

Soil Test Correlation & Calibration: Why its Important

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Experiment Station

ALTA 2023 Summer Meeting, Aug 28-29



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<https://soiltestfrst.org/>

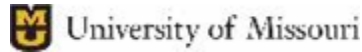
Discussion Topics

- 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

Daniel McAdamson	University of Wyoming	Sindhu Jagadamma	University of Tennessee	Mark Reiter	Virginia Tech University
Nutifafa Adotey	University of Tennessee	John Jones	University of Wisconsin	Edwin Ritchey	University of Kentucky
Uzair Ahmad	University of Arkansas	Daniel Kaiser	University of Minnesota	Matthew Ruark	University of Wisconsin
Shannon Alford	Clemson University	Gurpreet Kaur	University of Missouri	Dorivar Ruiz Diaz	Kansas State University
Brian Arnall	Oklahoma State University	Quirine Ketterings	Cornell University	Amir Sadeghpour	Southern Illinois University
Dana Ashford	USDA-NRCS	Gene Kim	USDA-NRCS	Hubert Savoy*	University of Tennessee
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Carl Bolster	USDA-ARS	Greg LaBarge	Ohio State University	Lakesh Sharma	University of Florida
Sylvie Brouder	Purdue University	Gabe LaHue	Washington State Univ.	Andrew Sharpley *	University of Arkansas
Tom Bruulsema	IPNI-Canada	Jay Lessl	University of Georgia	Amy Shober	University of Delaware
Michael Buser	USDA-ARS	Sarah Lyons	FFAR	Frank Sikora	University of Kentucky
Miguel Cabrera	University of Georgia	Rory Maguire	Virginia Tech University	Gurbir Singh	University of Missouri
Ignacio Ciampitti	Kansas State University	Antonio Mallarino	Iowa State University	Hardeep Singh	University of Florida
Jason Clark	South Dakota State Univ.	Renuka Mathur	University of New Hampshire	Jasdeep Singh	University of Illinois
Adrian Correndo	Kansas State University	Andrew Margenot	University of Illinois	Henry Sintem	University of Georgia
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Leo Deiss	Ohio State University	Marshall McDaniel	Iowa State University	Jared Spackman	University of Idaho
Jagman Dhillon	Mississippi State Univ.	Fernando Miguez	Iowa State University	Carissa Spencer	USDA-FSA
Gerson Drescher	University of Arkansas	Robert Miller	Formerly Colorado State	Juan Solomon	University of Nevada, Reno
Bhupinder Farmaha	Clemson University	Amber Moore	Oregon State University	David Sotomayor	University of Puerto Rico
Joshua Faulkner	University of Vermont	Tom Morris*	University of Connecticut	John Spargo	Penn State
Fabian Fernandez	University of Minnesota	Ayman Mostafa	University of Arizona	Kurt Steinke	Michigan State University
Bronc Finch	University of Arkansas	Jake Mowrer	Texas A&M University	Haiying Tao	University of Connecticut
Robert Florence	University of Tennessee	Stephanie Murphy	Rutgers University	David Tarkalson	USDA-ARS
Robert Flynn	New Mexico State Univ.	Rao Mylavarapu	University of Florida	Gurpal Toor	University of Maryland
Luke Gatiboni	North Carolina State Univ.	Kelly Nelson	University of Missouri	Teferi Tsegaye	USDA-ARS
Daniel Geisseler	Univ. of California - Davis	Nathan Nelson	Kansas State University	Qudus Uthman	North Carolina State Univ.
John Grove	University of Kentucky	Leanna Nigon	The Fertilizer Institute	Pete Vadas	USDA-ARS
David Hardy	NCDA&CS	Deanna Osmond	North Carolina State Univ.	Jeff Volenec	Purdue University
Daren Harmel	USDA-ARS	Rasel Parvej	Louisiana State University	Jordon Wade	University of Missouri
Joseph Heckman	Rutgers University	Austin Pearce	North Carolina State Univ.	Forbes Walker	University of Tennessee
John Hoban	East Carolina University	Eugenia Pena-Yewtukhiw	Univ. of West Virginia	Jim Wang	Louisiana State University
Bryan Hopkins	Brigham Young University	Tim Pilkowski	USDA-NRCS	Charles White	Penn State
aved Iqbal	University of Nebraska	Rishi Prasad	Auburn University	Stephen Wood	The Nature Conservancy
Jim Ippolito	Colorado State University & Ohio State University	Tony Provin	Texas A&M University	Frank Yin	University of Tennessee
		Vaughn Reed	Mississippi State Univ.	Matt Yost	Utah State University

