> 50 ppm
Potassium (K)	71	142	< 61	61 – 90	91 – 130	131 – 175	> 175
Zinc (Zn)	7.4	14.8	< 1.6	1.6 – 2.5	2.6 – 4.0	4.1 – 8.0	> 8.0

Mehlich III Nutrient	ppm	lbs/acre
Sulfate-S (SO4-S)	8	16
Calcium (Ca)	1654	3308
Magnesium (Mg)	208	416
Iron (Fe)	268	536
Manganese (Mn)	212	424
Copper (Cu)	0.5	1.0
Boron (B)	0.9	1.8
Nitrate (NO3-N)		

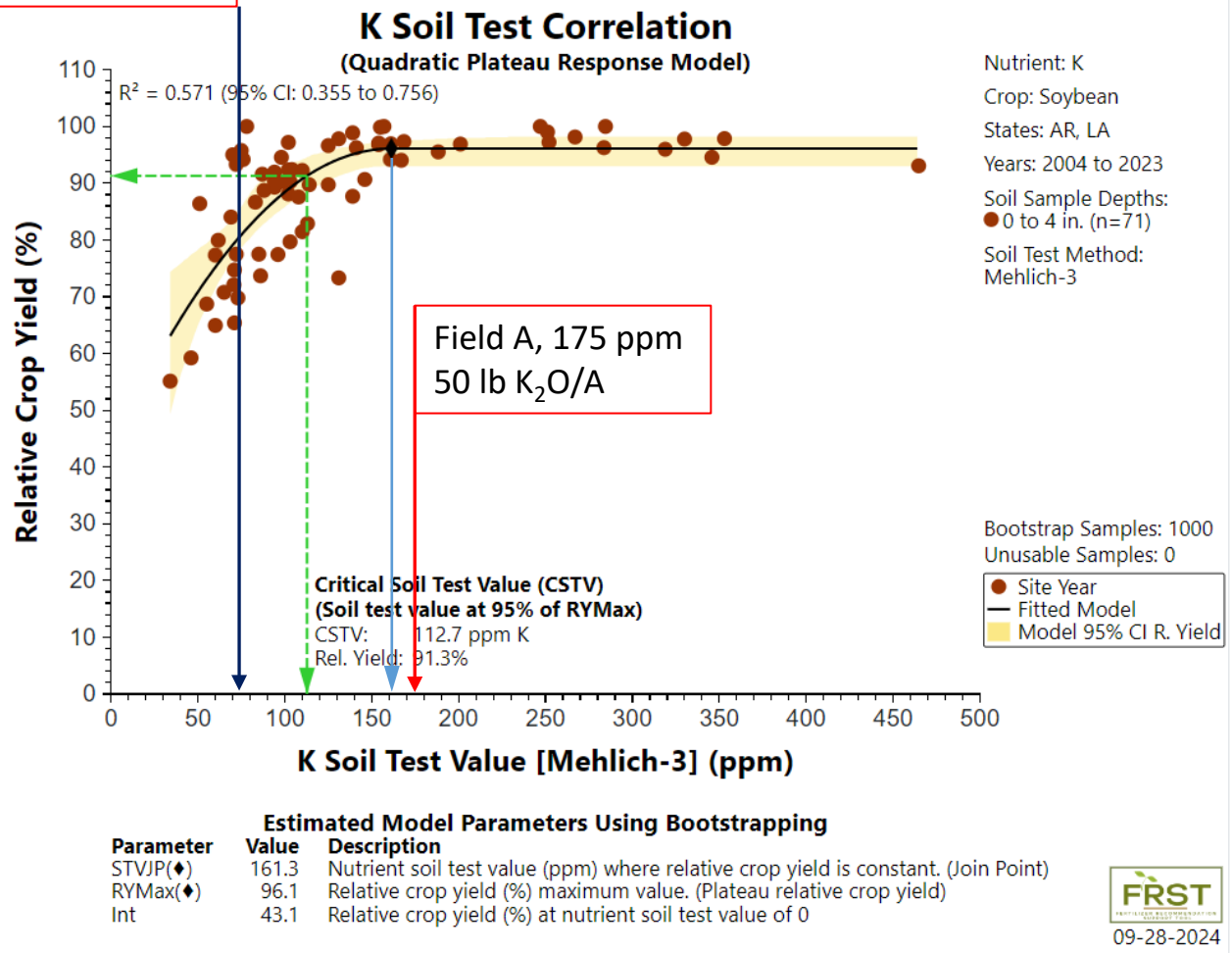
Other Soil Properties				Units
Electrical Conductivity (EC)				µmhos/cm
Estimated CEC (ECEC)			12	cmolc/kg
Organic Matter				%
Estimated Soil Texture	Silt Loam - Silty Clay Loam			
Base Saturation	84	Ca	67.2	% of ECEC
		Mg	14.1	% of ECEC
		K	1.5	% of ECEC
		Na	1.0	% of ECEC

Methods: Soil pH and EC in 1:2 soil-water volume mixture; nutrients other than NO3-N extracted with Mehlich-3 determined by ICAP; Nitrate extracted with Al2(SO4)3 and determined by electrode; ECEC by cation summation; organic matter by weight loss on ignition.

Comments: Unit of lbs/acre assumes the sample depth represents a plow layer weighing 2 million pounds.

Code	Name	N	P_2O_5	K_2O	SO_4-S	Zn	B	Lime	
14	Soybean - Full-Season	0	0	120	0	0	0	0	lb/acre

Field B, 71 ppm
120 K_2O/A



Precautions & Looking Forward

- Relationships based on current database
  - Relationships may vary among geographic regions & crops
- Sufficient data???
- Many effective management approaches

- We continue to
  - Build the FRST database with data from recent and current field trials
  - Develop features for the FRST decision aid tool
    - Probability of response
    - Calibration
    - Yield filter
  - Develop a dataset for and add it to the tool

Soil Test Interpretation

- The Fertilizer Recommendation Support Tool (FRST) is designed to help interpret soil test results by
  - Informing users about the
    - Crop response curve to soil test P or K in the absence of fertilization
    - Critical Soil Test Value
    - Soil test values where crop yields plateau (no response to fertilization)
- FRST is designed to augment recommendations, not replace recommendations

Fertility Costs Are In Focus As Farmers Consider Cutting Back

spreading fertilizer in field
(Darrell Smith, Farm Journal)

