Soil Test Correlation & Calibration: Why its Important

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DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Arkansas Agricultural Experiment Station

ALTA 2023 Summer Meeting, Aug 28-29

FRST
FERTILIZER RECOMMENDATION SUPPORT TOOL

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https://soiltestfrst.org/

Discussion Topics

- Introduction to FRST, FRST activities and collaborators
- Why soil test correlation is important
  - Define soil test correlation & calibration
  - Problems and assumptions of soil testing and correlation
- Review Mehlich-3 correlation research
  - Corn and Soybean
  - Phosphorus & potassium

FRST Team + Collaborators

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Brian Arnall	Oklahoma State University
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David Hardy	NCDA&CS
Daren Harmel	USDA-ARS
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aved Iqbal	University of Nebraska
Jim Ippolito	Colorado State University & Ohio State University
Sindhu Jagadamma	University of Tennessee
John Jones	University of Wisconsin
Daniel Kaiser	University of Minnesota
Gurpreet Kaur	University of Missouri
Quirine Ketterings	Cornell University
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Gabe LaHue	Washington State Univ.
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Emma Matcham	University of Florida
Marshall McDaniel	Iowa State University
Fernando Miguez	Iowa State University
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Ayman Mostafa	University of Arizona
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Stephanie Murphy	Rutgers University
Rao Mylavarapu	University of Florida
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Nathan Nelson	Kansas State University
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Rasel Parvej	Louisiana State University
Austin Pearce	North Carolina State Univ.
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Mark Reiter	Virginia Tech University
Edwin Ritchey	University of Kentucky
Matthew Ruark	University of Wisconsin
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Amir Sadeghpour	Southern Illinois University
Hubert Savoy*	University of Tennessee
Charles Shapiro*	University of Nebraska
Lakesh Sharma	University of Florida
Andrew Sharpley *	University of Arkansas
Amy Shober	University of Delaware
Frank Sikora	University of Kentucky
Gurbir Singh	University of Missouri
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Henry Sintem	University of Georgia
Nathan Slaton	University of Arkansas
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Juan Solomon	University of Nevada, Reno
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Gurpal Toor	University of Maryland
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Stephen Wood	The Nature Conservancy
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*Retired

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Visit **soiltestfrst.org**

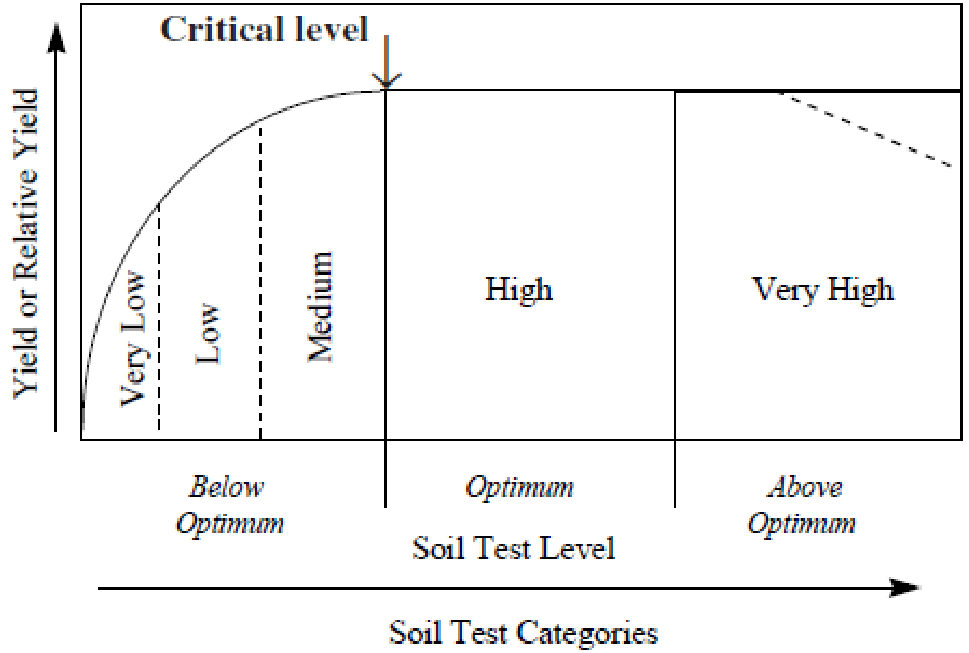
FRST Activities

- Survey of land grant faculty on current soil test practices and recommendations (Spargo)
- Define a minimum dataset requirement for soil test correlation and calibration trials (Slaton)
- Collect legacy soil test correlation and calibration data and develop an accompanying relational database (Lyons & Arthur)
- Determine the most appropriate relative yield definition for FRST (Pearce, Lyons, & Slaton)
- Collaborator soil test fertility trials 2021 (Osmond & Lyons)
- Collaborator soil test fertility trials 2023 (Osmond)
- Sampling depth study (Culman & Spargo)
- **Modeling soil test correlation data (Slaton & Pearce)**
- Develop a user-friendly, searchable interface (decision tool) and internal structure that allows for input, output, and geospatial context (Buol, Arthur, & Osmond)
- Lime Project (Miller & Jones)

Why soil test **correlation** is important

- **First Step of Soil Testing** - *Process of determining the relationship between a soil test nutrient concentration and crop response to fertilization*
- Answers the question ”*Can a soil test distinguish soils that are nutrient deficient and need fertilization from soils that are nutrient sufficient and crops do NOT respond positively to fertilization?*“
- Soil test correlation data and analyses should inform about the
  - magnitude of yield response
  - frequency of yield response
  - strength of the relationship
- Soil test correlation is different from validation and calibration
  - Calibration defines fertilizer-nutrient rate requirement
  - Validation assesses whether recommendations work

- **Questions about the data we are using for soil-test-based fertilizer recommendations:**
  - Does the soil test correlation data exist?
  - Does data support recommendations?
  - How strong (or weak) is the relationship?



Source: Rutgers, FS719, Heckman

Assumptions about soil-test-based recommendations #1

- **Recommendations follow the foundational concepts of soil testing**
  - Soils with low nutrient availability indices respond to fertilization and the response declines as availability increases
  - Greater fertilizer rates are needed on soils with low nutrient availability and decline as availability increases

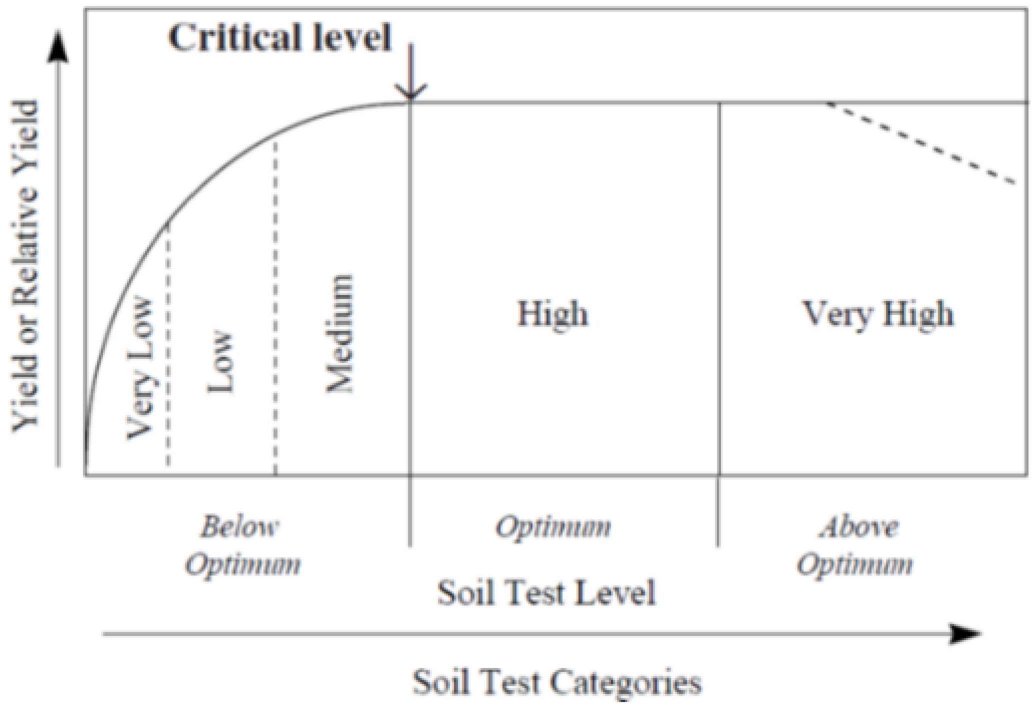
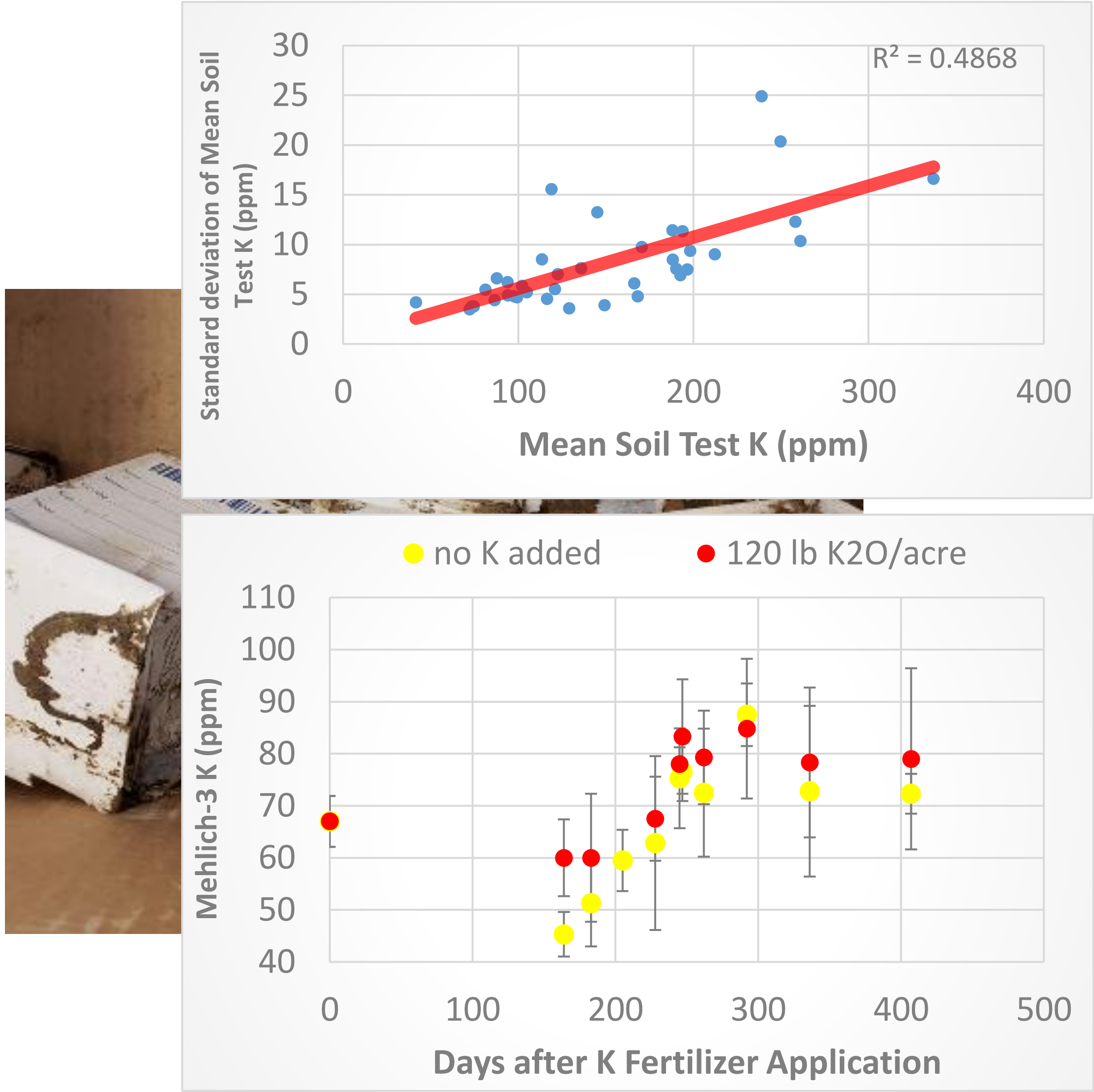