*Retired



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Visit soiltestfrst.org

FRST Activities

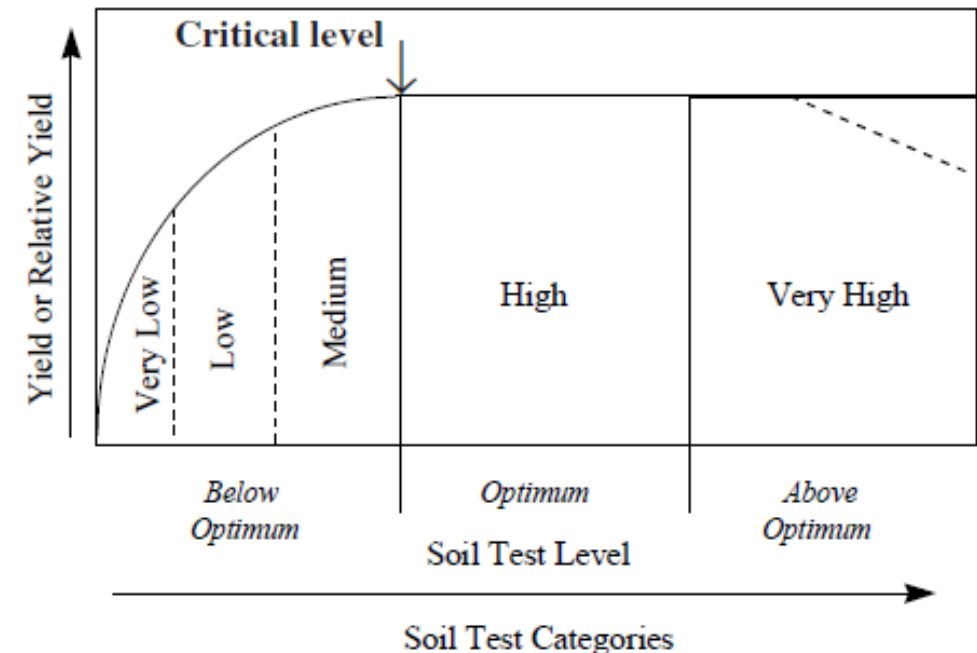
- Survey of land grant faculty on current soil test practices and recommendations (Spargo)
- Define a minimum dataset requirement for soil test correlation and calibration trials (Slaton)
- Collect legacy soil test correlation and calibration data and develop an accompanying relational database (Lyons & 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?