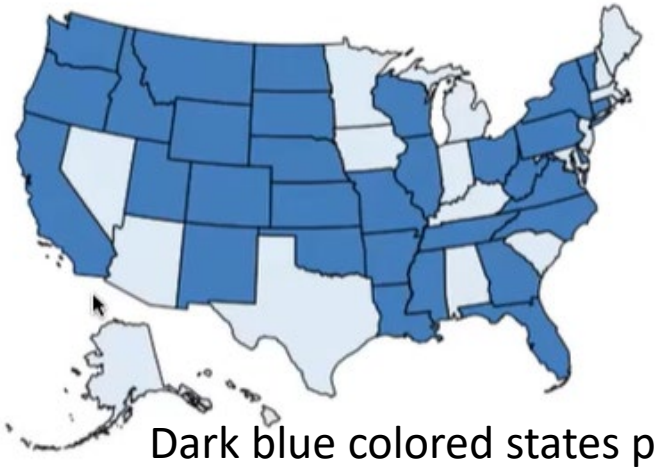
By **AGDAY TV** August 14, 2024

NEWS / RETAIL INDUSTRY

5 Ways To Prioritize Fertilizer Dollars

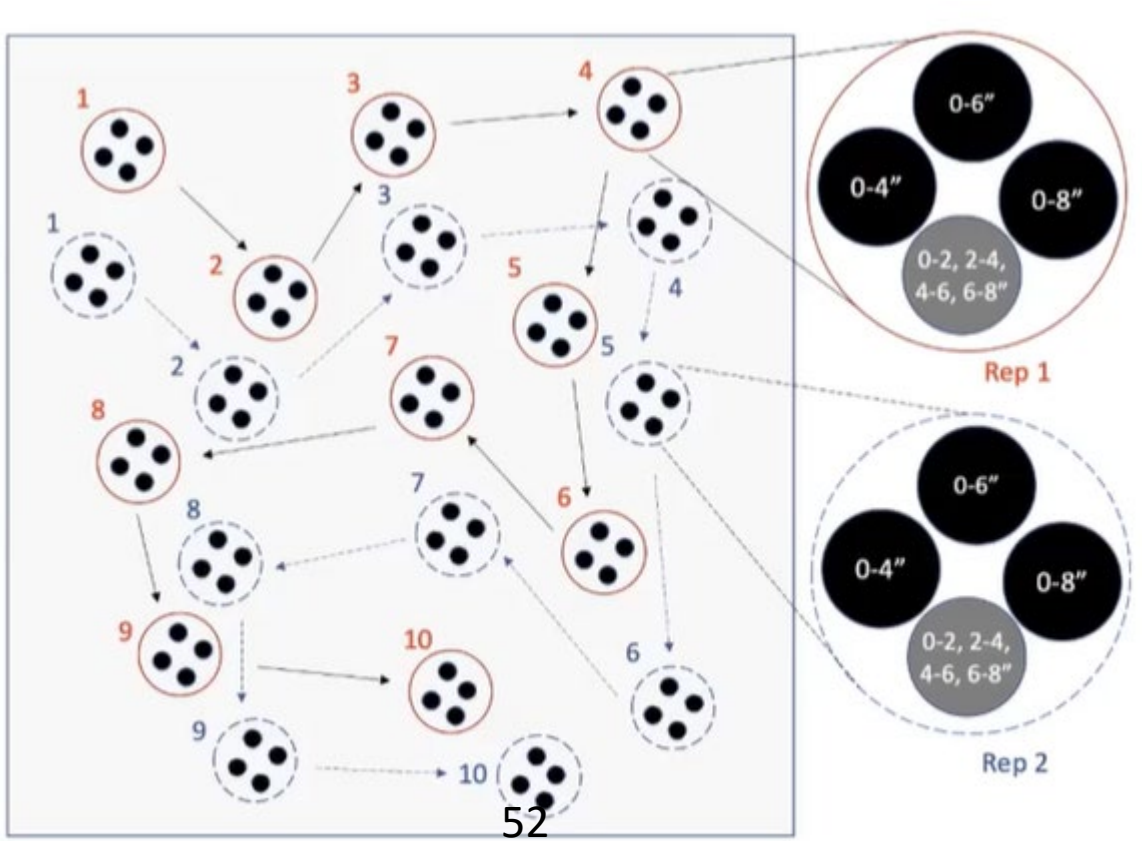
Soil test depth

Soil Sample Depth Study



Dark blue colored states providing samples

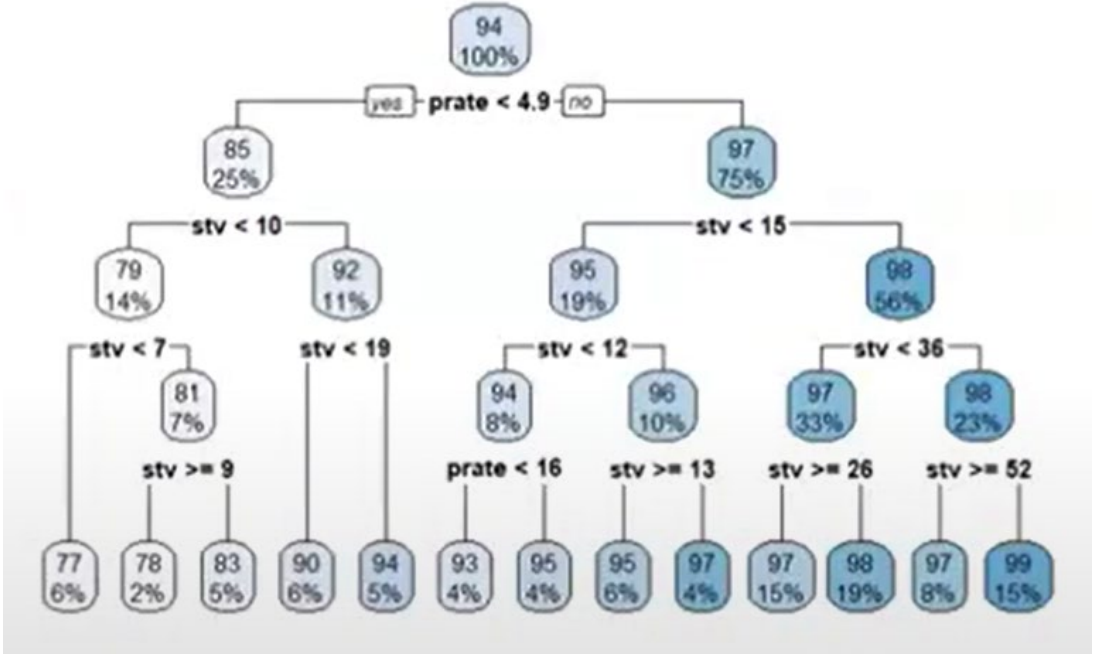
- Objectives
  - Develop equations for converting soil test values to a depth different than what was sampled
  - Evaluate the sample depth averaging on soil test chemical properties compared to whole-depth samples.
- 36 FRST collaborators collected 197 soils from 32 states across the USA
  - 50 West of Mississippi & 147 East of Mississippi River
- Samples collected from 0-4, 0-6, 0-8, and 0-2, 2-4, 4-6, 6-8 inch depths
- Metadata on each site (previous crop, soil chemical properties (Olsen P, Modified Morgan P, Mehlich-3, SOM, & pH)
- Activity lead by Culman & Spargo

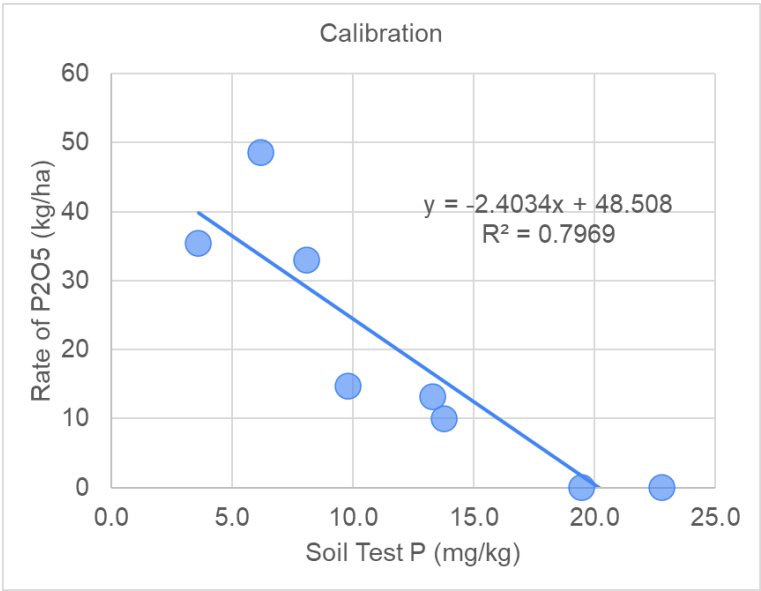


Calibration step

Modeling for Soil Test Calibration

- Objective
  - Add a calibration component to the FRST decision aid to define research-based sufficiency rate.
- Modeling evaluation
  - Data in bins
  - Multiple regression
  - Decision trees (e.g., CART)
- Calibration Activity and Committee led by Luke Gatiboni (NCSU)





Sulfur database

Expansion of FRST Database

- ***Is soil-test sulfur (S) useful for predicting crop response to S?***
- Minimum dataset for soil test S correlation and calibration
  - Matt Yost, Utah State Univ. leading activity
- S will be added to FRST Database & Decision Aid
  - Data template developed and being beta tested
  - 3 legacy datasets (NY, OH, & TN) uploaded

Spargo et al. Survey	Yes	No	Unknown
	n = 49		
Is crop S deficiency increasing in your state?	24	12	13
Does your institution test for soil test S?	18	25	6
Does your institution have recommendations using soil test S?	22	21	6

Spargo et al. (2022). A survey to evaluate the current status of land grant university and state department of agriculture soil fertility recommendations and analytical methods. Ag Data Commons. https://doi.org/10.15482/USDA.ADC/1526506

Liming research

- Survey land grant institution lime rate determination methods and recommendations (Miller, Jones, & Slaton)
- Calibrate lime rate recommendations (Shober & Miller)

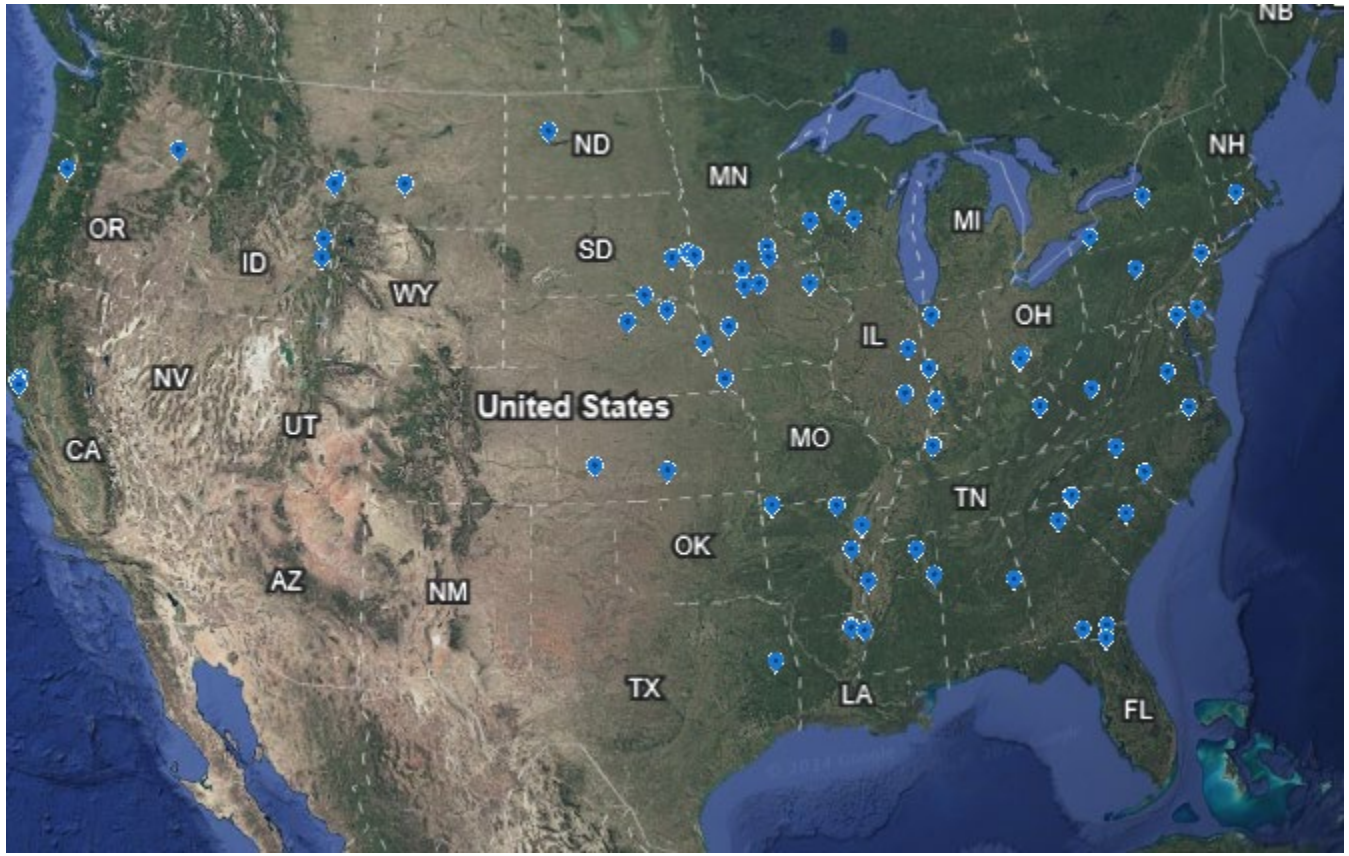
Soil pH and Lime Requirement Survey

- Survey Launched in 2022
  - Document current soil pH and lime requirement determination methods and compare to 1980 from Follett & Follett (1983)
  - Compare state recommended lime rates for 6 soils using analytical data
- Activity led by Bob Miller & John Jones
- Manuscript near ready to submit

- Key Points
- Soil pH methods documented for 48 institutions
- Lime requirement method documented for 35 institutions
- Recommended lime rates
  - “Conceptual” agreement on the relative amounts of lime needed to adjust soil pH
  - CV of mean lime rates was 46% to 67% for the 6 soils

Lime Calibration Study

- Collected 110 bulk soil samples from across the US
  - Pilot study ongoing (Miller)
  - Incubation trial planned for 2025 to calibrate multiple methods for lime requirement estimation
- Plan to publish a complete dataset for private and public laboratory use
- Activity led by Shober & Miller



Other activities

- Survey stakeholders to determine how soil test data is used (Slaton)
- Evaluate fertilizer recommendation strategies and terms used by land grant institutions (Slaton)
- Develop model(s) for calibration of fertilizer-P & -K rates (Gatiboni)
- Develop minimum dataset for S and S to the database and FRST tool (Yost)
- Develop model(s) for frequency of response to fertilization (Buol)
- Develop a user-friendly decision support tool to provide soil test user information for a soil-test and crop-response-to-fertilization searchable web-based decision tool. (Osmond & Lyons)
- Support state-level soil test correlation and calibration trials