Figure from Rutgers Fact sheet FS719 (2006)

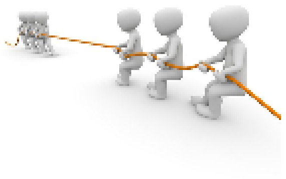
Assumptions about soil-test-based recommendations #2

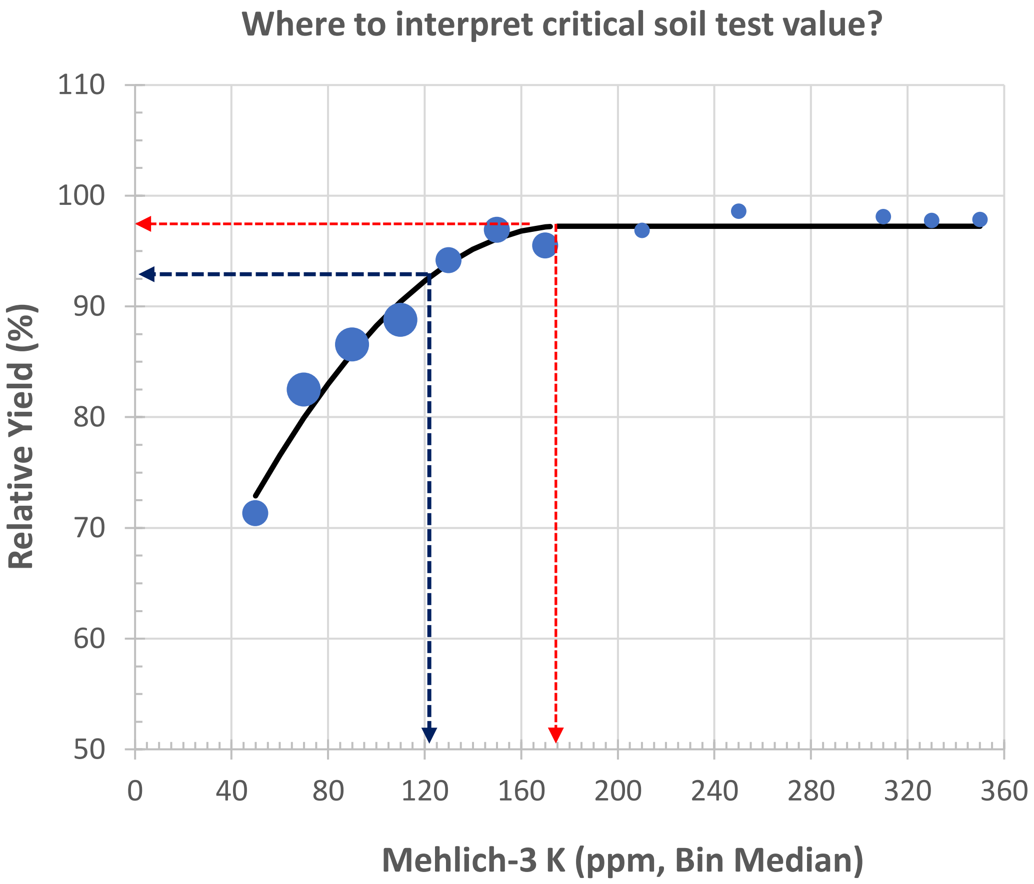
- **Soil samples are representative of the fields they are collected from and analytical results are accurate and precise**
  - Sample collection was performed properly
  - Sample time is consistent with soil test correlation
  - Change in availability is minimal
  - Environmental conditions have minimal effect
  - Within-sample variability is minimal



Assumptions about soil-test-based recommendations #3

- **Agronomic interpretation of the reported soil nutrient availability index is accurate**
  - Soil nutrient availability is meaningful and well correlated with crop growth (and yield ?)
    - Yield is the most meaningful dependent variable for correlation but may be the worst for correlation
  - Variance in methods of determining critical soil test value has a minimal effect on recommendations (?)
  - Sufficiency level of interpretation is intuitive and consistent (?)
  - Data supporting recommendations exists and is reasonably current