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

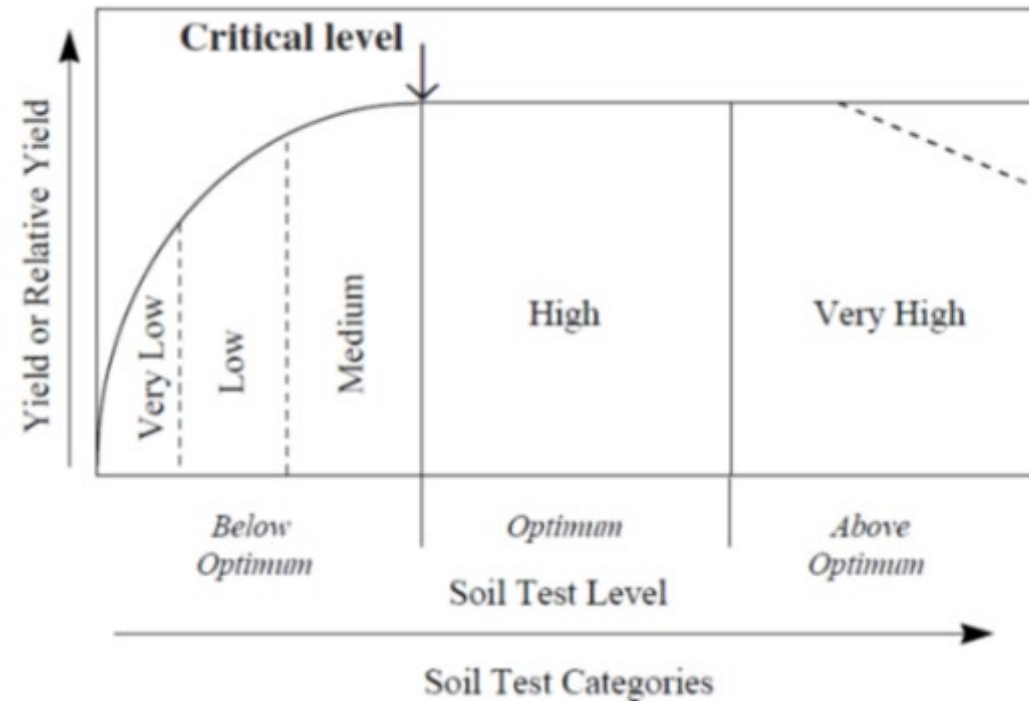
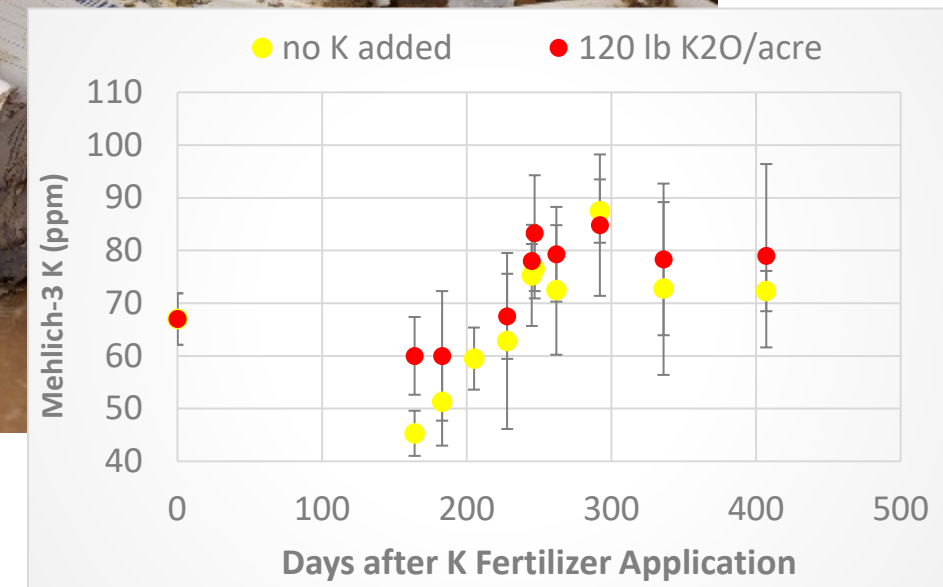
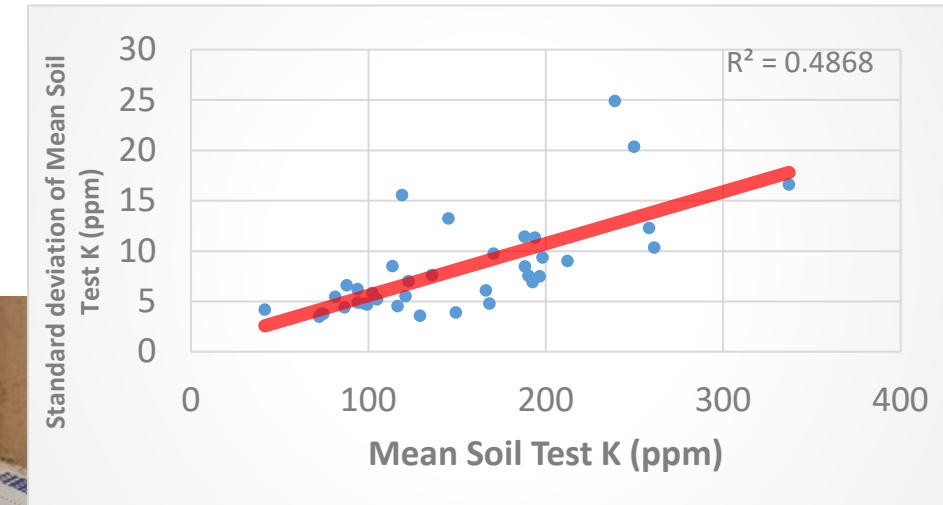