FRST Activities https://soiltestfrst.org/resources/

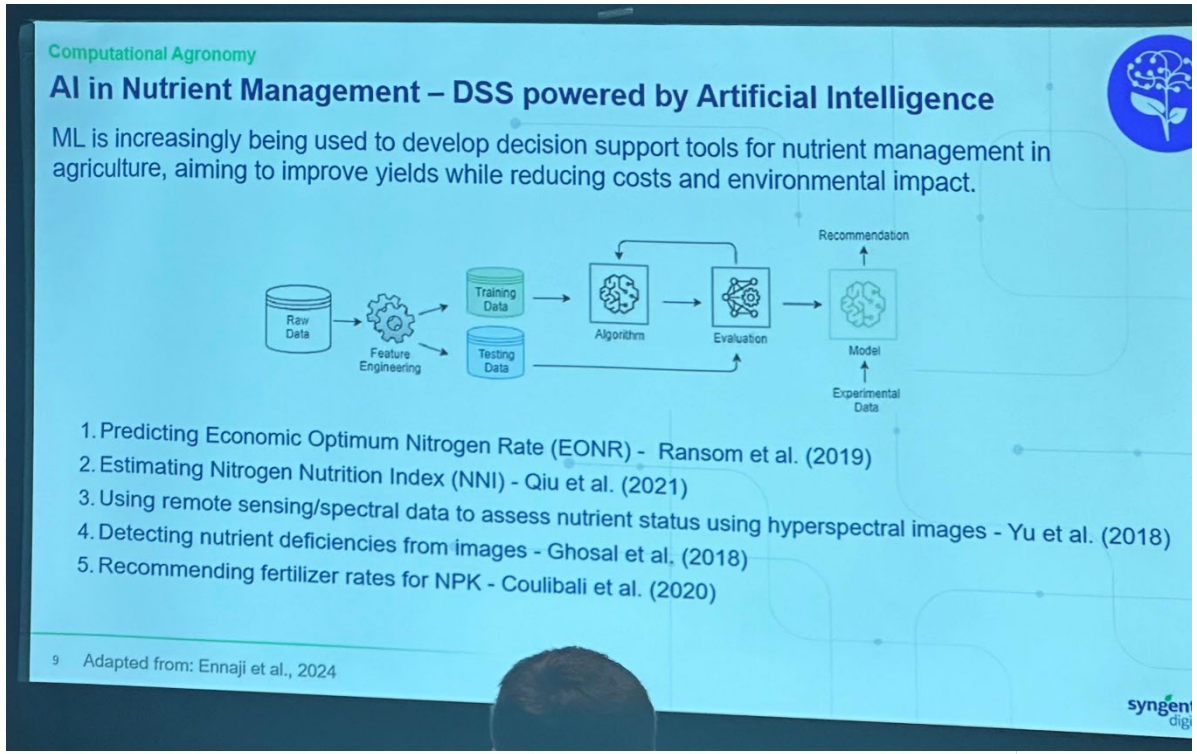
Current/Ongoing Activities

- **Develop and maintain the FRST database for correlation and calibration**
  - **Legacy data**
  - **New data**
- Support state-level soil test correlation and calibration trials
- Develop model(s) for calibration of fertilizer-P & -K rates (Gatiboni)
- Analysis of soil sampling depth influence on soil test outcomes (Culman)
- **Develop a user-friendly decision support tool to provide soil test user information for a soil-test and crop-response-to-fertilization searchable web-based decision tool. (Osmond & Lyons)**

- Develop minimum dataset for S and S to the database and FRST tool (Yost)
- Develop model(s) for frequency of response to fertilization (Buol)

FRST Future

- No shortage of issues to address
- Industry appears poised to use AI to make chemical and fertilizer recommendations
  - Can the FRST database be useful to this effort?
- Continue to develop database and populate with current and complete data
- Funding sources?
  - Viewed as old technology without good fitting funding ops in NIFA



tasks, and how do we make those just completed using AI," he offers.

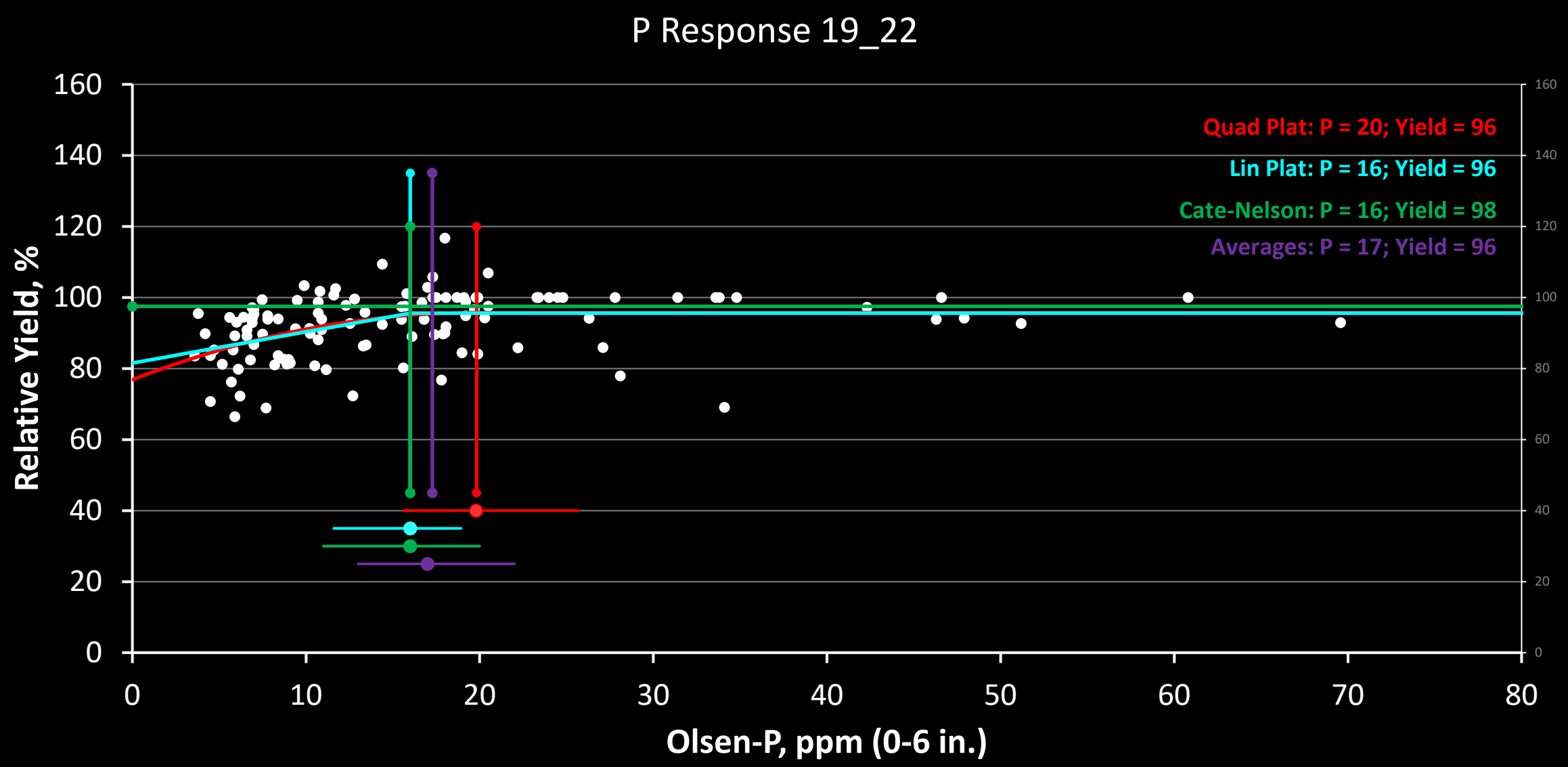
Three specific applications he sees AI taking over in the next three years include:

- Fertilizer and chemical recommendations
- Most bookkeeping tasks
- Route planning and scouting

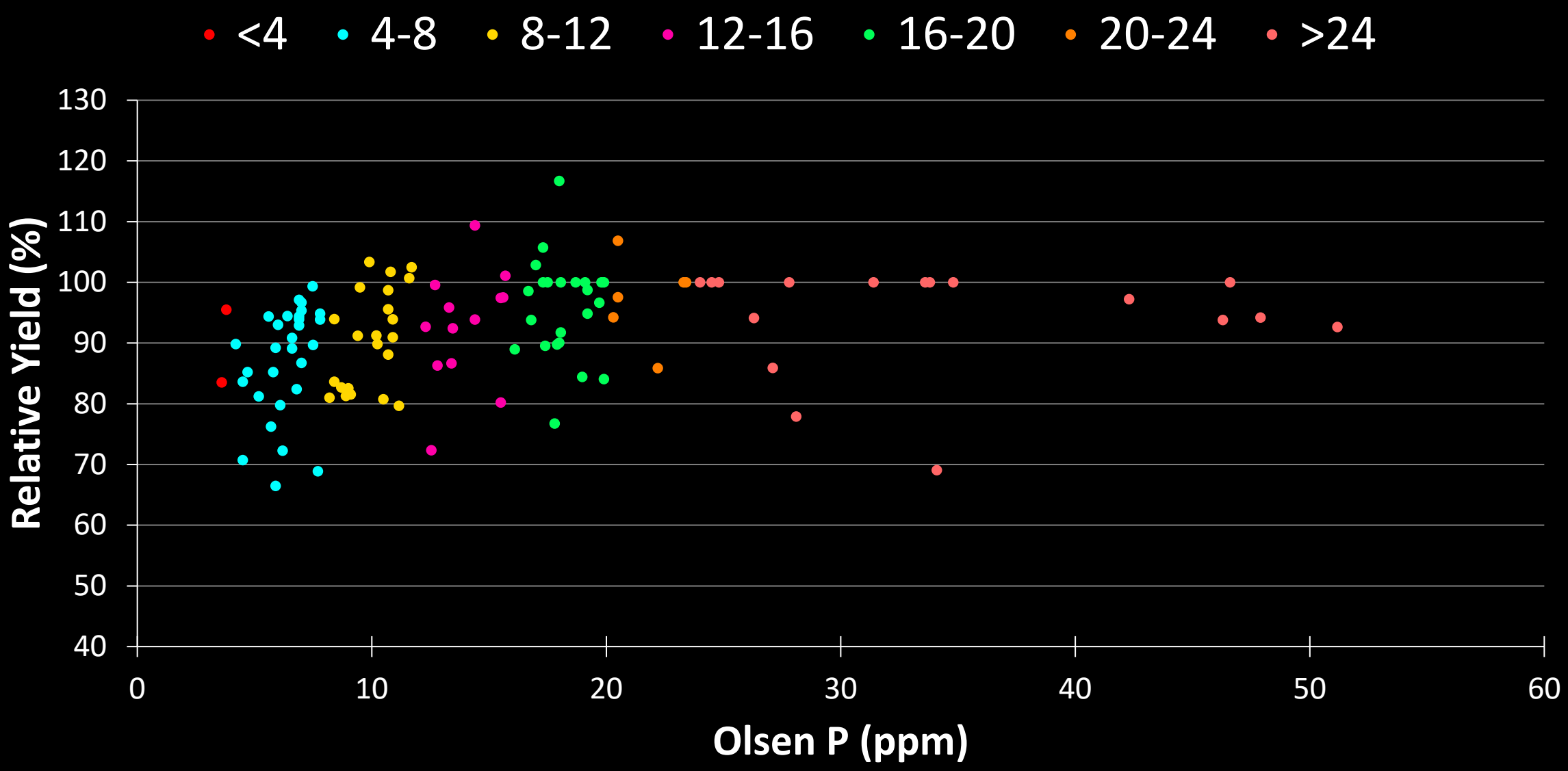
He'll be part of a panel discussion at the upcoming Ag Retailers Association Conference, Dec. 3 to 5 in Houston. Click here for the full agenda and to register.