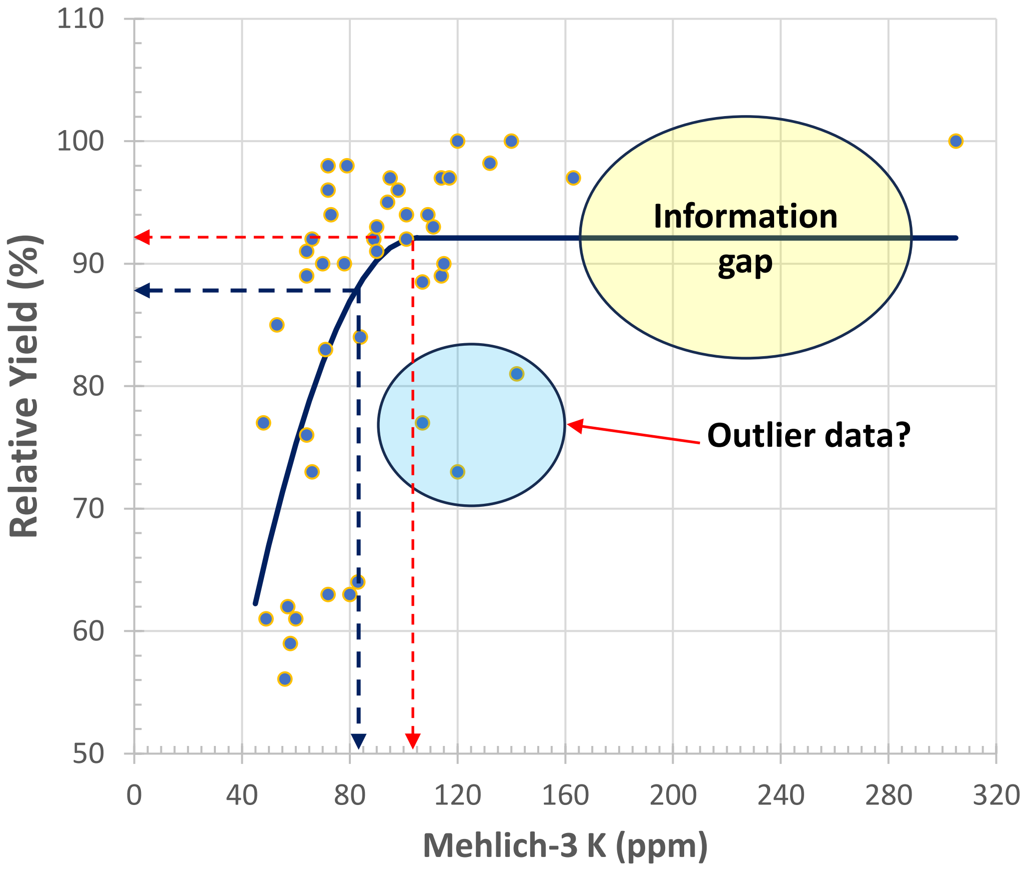




Mehlich-3 Correlation for Row Crops

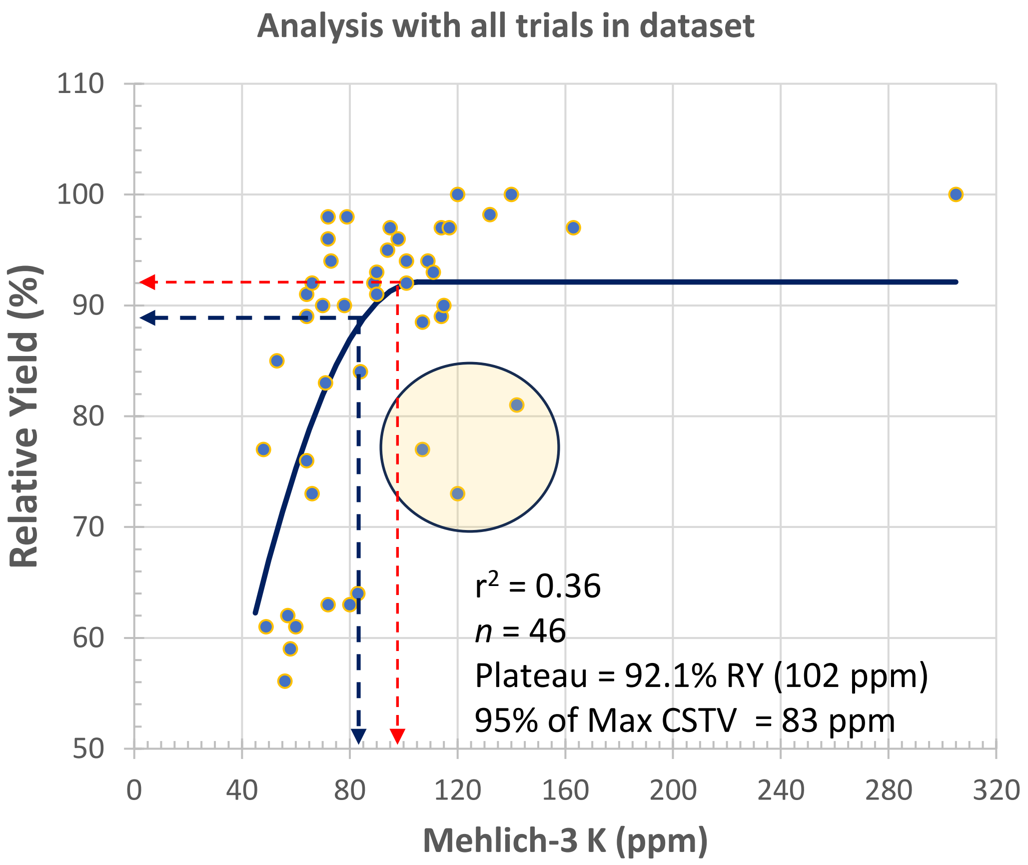
- **Mehlich-3 K for Corn (6-inch soil depth)**
  - Quadratic plateau model
  - Arkansas data with and without outliers
  - Arkansas + Iowa data (all data)
    - *Note: Iowa data is Ammonium Acetate*
- **Mehlich-3 K for Soybean (4-inch sample depth)**
  - Quadratic plateau model
  - Trial data vs trial means in bins
  - *Arkansas vs Arkansas + Louisiana data*
  - Response Frequency (Bin data)
  - Relative yield vs Response Frequency
- **Mehlich-3 P for Corn (6-inch soil depth)**
  - Quadratic plateau model
  - *Arkansas + Iowa data example*
  - Response Frequency (Bin data)
  - Fertilizer-P rate calibration
    - 9-16 ppm M3-P
    - 17-24 ppm M3-P
- **Mehlich-3 P for Soybean (4-inch sample depth)**
  - Quadratic plateau model
  - Arkansas vs Arkansas + Louisiana data

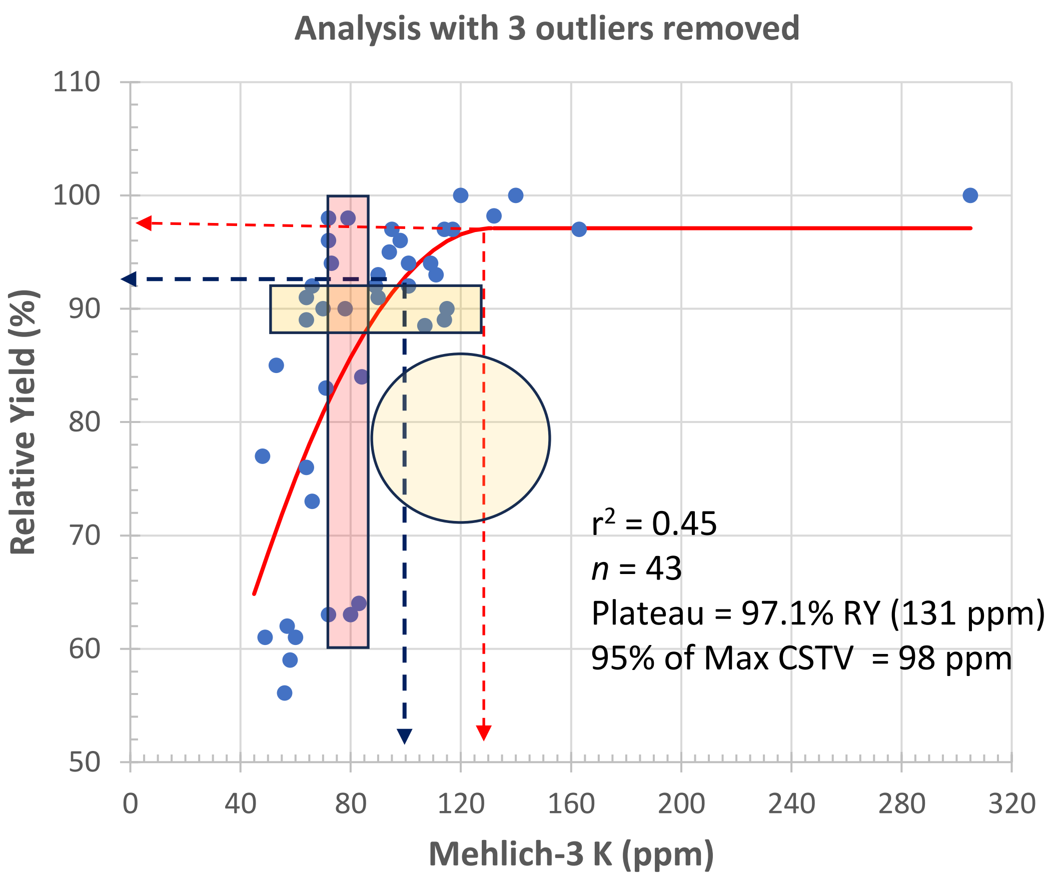
Mehlich-3 K, Irrigated Corn Data (Arkansas, 6-inch depth)



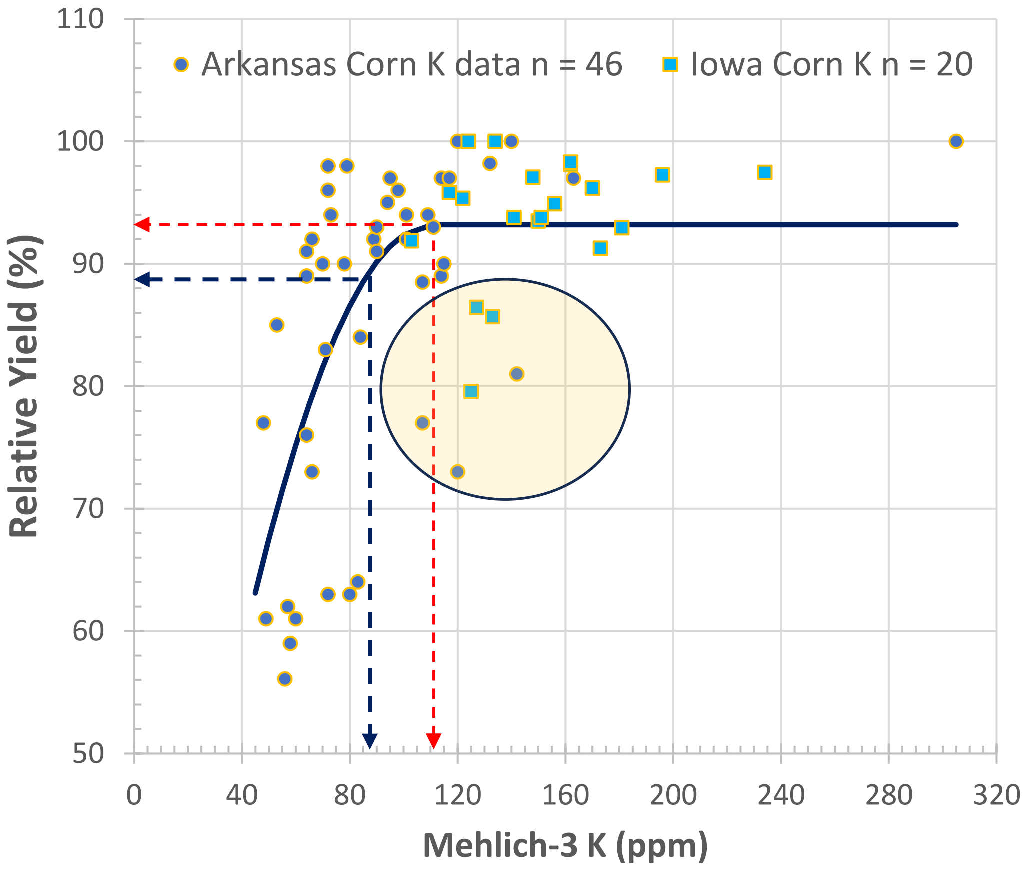
- Corn data, Mehlich-3 K
  - *n* = 46
  - Plateau = 92.1% RY & 102 ppm
  - 95% CI = 70-140 ppm
  - 95% of Max CSTV = 83 ppm
  - r^2 = 0.36
  - Arkansas data from *Drescher et al. (4 site years, 2022) & Crop Forage & Turfgrass Mgmt,* 2021;7:e20120)
    - wileyonlinelibrary.com/journal/cft2 https://doi.org/10.1002/cft2.20120

Mehlich-3 K, Irrigated Corn Data (Arkansas, 6-inch depth)