Figure from Rutgers Fact sheet FS719 (2006)

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

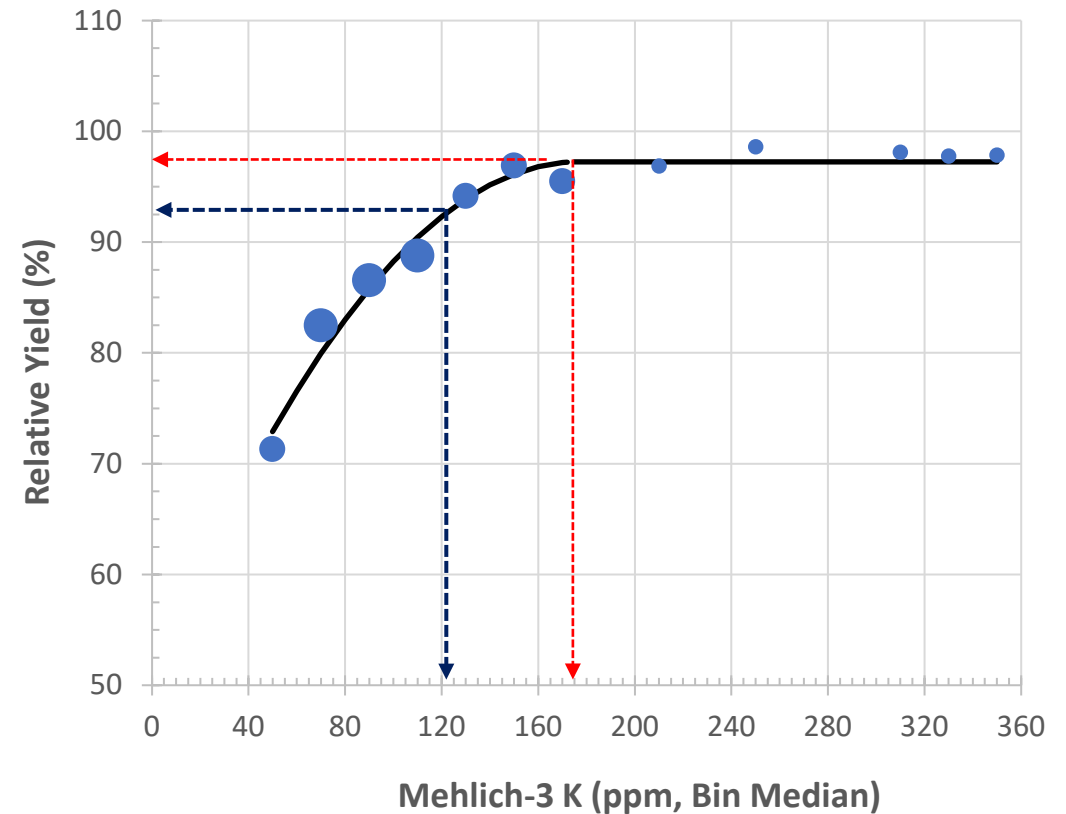


Assumptions about soil-test-based recommendations #3

- **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



Where to interpret critical soil test value?