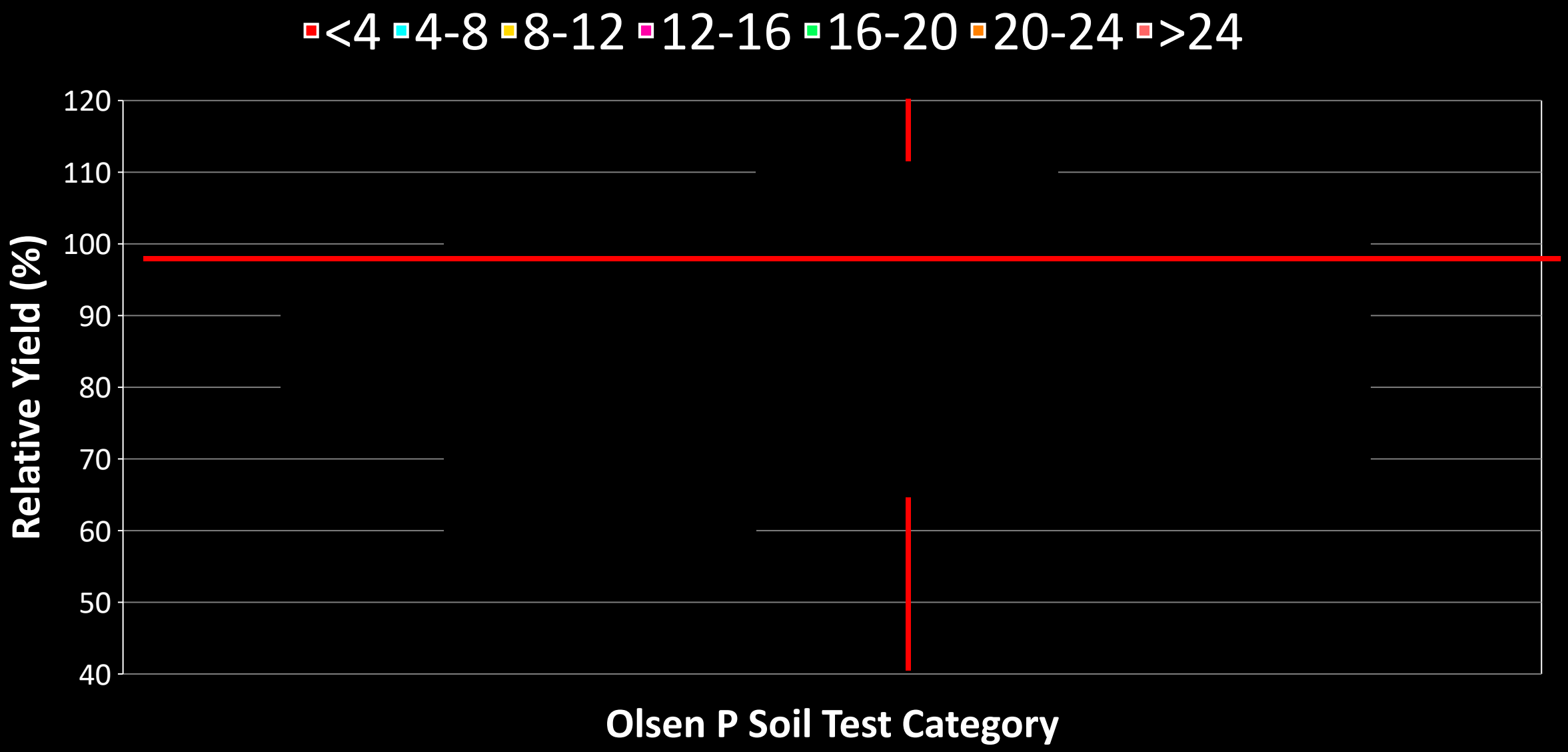
Evaluating critical soil test P in South Dakota

Current P critical value is accurate: 16 ppm



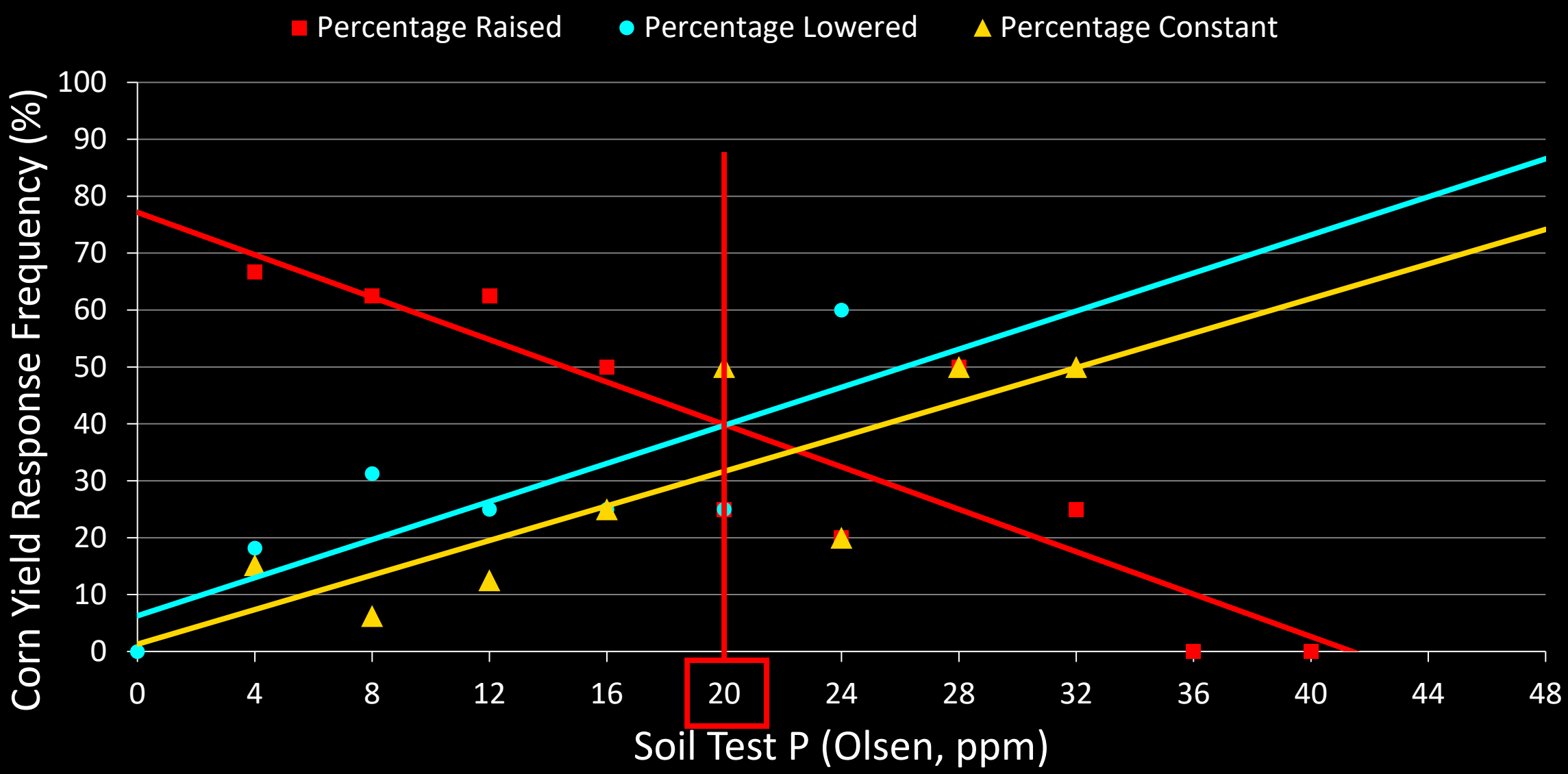
Increase in STP category then increase in relative yield




<4
4-8
8-12
12-16
16-20
20-24
>24
120
110
100
90
80
70
60
50
40
Relative Yield (%)
Olsen P Soil Test Category

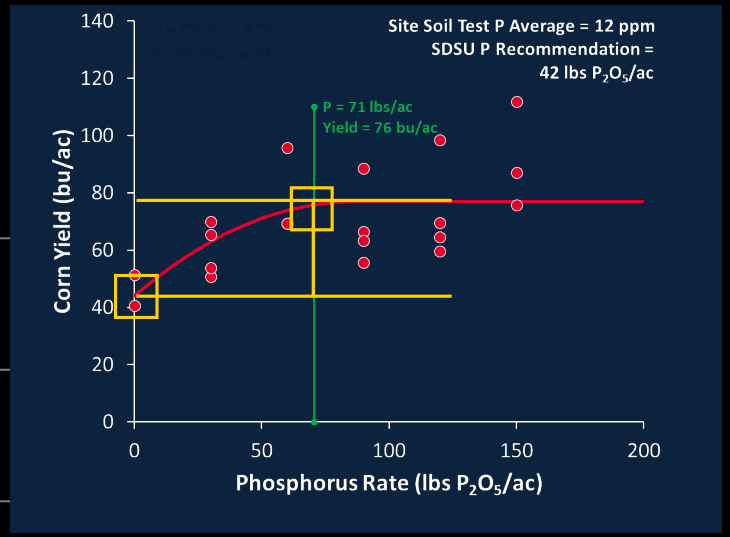
Yield response frequency critical value

Yield response frequency critical value: 20 ppm



Yield change critical value

Yield change critical value: ~22 ppm



Average Change in Yield (bu/ac)

20
15
10
5
0
-5
-10
-15

22

0
4
8
12
16
20
24
28
32
36
40

Soil Test P (Olsen, ppm)