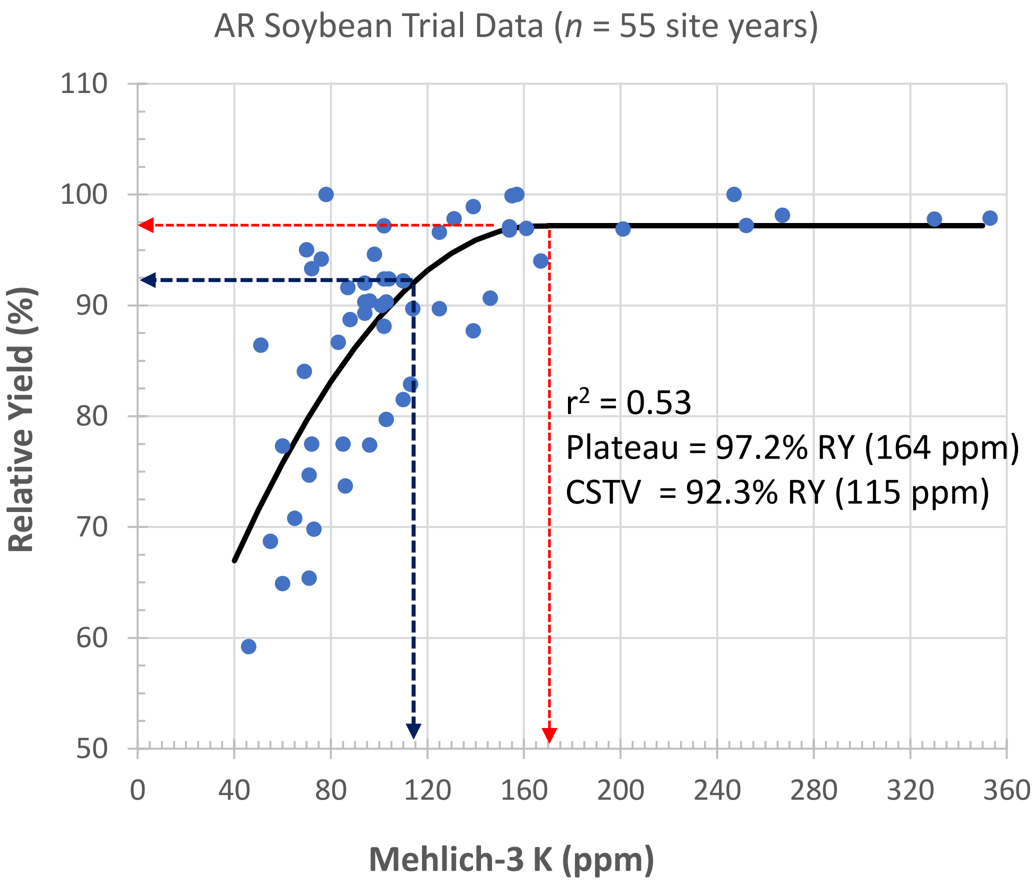


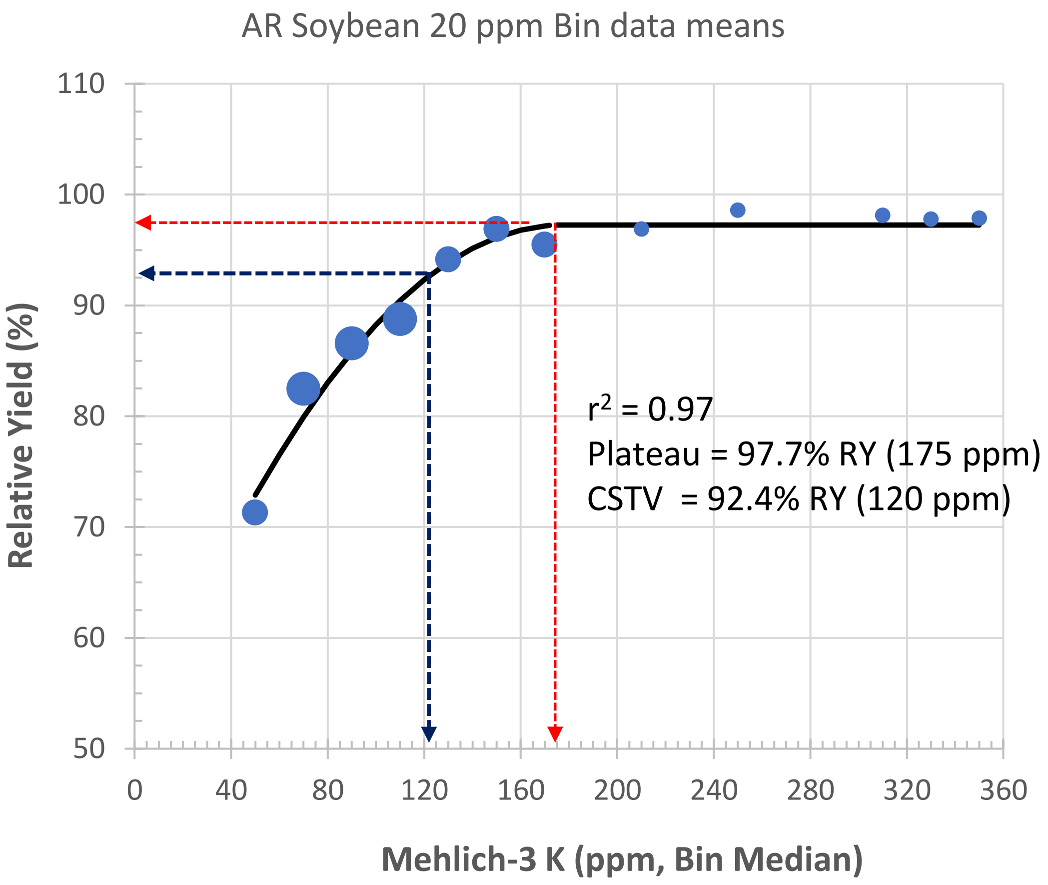
Mehlich-3 K, Irrigated Corn Data (6-inch depth, Arkansas with Iowa data)



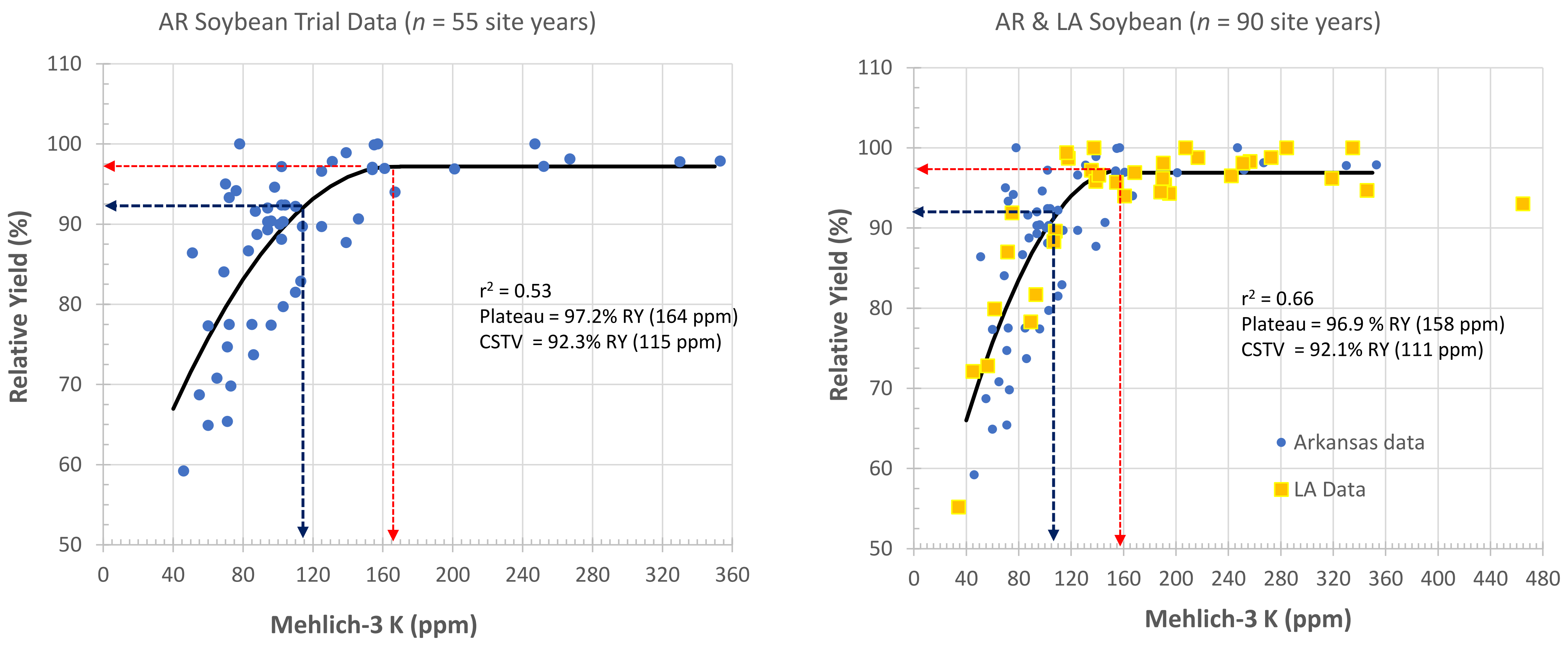
- Corn data, Mehlich-3 K
  - *n* = 66
  - Plateau = 93.2% RY & 111 ppm
    - 95% CI = 82-141 ppm
  - 95% of Max CSTV = 85 ppm
  - r^2 = 0.40
  - Arkansas data from *Drescher et al. (4 site years, 2022) & Crop Forage & Turfgrass Mgmt,* 2021;7:e20120)
    - wileyonlinelibrary.com/journal/cft2 https://doi.org/10.1002/cft2.20120
  - Iowa data from Clover et al. (2012; *SSSAJ 77:630-642*).
    - Ammonium Acetate K
    - doi:10.2136/sssaj2012.0223