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

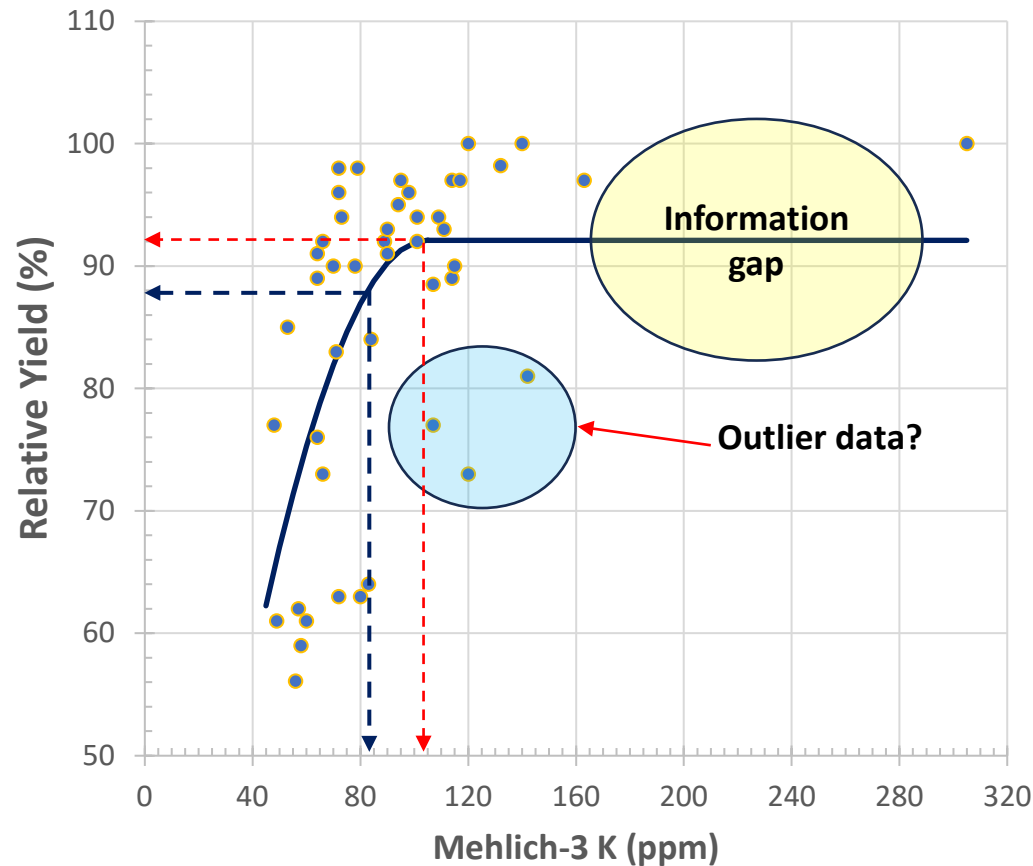
- **Mehlich-3 P for Corn (6-inch soil depth)**