Higher P = less response to P fertilization

Olsen P Categories
< 4
4 — 8
8 — 12
12 — 16
16 — 20
20 — 24
≥ 24

P Critical Value Summary

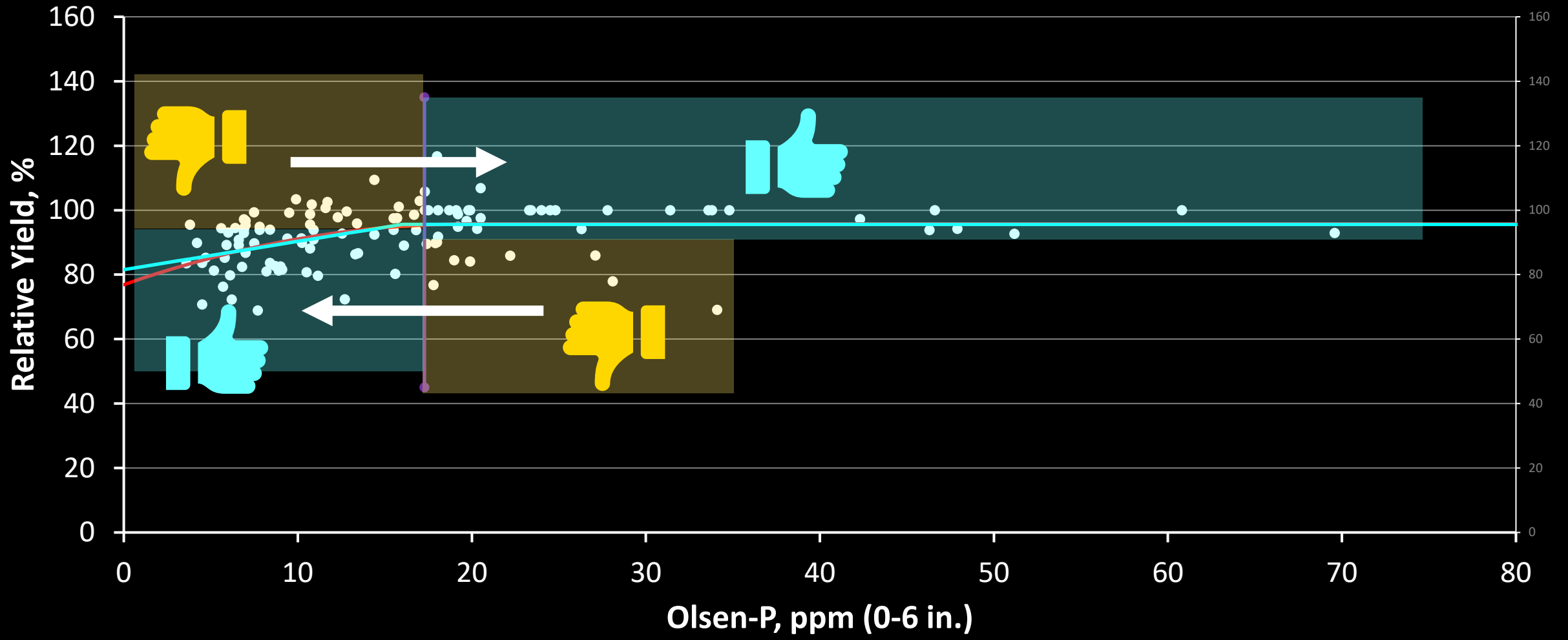
- Critical Value: **16-20 ppm**
- Confidence Range: **13-22 ppm**
- 5% or 5 bu/ac response: **16 ppm**

- Accuracy of using only soil test P: **68%**

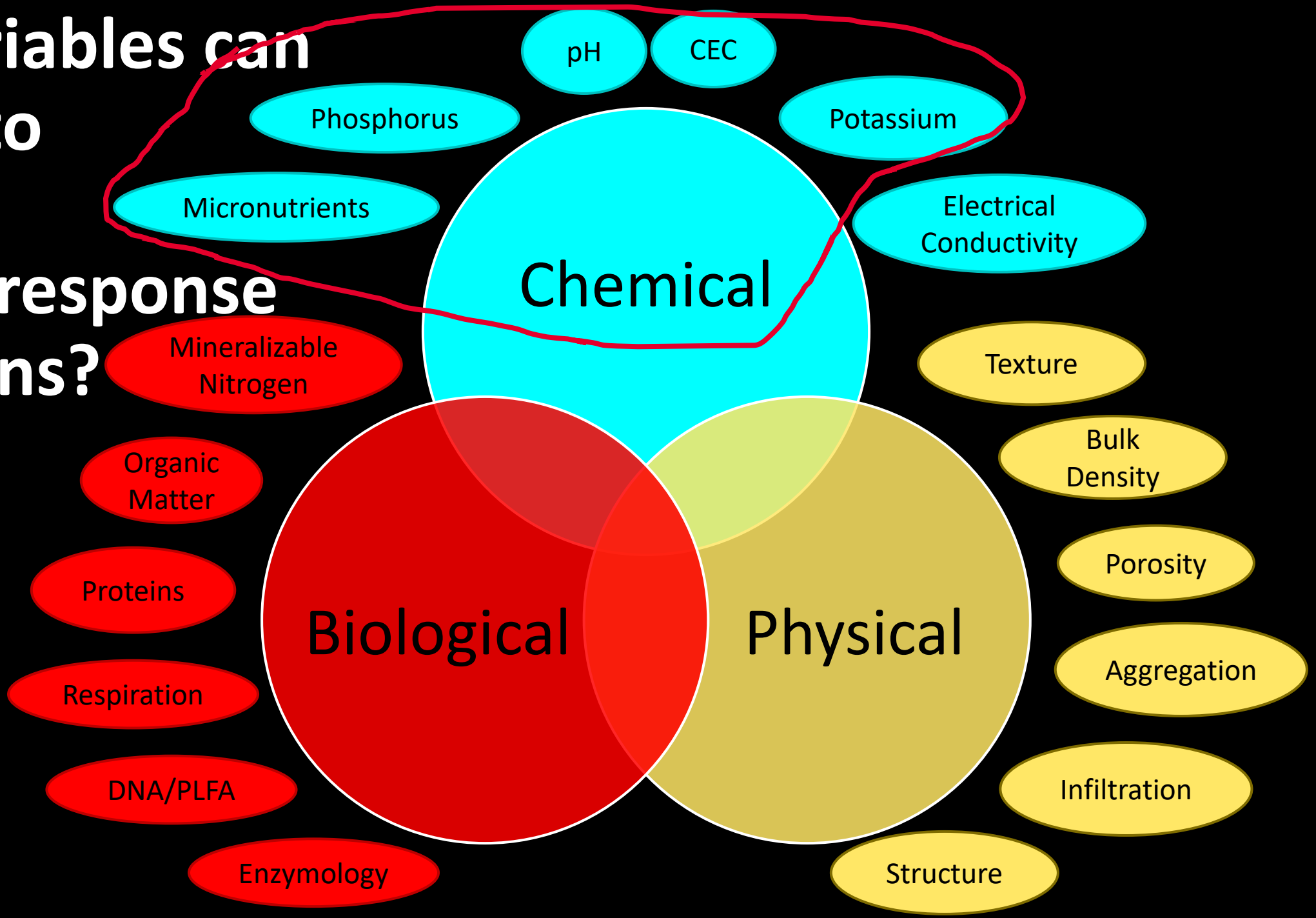
Can additional soil measurements improve accuracy?

Correctly predicted 68% as responsive or non-responsive

Where is the error and how can we improve?

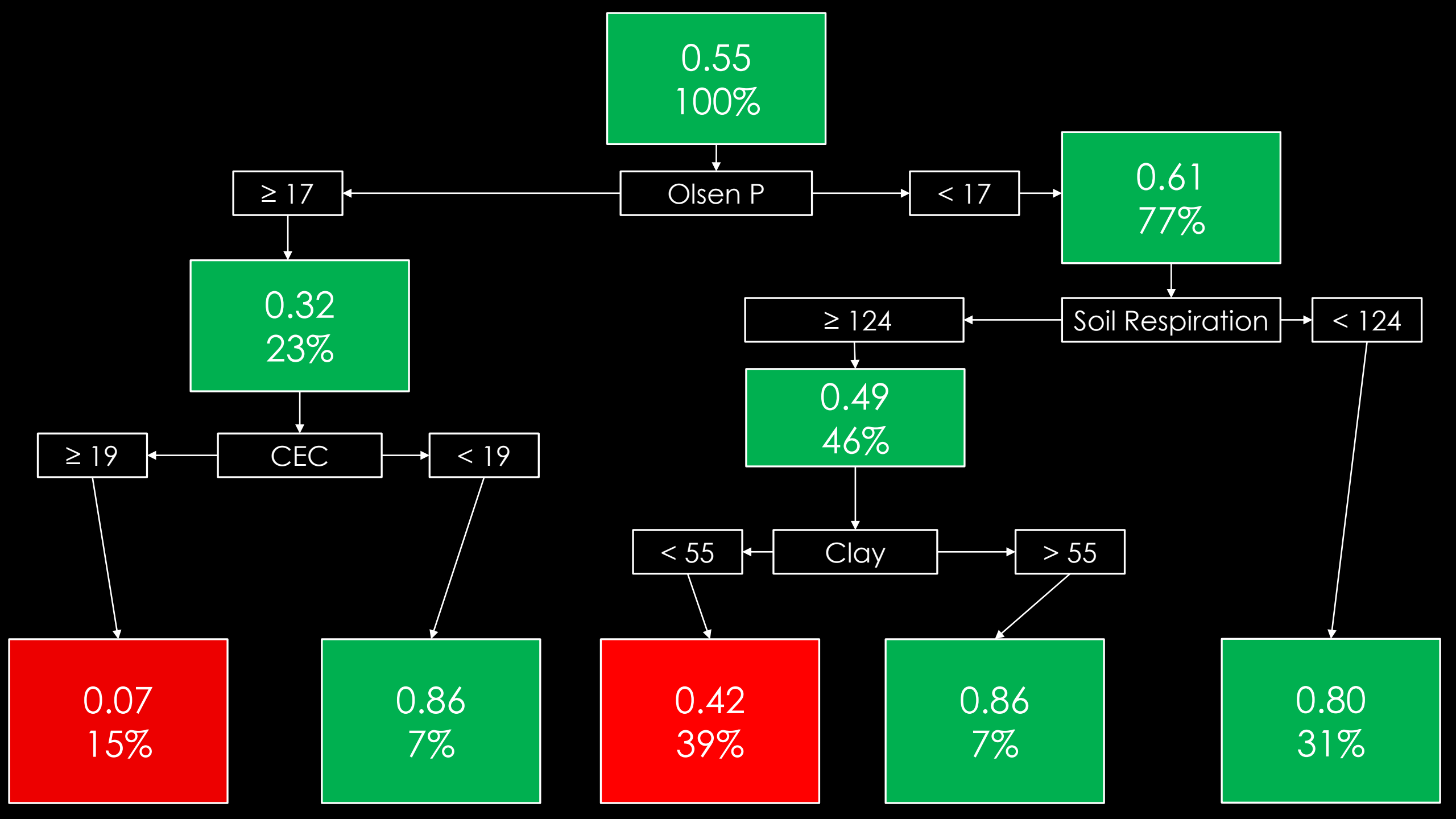


What variables can be used to improve fertilizer response predictions?