2 Representations of Mehlich-3 K Correlation Data for Soybean (Arkansas data)





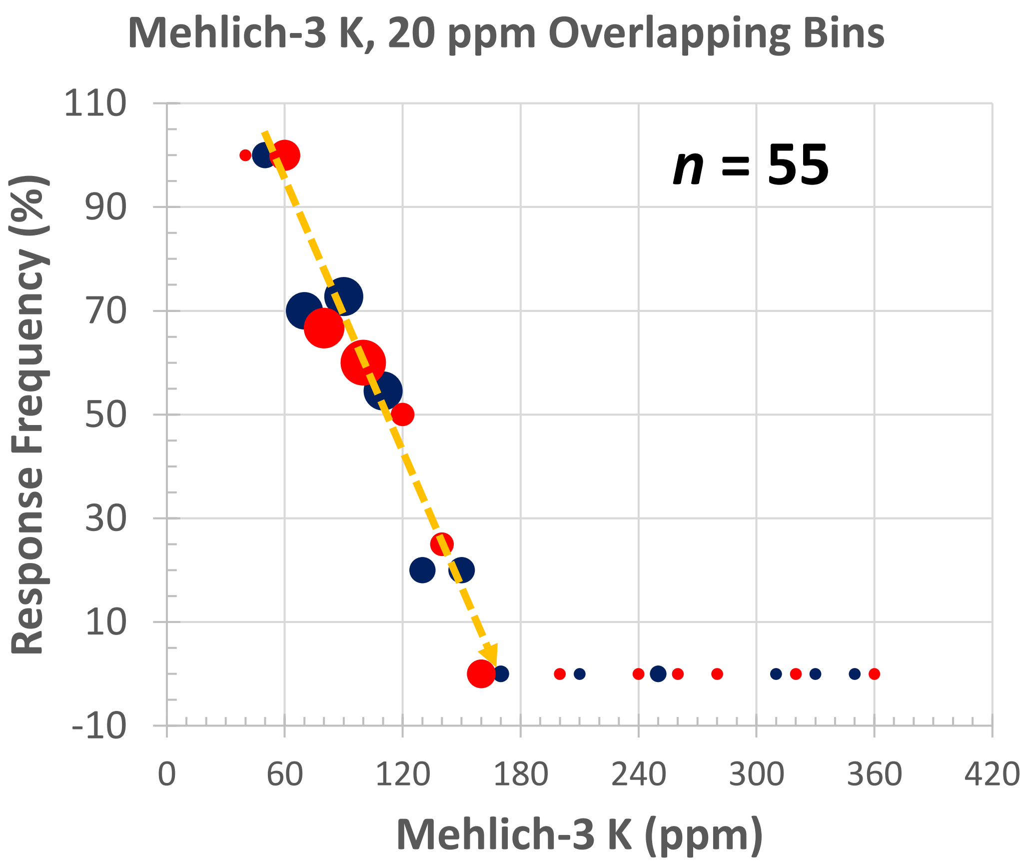
Representations of Mehlich-3 K Correlation Data for Soybean (Arkansas vs Ark+LA data)



0-to 4-inch sample depth

Louisiana data provided by Dr. Rasel Parvej, LSU AgCenter

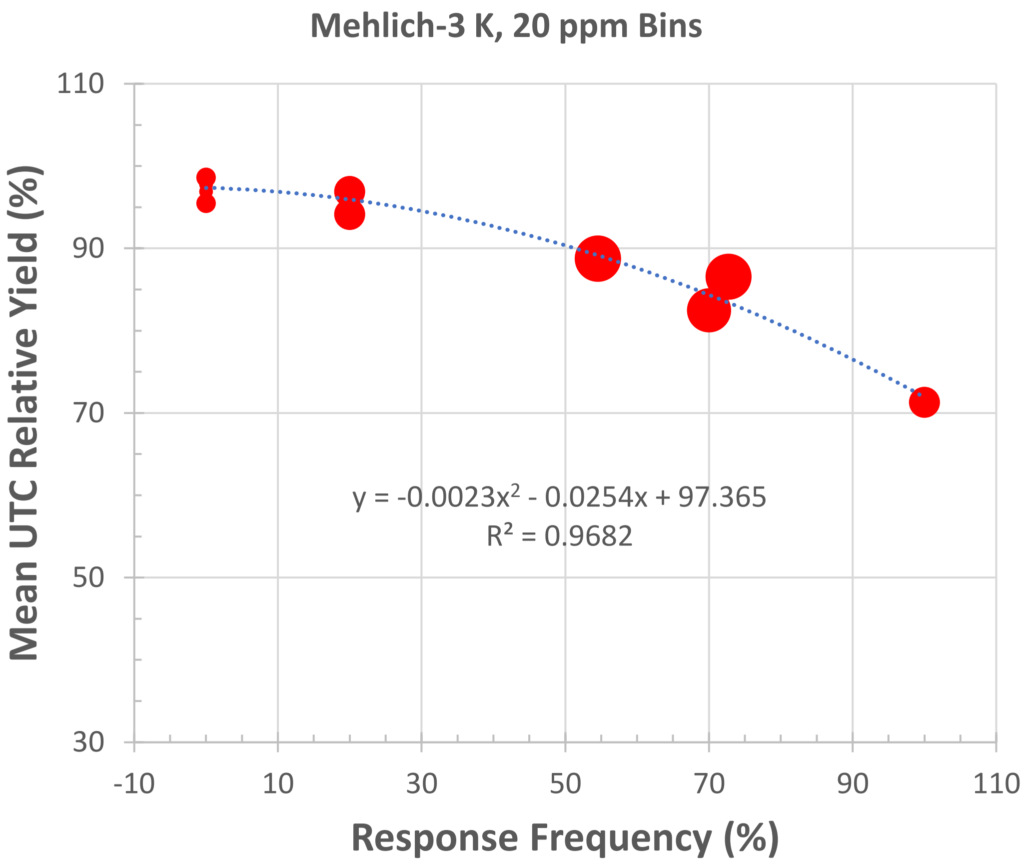
Mehlich-3 K for Soybean Overlapping 20 ppm Bins



Bin Median	Obs. No.	Responsive Sites %	Mean %RY	Mean UTC-AY	Mean Max-AY
ppm	#	%	%	Bu/acre	Bu/acre
50	5	100	71	37.5	52.0
70	10	70	82	48.2	58.8
90	11	73	87	53.5	61.9
110	11	55	89	53.6	60.6
130	5	20	94	57.5	61.0
150	5	20	97	64.2	66.1
170	2	0	95	66.1	69.2
190	-	--	--	--	--
210	1	0	97	65.2	67.3
230	--	--	--	--	--
250	2	0	99	53.8	54.6
270	--	--	--	--	--
290	--	--	--	--	--
310	1	0	98	53.8	54.8
330	1	0	98	72.5	74.1
350	1	0	98	75.2	76.9

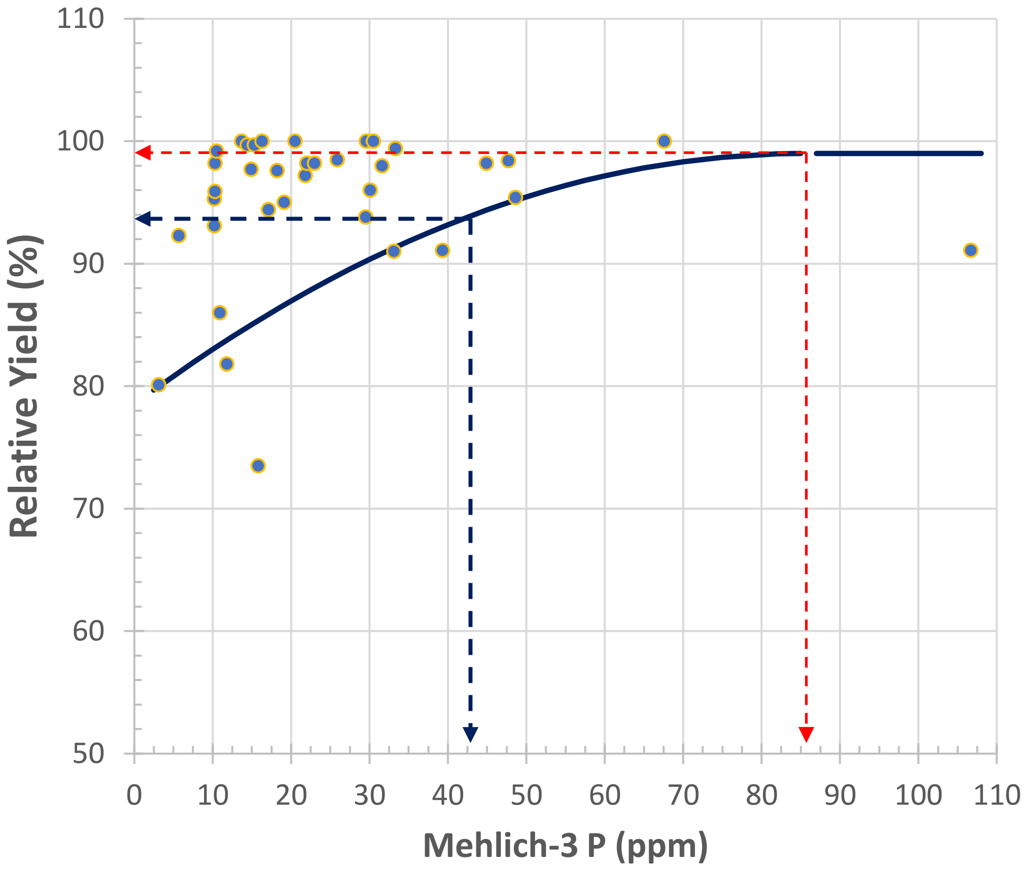
Data Source: FRST Database, Slaton et al. & Fryer et al. (Arkansas data)