- 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

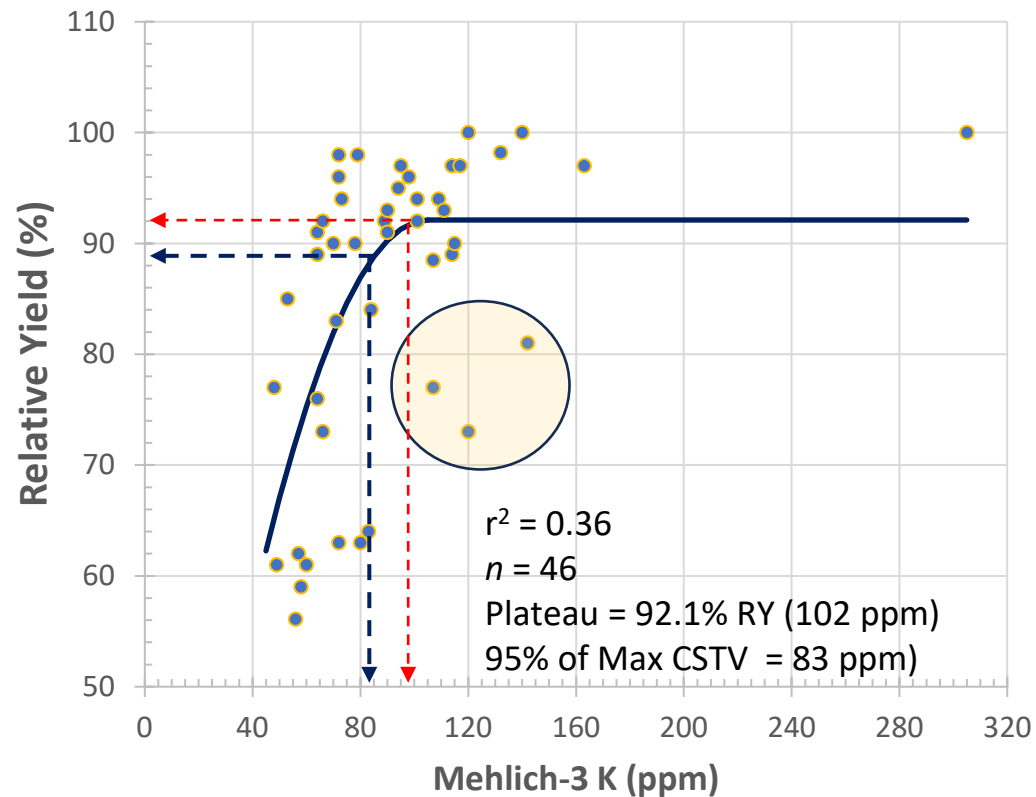
Mehlich-3 K, Irrigated Corn Data (Arkansas, 6-inch depth)