What variables improved P recommendations?

- Olsen P
- Soil respiration
- CEC
- Clay


0.55
100%
Olsen P
≥ 17
< 17
0.61
77%
0.32
23%
Soil Respiration
≥ 124
< 124
0.49
46%
CEC
≥ 19
< 19
Clay
< 55
> 55
0.07
15%
0.86
7%
0.42
39%
0.86
7%
0.80
31%

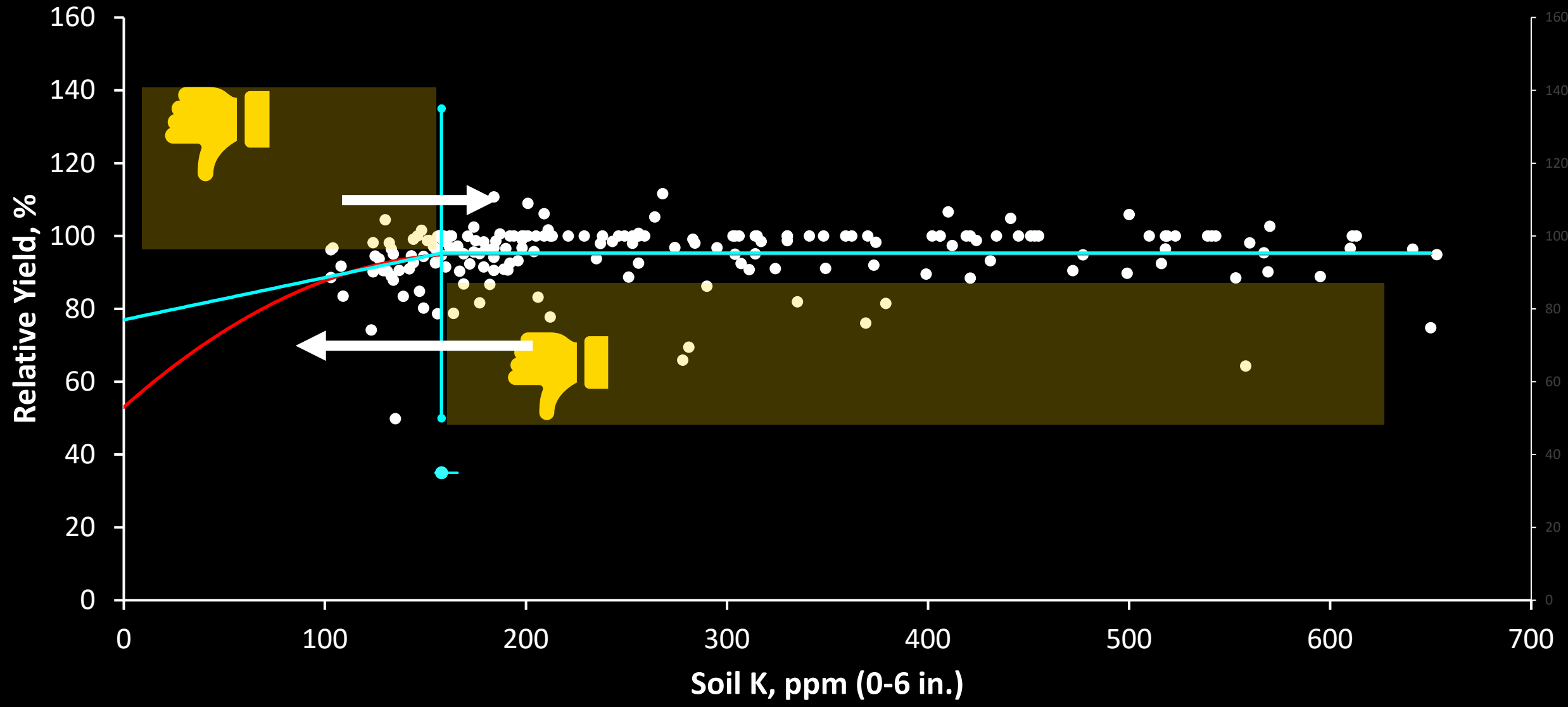
Answer:
What about adding soil health to the equation?

Accuracy of yield response prediction:

- Olsen P: **68%**
- Olsen P + soil respiration + CEC + Clay: **74%**

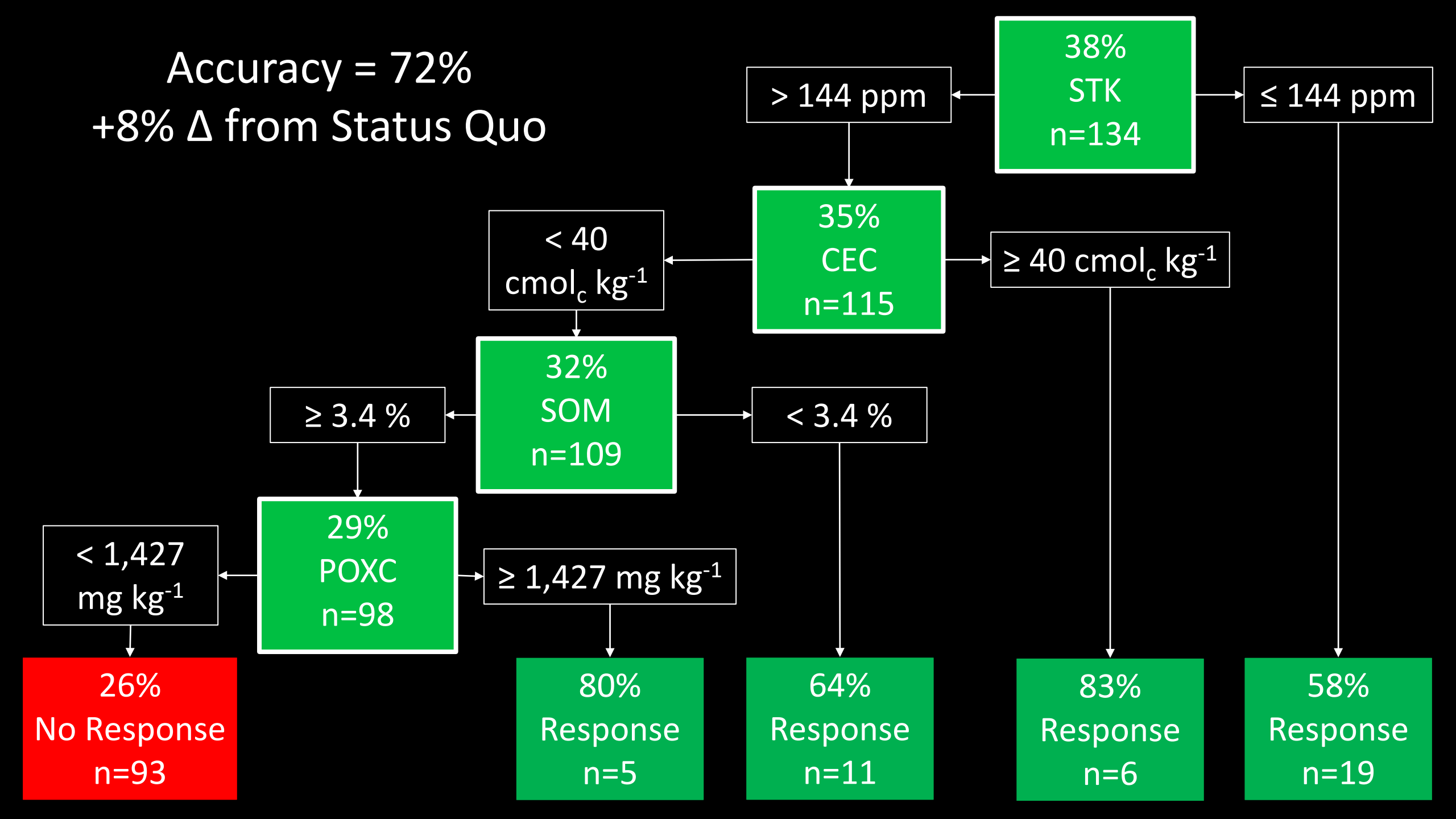
Potassium

Critical K value: 144 ppm



What variables improved K recommendations?

- Ammonium acetate K
- CEC
- Soil organic matter (SOM
- Permanganate oxidizable C (POX-C)


Accuracy = 72%
+8% Δ from Status Quo
38%
STK
n=134
> 144 ppm
≤ 144 ppm
35%
CEC
n=115
< 40
cmol$_c$ kg^{-1}
≥ 40 cmol$_c$ kg^{-1}
32%
SOM
n=109
≥ 3.4 %
< 3.4 %
29%
POXC
n=98
< 1,427
mg kg^{-1}
≥ 1,427 mg kg^{-1}
26%
No Response
n=93
80%
Response
n=5
64%
Response
n=11
83%
Response
n=6
58%
Response
n=19

What about adding soil health to the equation?