Relative Yield vs Response Frequency Mehlich-3 20 ppm Bins



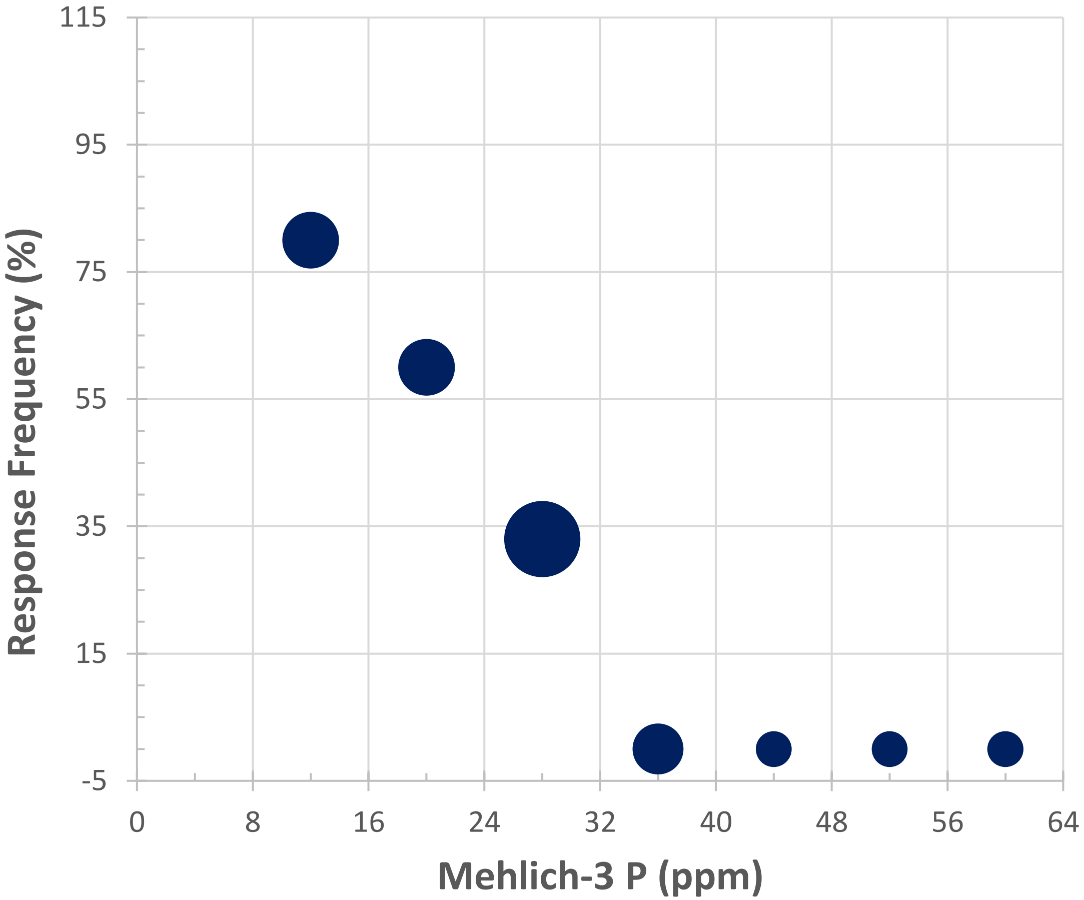
- For this dataset relative yield and the % of fertilizer-responsive trials is well correlated
  - The relationship will differ among datasets and nutrients
  - Positive relationship between the two response parameters builds confidence in soil-test-based recommendations

Mehlich-3 P, Irrigated Corn Data (Arkansas, 6-inch depth)



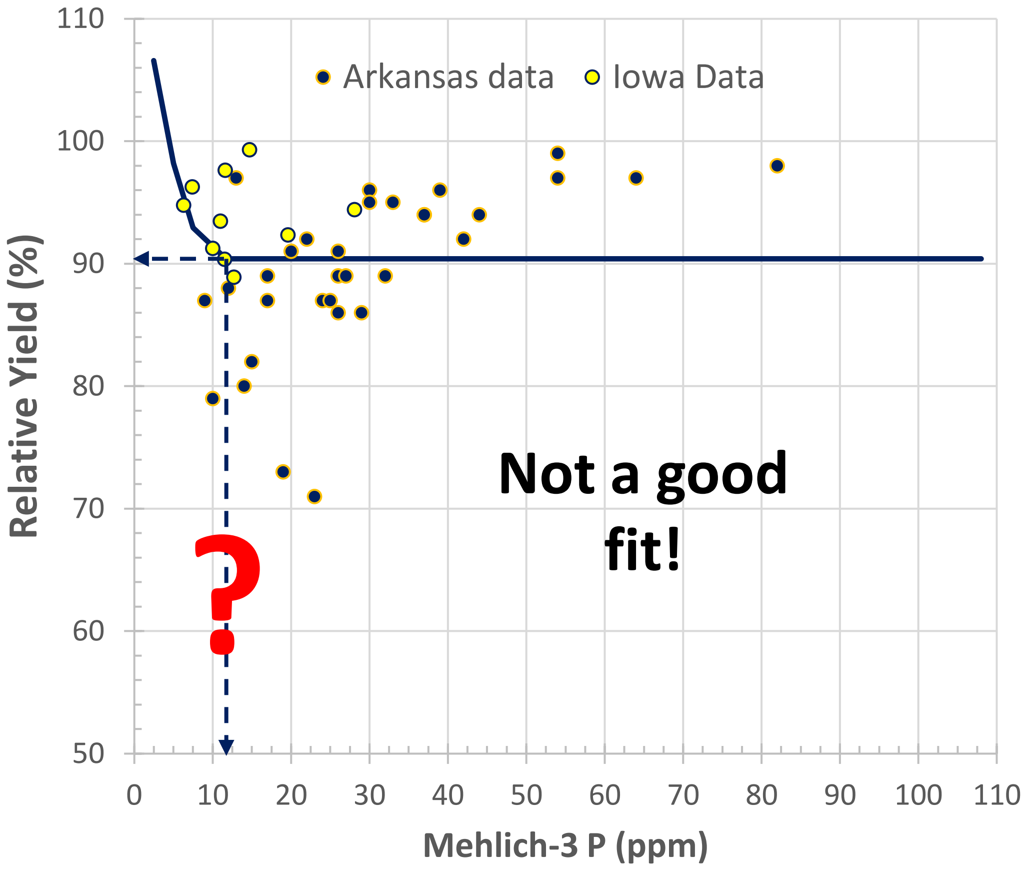
- **Corn data, Mehlich-3 P**
  - *n* = 33
  - CSTV = 43 ppm
  - r^2 = 0.39
  - Arkansas Data from *Crop Forage & Turfgrass Mgmt.* 2021;7:e20120
    - wileyonlinelibrary.com/journal/cft2 https://doi.org/10.1002/cft2.20120

Mehlich-3 P, Irrigated Corn Data (Arkansas, 6-inch depth)



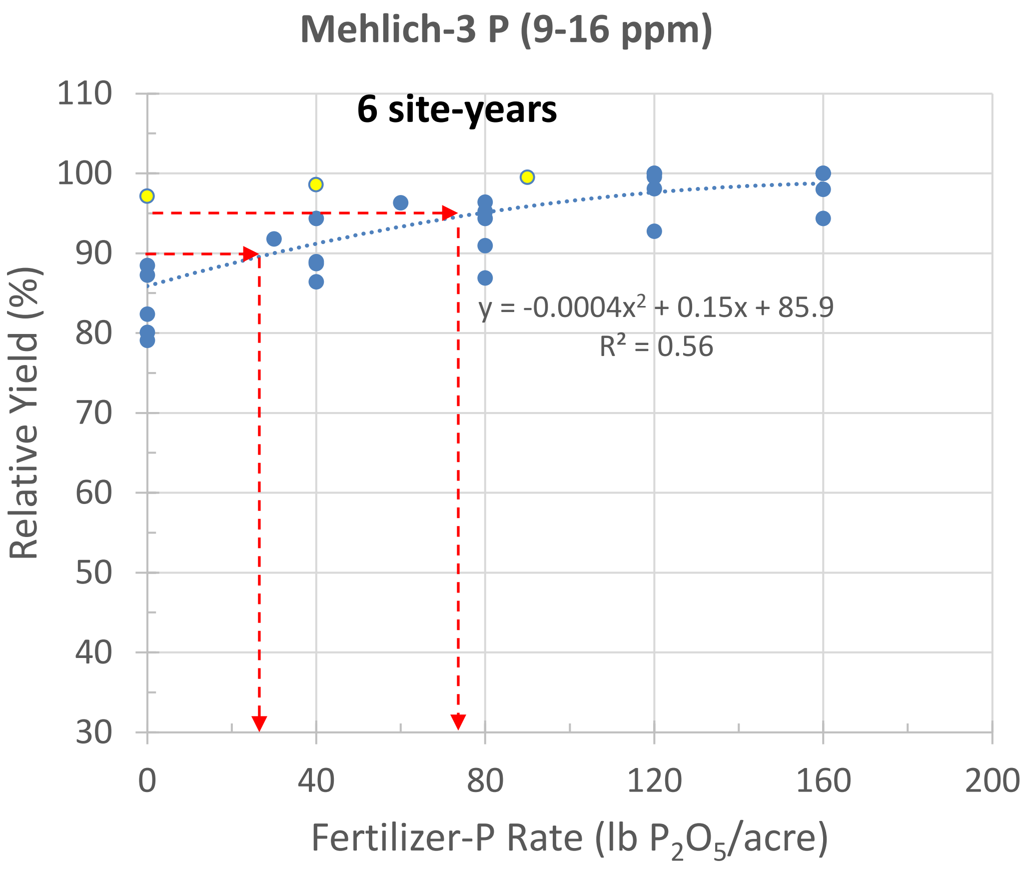
Soil-test P interval	Number of sites	Mean no-P control yield	Mean maximum yield	Mean no-P control relative yield	Response Frequency
ppm	#	Bu/acre	Bu/acre	%	%
1-8	0	-	-	-	
9-16	5	170	204	83	80
17-24	5	202	226	89	60
25-32	9	197	219	90	33
33-40	4	234	247	95	0
41-48	2	272	294	93	0
49-56	2	223	228	98	0
57-64	2	196	201	98	0