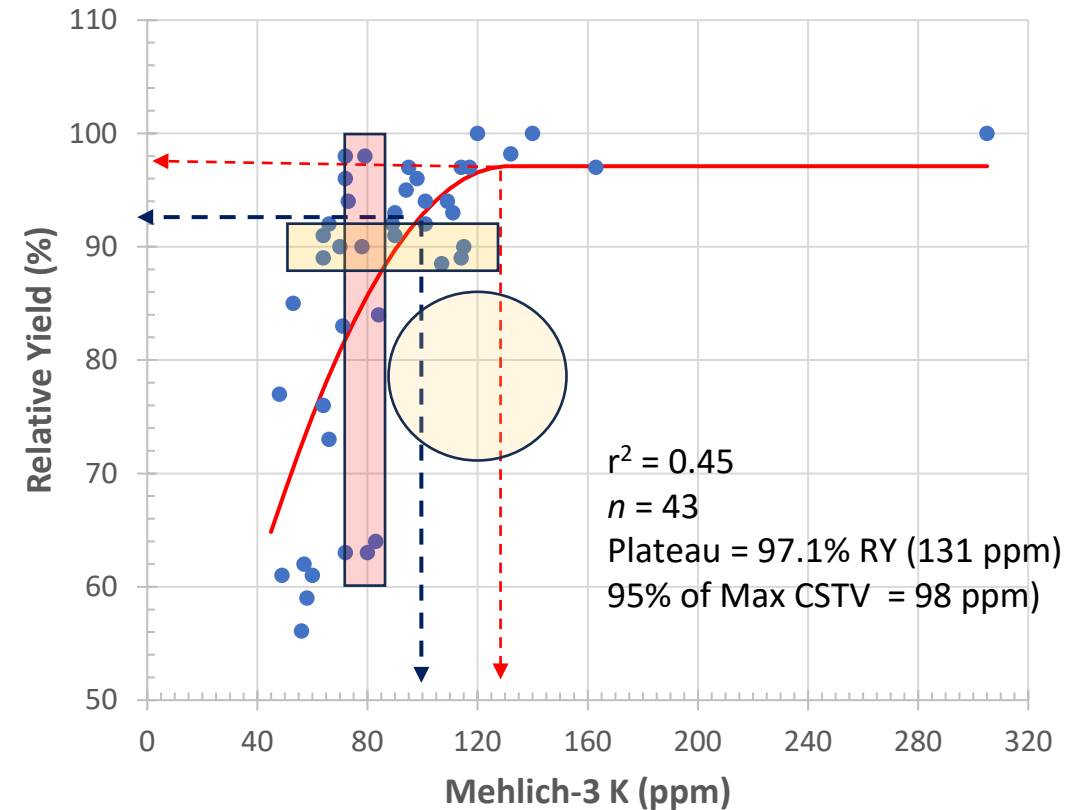
- Corn data, Mehlich-3 K
 - $n = 46$
 - Plateau = 92.1% RY & 102 ppm
 - 95% CI = 70-140 ppm
 - 95% of Max CSTV = 83 ppm
 - $r^2 = 0.36$
 - Arkansas data from *Drescher et al. (4 site years, 2022) & Crop Forage & Turfgrass Mgmt, 2021;7:e20120*
 - [wileyonlinelibrary.com/journal/cft2](https://doi.org/10.1002/cft2.20120)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