Accuracy of yield response prediction:

- Soil test K: **64%**
- Soil test K + CEC + organic matter + POX-C: **72%**

Take Homes

Phosphorus and Potassium Recommendations

- Additional soil biological and physical measurements can help

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U.S. Department of Agriculture
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410; or

fax:
(833) 256-1665 or (202) 690-7442;

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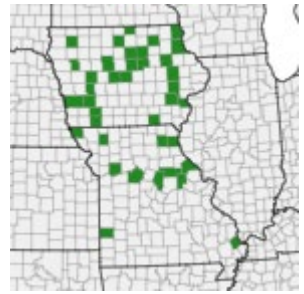
Soil sampling depth

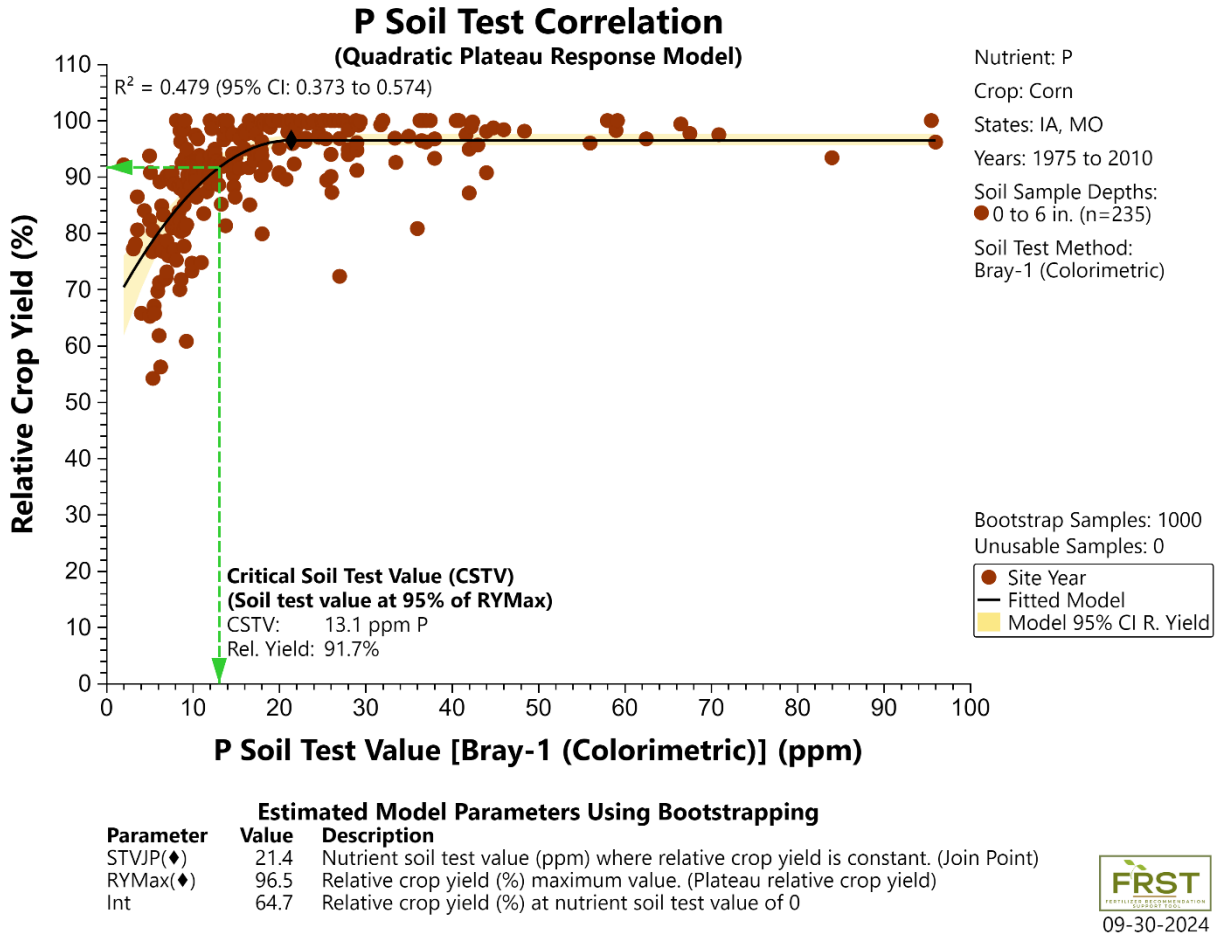
State	P	K	S	N
MN	6-8”	6-8”	0-6”*	0-6, 6-24”**
Iowa	0-6”	0-6”	0-6”	Early spring: 0-12”
SD	0-6”	0-6”	0-6, 6-24”	0-6, 6-24”

FRST Decision Aid with Recommendation Tables



Bray-1 P	Soil Test Level	Removal 200 bu/a	8-yr Build	Total Rate
ppm		- - - - - - lbs P_2O_5/acre - - - - - -		
1	Very Low 1-7 ppm	90	73	163
7		90	41	131
8	Low 8-11 ppm	90	37	127
11		90	28	118
12	Medium 12-22 ppm	90	25	115
15		90	17	107
18		90	10	100
22		90	1	91
24	High 23-35 ppm	90	0	90
28		90	0	90
35		90	0	90
>36	V High 36-68 ppm	0	0	0

Recommendations to Build & Maintain soil test to 23-35 ppm



Estimated Model Parameters Using Bootstrapping

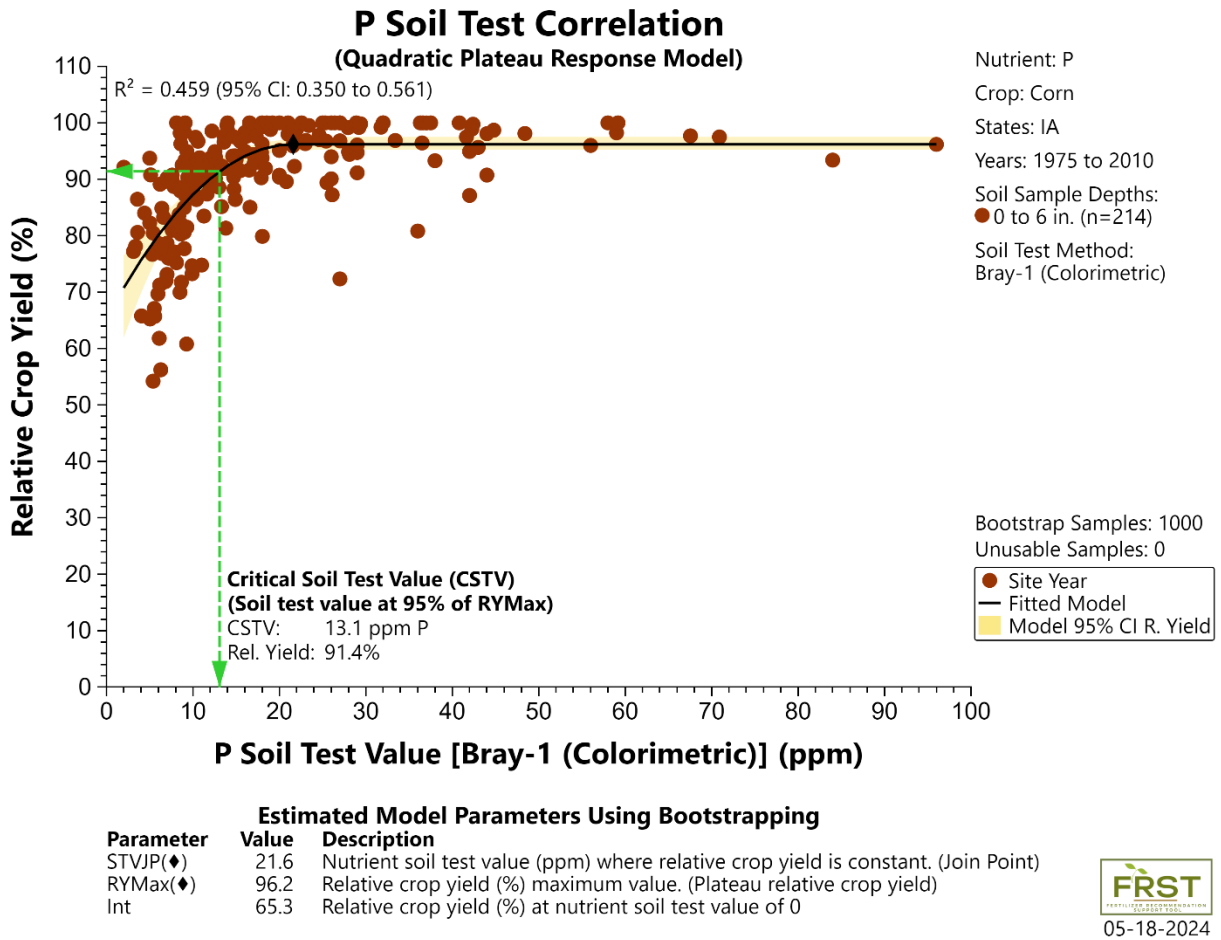
Parameter	Value	Description
STVJP(♦)	21.4	Nutrient soil test value (ppm) where relative crop yield is constant. (Join Point)
RYMax(♦)	96.5	Relative crop yield (%) maximum value. (Plateau relative crop yield)
Int	64.7	Relative crop yield (%) at nutrient soil test value of 0

09-30-2024

Published Research Comparison

Critical soil-test P values from 25 site-years of fertilizer response trials in Iowa determined using various response models, sufficiency levels, and extractants (adopted from Mallarino & Blackmer, 1992).

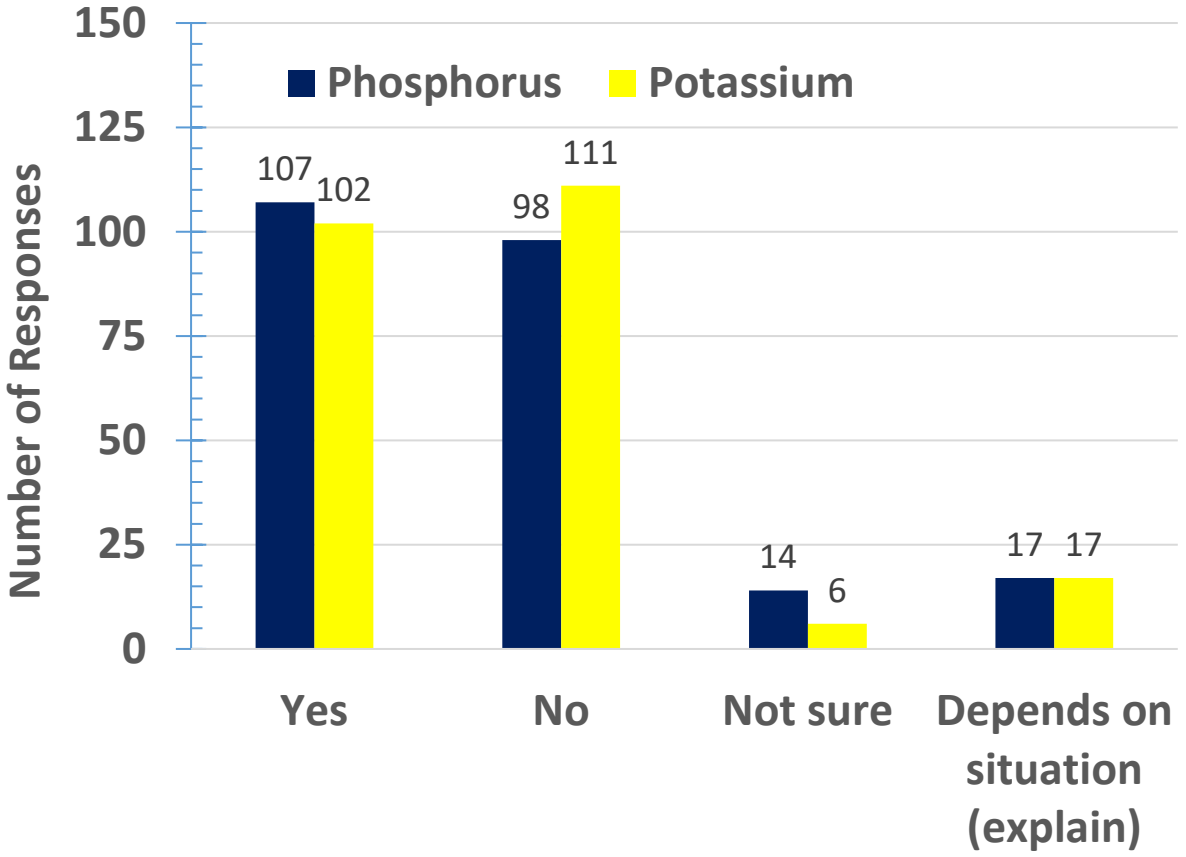
Model	Sufficiency level	Critical soil-test P		
		Bray-1	Mehlich-3	Olsen
	%	ppm (mg/kg)		
Cate-Nelson	100	**13**	12	5
Linear-Plateau	100	**15**	14	6
Quad-Plateau	100	**24**	18	8
Quad-Plateau	99	**18**	15	7
Quad-Plateau	95	**10**	11	5
Quad-Plateau	90	**4**	8	4
Exponential	99	**26**	18	8
Exponential	95	**11**	11	5
Exponential	90	**4**	8	4