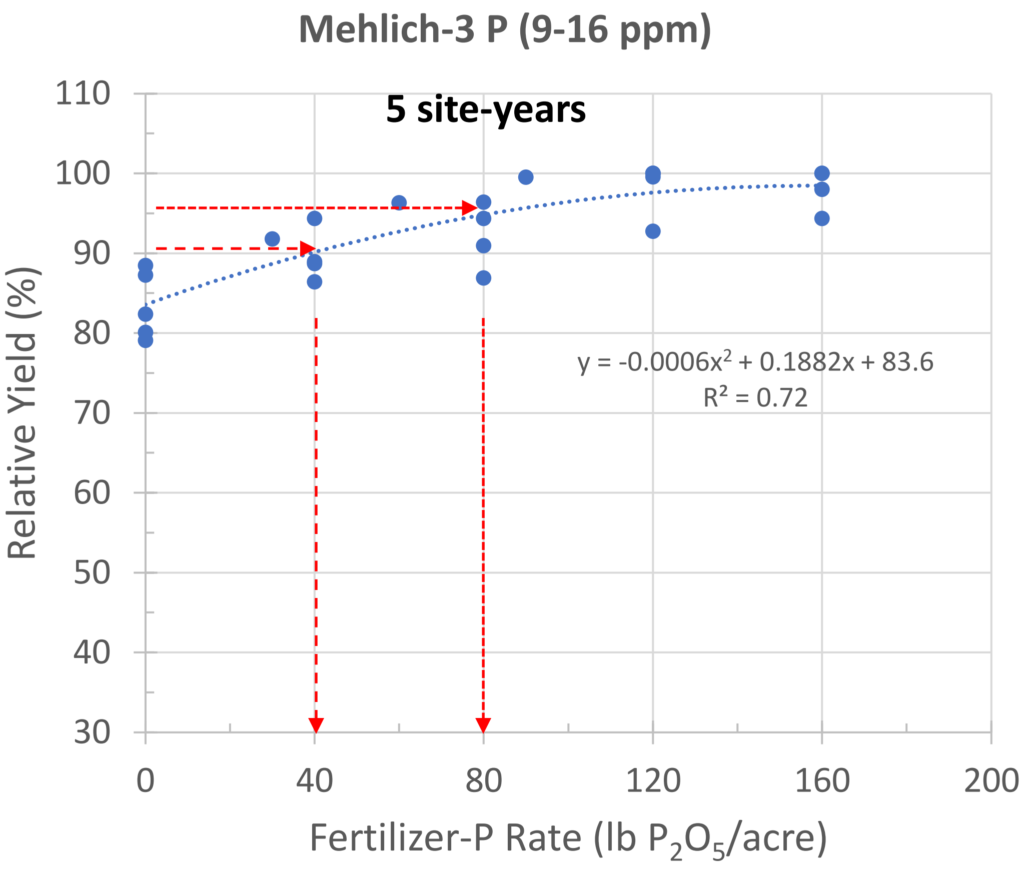
Mehlich-3 P, Irrigated Corn Data (Arkansas + Iowa Data, 6-inch depth)



- **Corn data, Mehlich-3 P**
  - *n* = 42
  - CSTV = **??** ppm
  - ***r*² = 0.02**
  - Arkansas data from *Crop Forage & Turfgrass Mgmt.* 2021;7:e20120
    - wileyonlinelibrary.com/journal/cft2 https://doi.org/10.1002/cft2.20120
  - Iowa Data from Mallarino et al. (Soil Sci. Soc. Am. J. 73:2143-2150)
    - doi:10.2136/sssaj2008.0383
    - 10 site-years

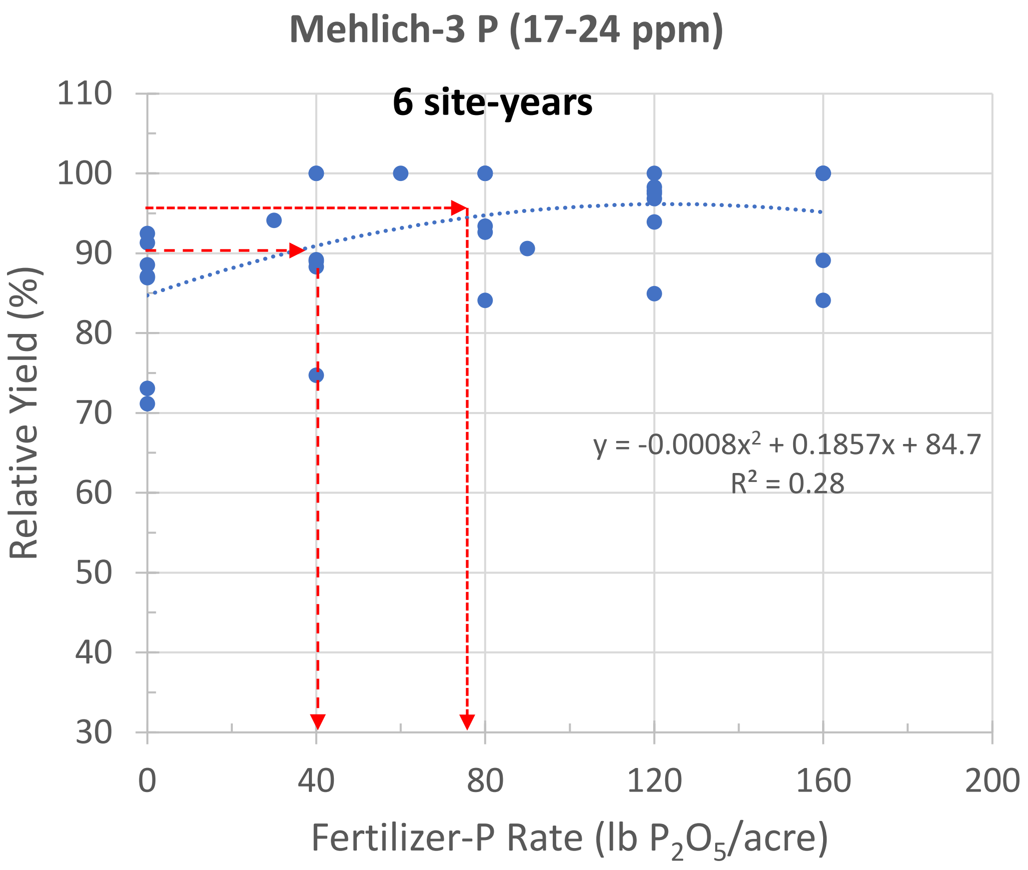
Calibration of Fertilizer-P Rate for Corn (Arkansas, Irrigated Corn)