Stakeholder Survey

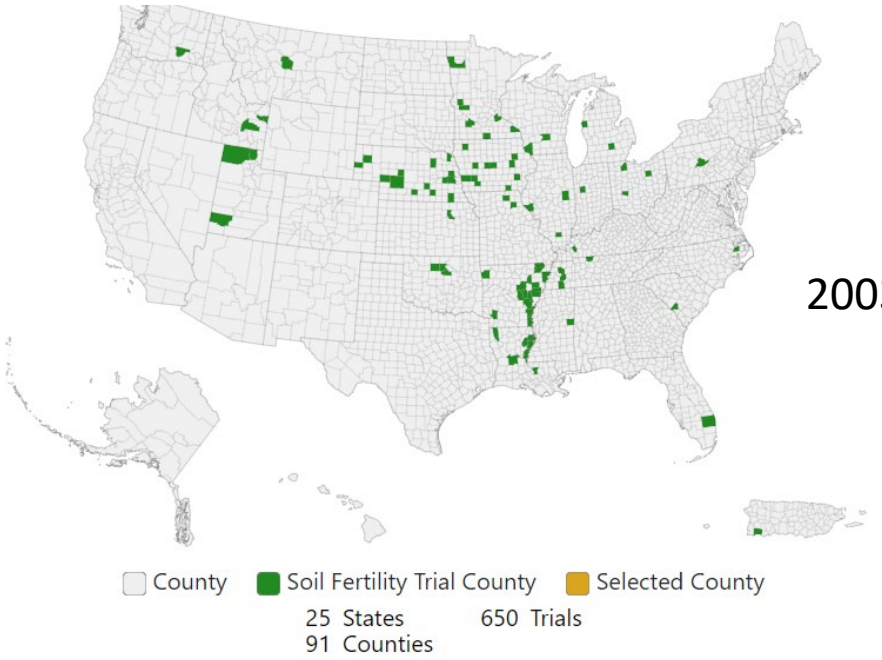
- Joint effort ALTA & FRST
- Two-part survey
  - 23 questions on demographics, soil testing, the fertilizer decision-making process, and fertilizer recommendation strategy.
  - 9 optional questions on soil sampling
- Questions
  - Multiple choice, ratings, or short answers
  - Estimate 20-25 minutes to complete
- *296 Responses*
- Activity led by Slaton

Do you use a Critical Soil Test Value (CSTV) in your crop fertilization strategy as the threshold for P/K fertilizer application (e.g., no P/K is applied when the soil test P/K value exceeds a specific number)?

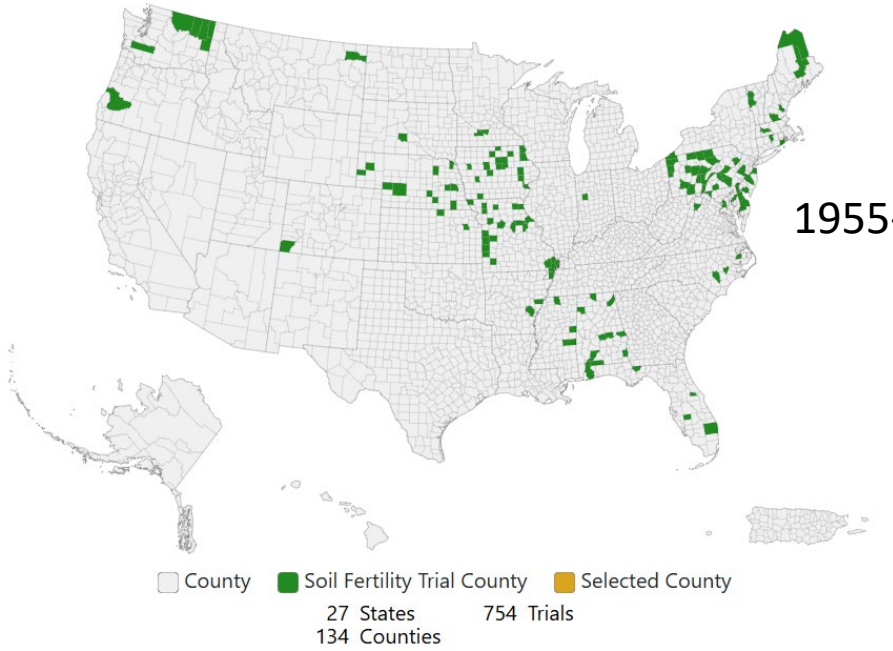


Data Age – Phosphorus data since 2003

Phosphorus Crop	Trials	States	Counties	% of Total
Total	650	25	91	46%
Corn	336	14	63	48%
Soybean	217	13	41	47%
Winter Wheat	13	2	5	42%
Bermudagrass	9	1	2	22%
Corn Silage	4	1	3	15%
Cotton	10	1	2	29%
Rice	24	1	4	100%
Alfalfa	7	2	2	21%



2003-2023

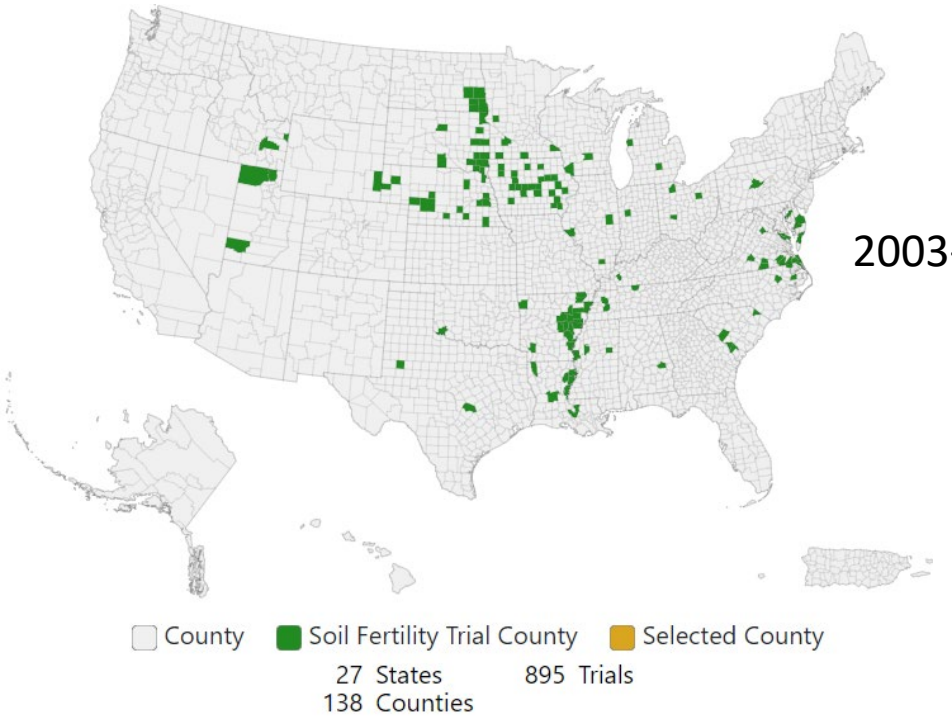


1955-2003

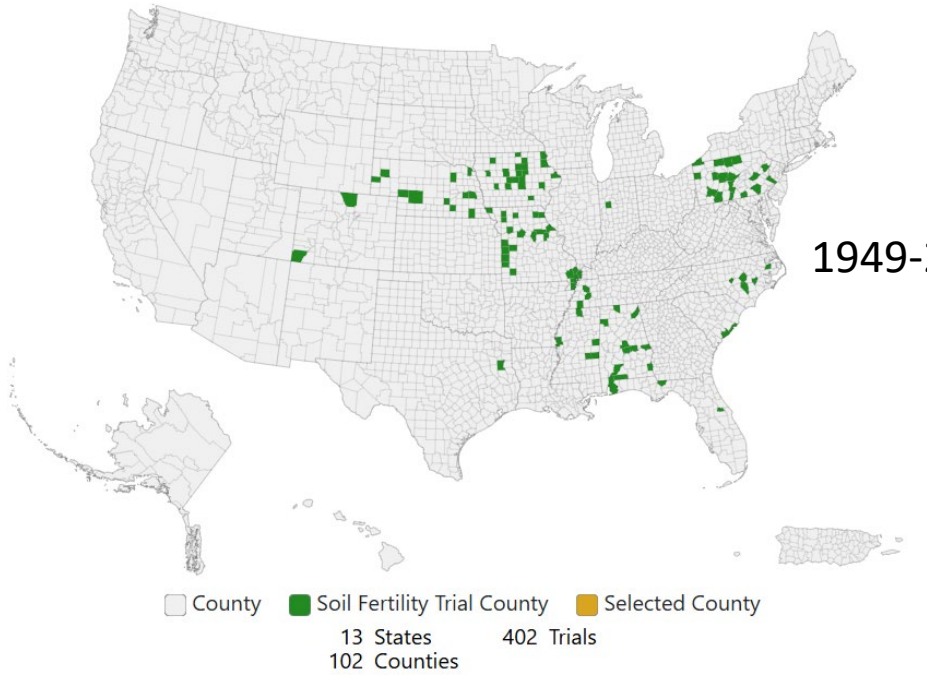
Data Age – Potassium data since 2003

Potassium Crop	Trials	States	Counties	% of Total
Total	*895*	*27*	*138*	*69%*
Corn	428	16	95	69%
Soybean	286	13	65	77%
Cotton	75	9	21	57%
Bermudagrass	9	1	2	16%
Rice	55	1	7	100%
Alfalfa	21	4	4	62%
Winter wheat	4	1	2	33%

Data as of 10.12.2024



2003-2023



1949-2003