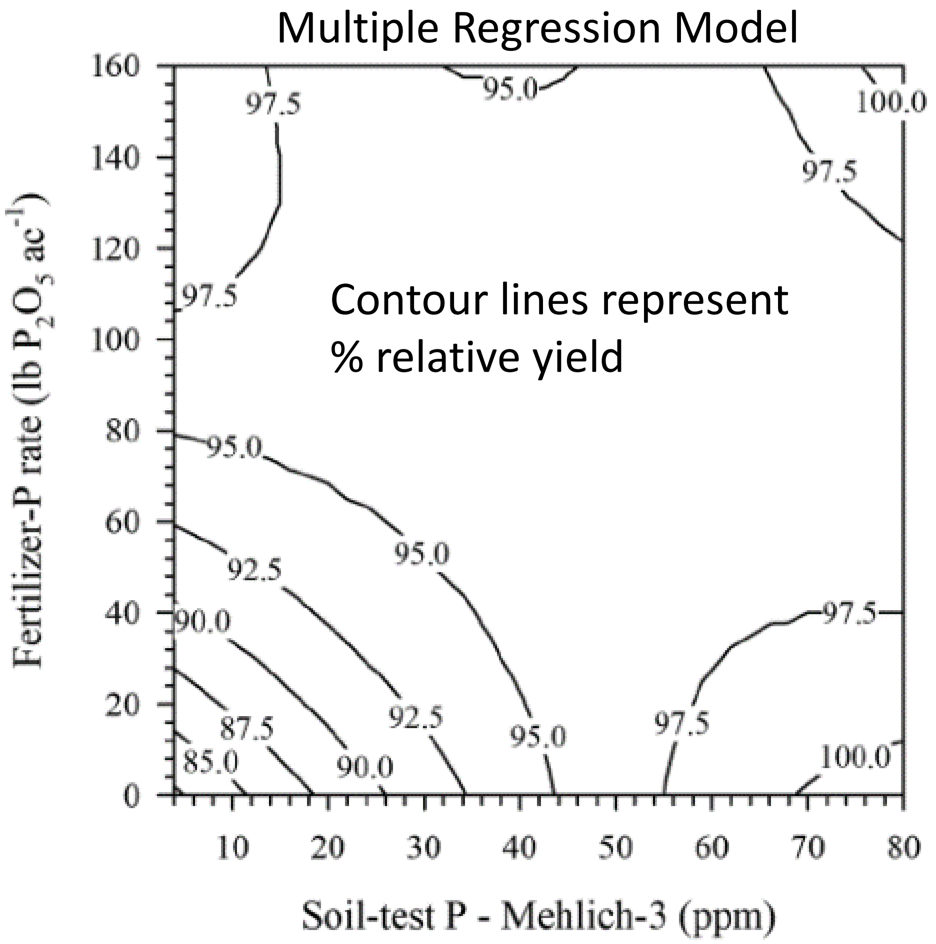




No data site-years with Mehlich-3 P <9 ppm

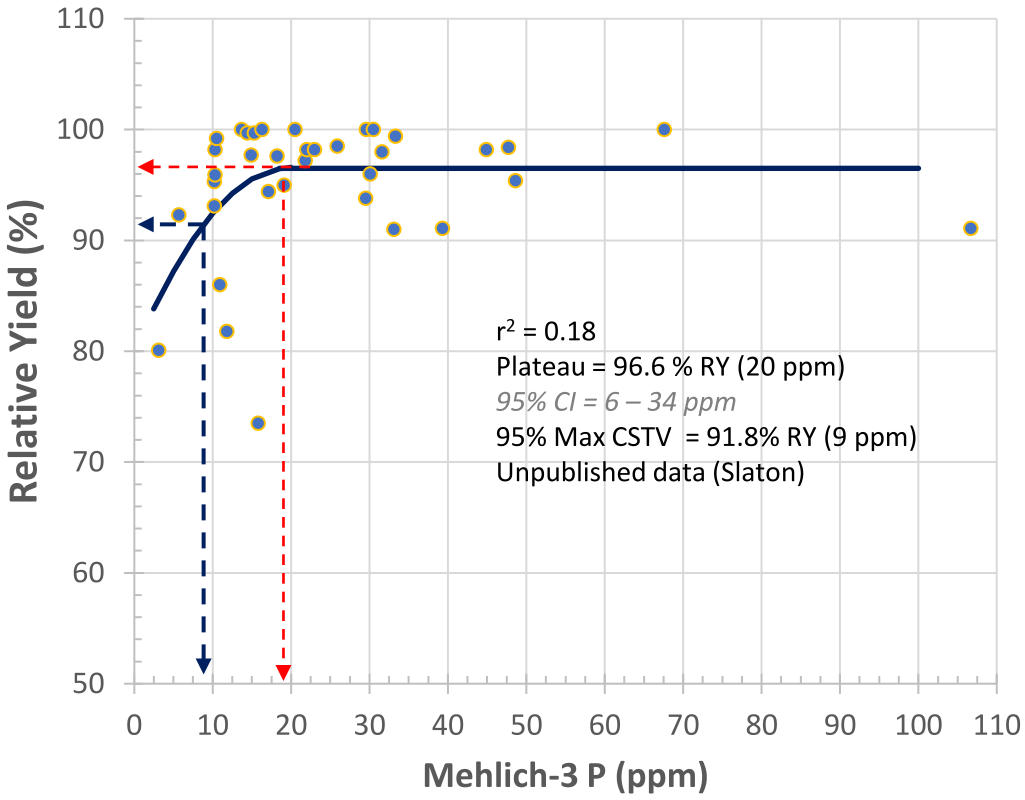
Calibration of Fertilizer-P Rate for Corn



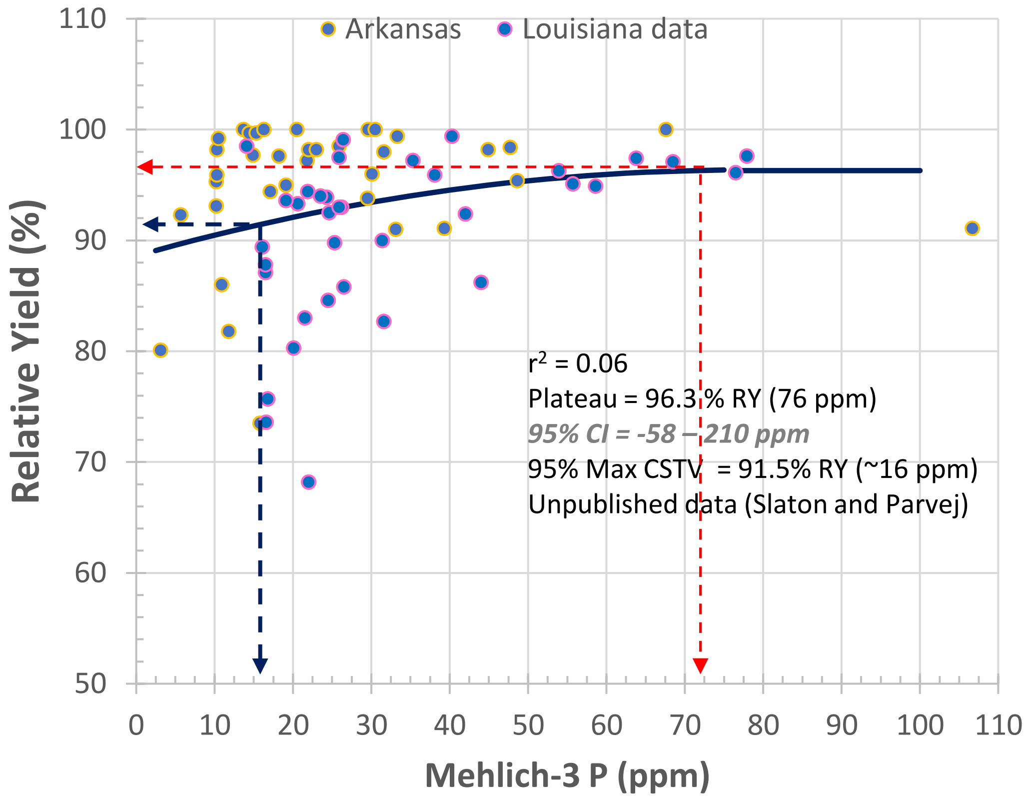


Mehlich-3 P, Irrigated Soybean Data (Arkansas vs ARK+LA data, 4-inch depth)

Arkansas Data (*n* = 36 site years)



ARK & LA Data Combined (*n* = 72 site years)



0-to 4-inch sample depth

Louisiana data provided by Dr. Rasel Parvej, LSU AgCenter

Summary of Mehlich-3 Correlation

- Mehlich-3 K is relatively accurate predictor of corn and soybean response to K fertilization
  - Limited published data available for Mehlich-3 soil test correlation from Midwest
- Mehlich-3 P is a reasonably good predictor of corn response to P fertilization in Arkansas
  - Iowa Mehlich-3 P data does not combine well with Arkansas data
  - In mid-South, soybean is not very responsive to K fertilization.
    - Similar for rice

- **Developing the national database with soil-test-correlation data from numerous states and extractants is important to**
  - Identify data gaps
  - Understand how good our soil tests work for identifying P- and K-deficient soils
  - Update old soil test correlation data with new field trial data

- Soil test P or K tend to explain **20-70%** of the variance in relative yield response to fertilization

How to improve soil-test-based recommendations?

- **What information would you like to have to better evaluate recommendations and enhance transparency of recommendation logic?**
  - Yield level
  - Relative yield
  - Response frequency
  - Correlation curve
  - Calibration curve
  - Correlation strength metric
  - Model information
  - Critical soil test value (CSTV)
  - Uncertainty around CSTV
  - Crop nutrient removal
  - Crop nutrient uptake
  - Effect on post-harvest soil test

Soil Test K	Level	Total Sites	Responsive Sites	RY	No K	Fertilized Max Yield	Average Yield Loss	
ppm		#	% of total	%	Bushels/acre		Bu/acre	%
<61	V Low	4	100	**63**	29	46	17	38
61-75	Low	6	100	**72**	44	61	17	28
76-90	Low	7	86	**78**	46	59	13	23
91-110	Med	16	44	**90**	51	57	6	10
111-130	Med	6	33	**91**	50	55	5	9
<130	Opt	6	0	**97**	62	64	2	4

Future Plans/Timeline for FRST Decision Tool

- Ongoing - Continue adding soil fertility trial data to the database
- Aug. 2023 – Complete work on beta version
- Sept. 2023 - Begin internal testing and review and make changes
- Fall 2023 – Expand review to other stakeholders
    - *Determine what other metrics can be included in FRST output?*
        - Response frequency
        - Economic considerations
- Fall 2023 through Spring 2024 – continue decision tool development
- March 2024 – Release FRST, Version 1
- Spring 2024 through Spring 2025
    - begin incorporating fertilizer rate calibration component

Tool Development Progress/Sneak Peak

- Update on FRST tool
  - https://alta.ag/presentations
- Additional webinars being planned

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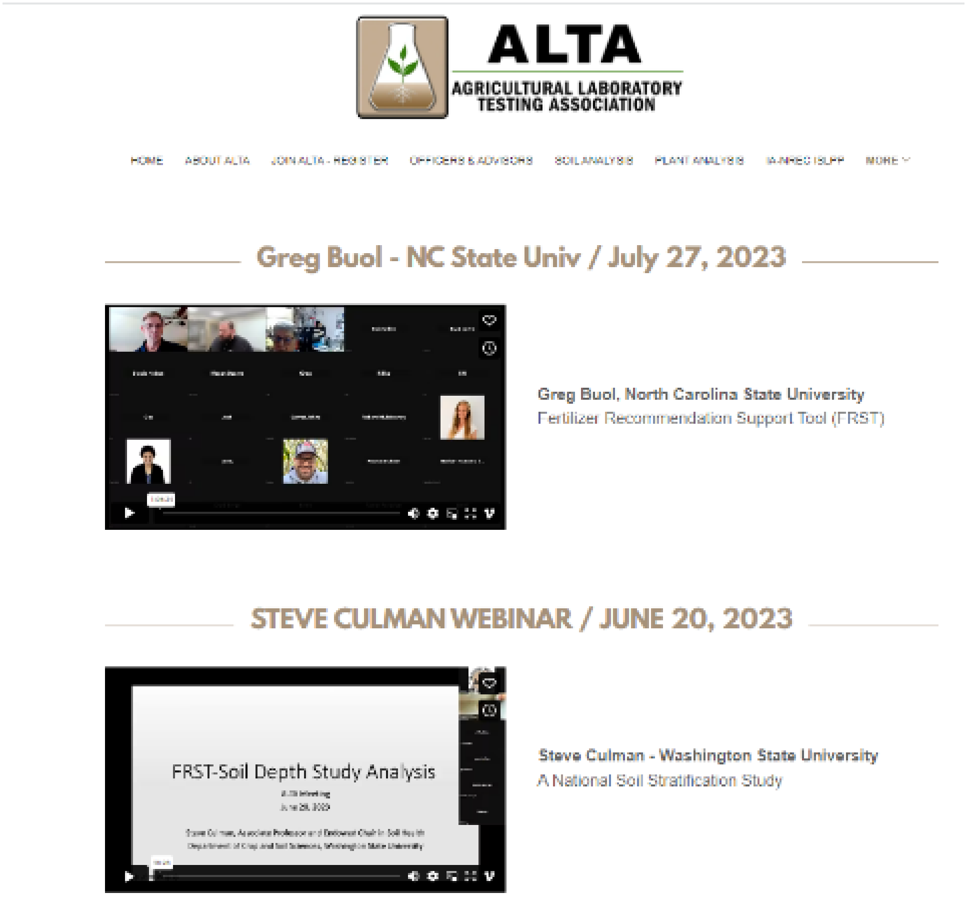

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