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

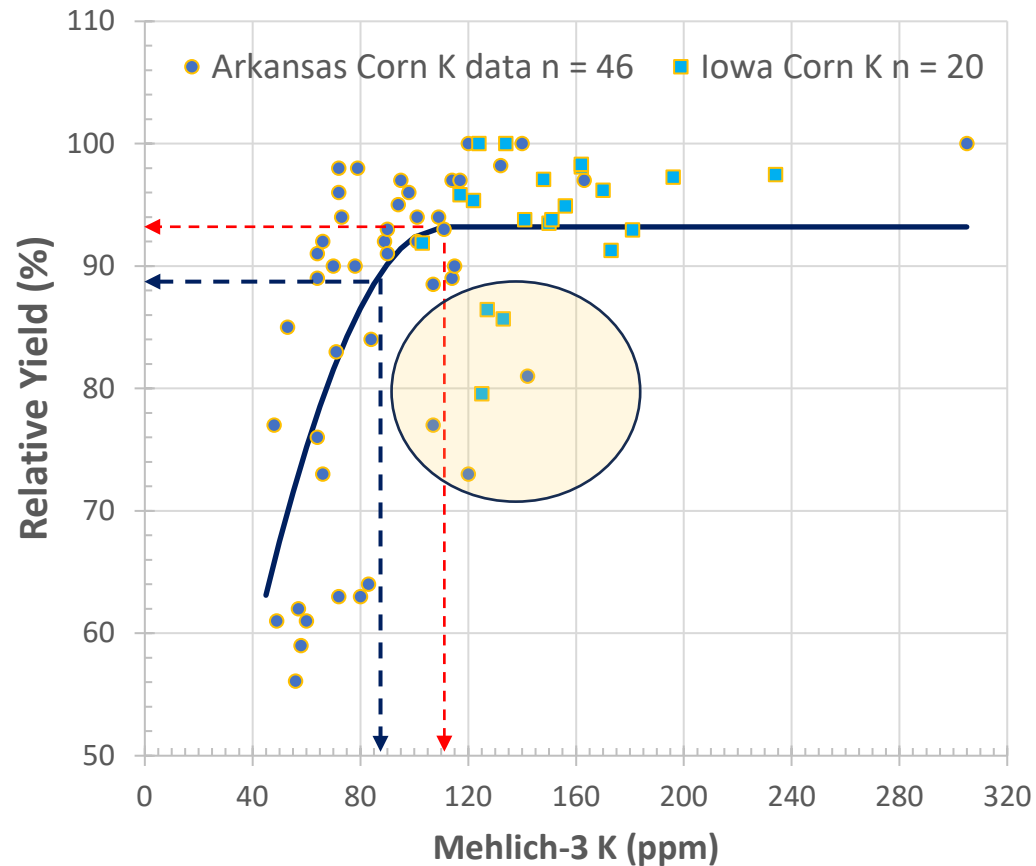
Analysis with all trials in dataset



Analysis with 3 outliers removed

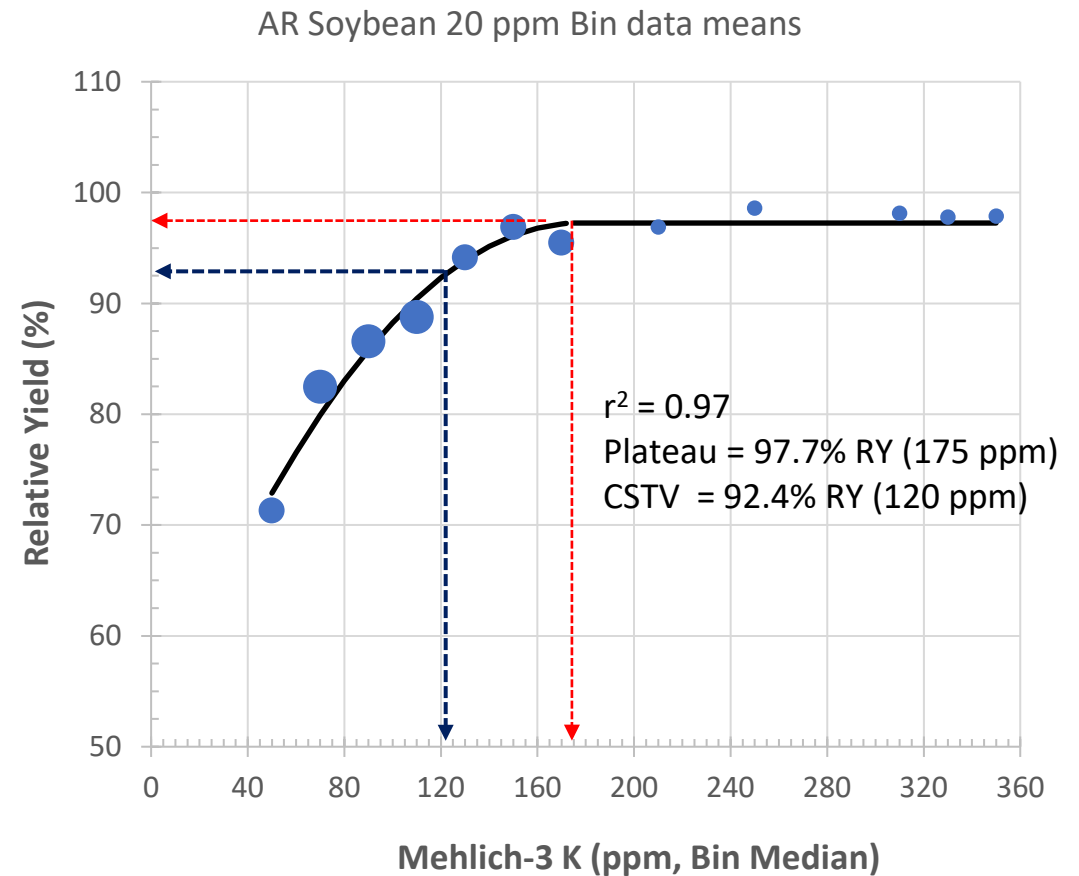
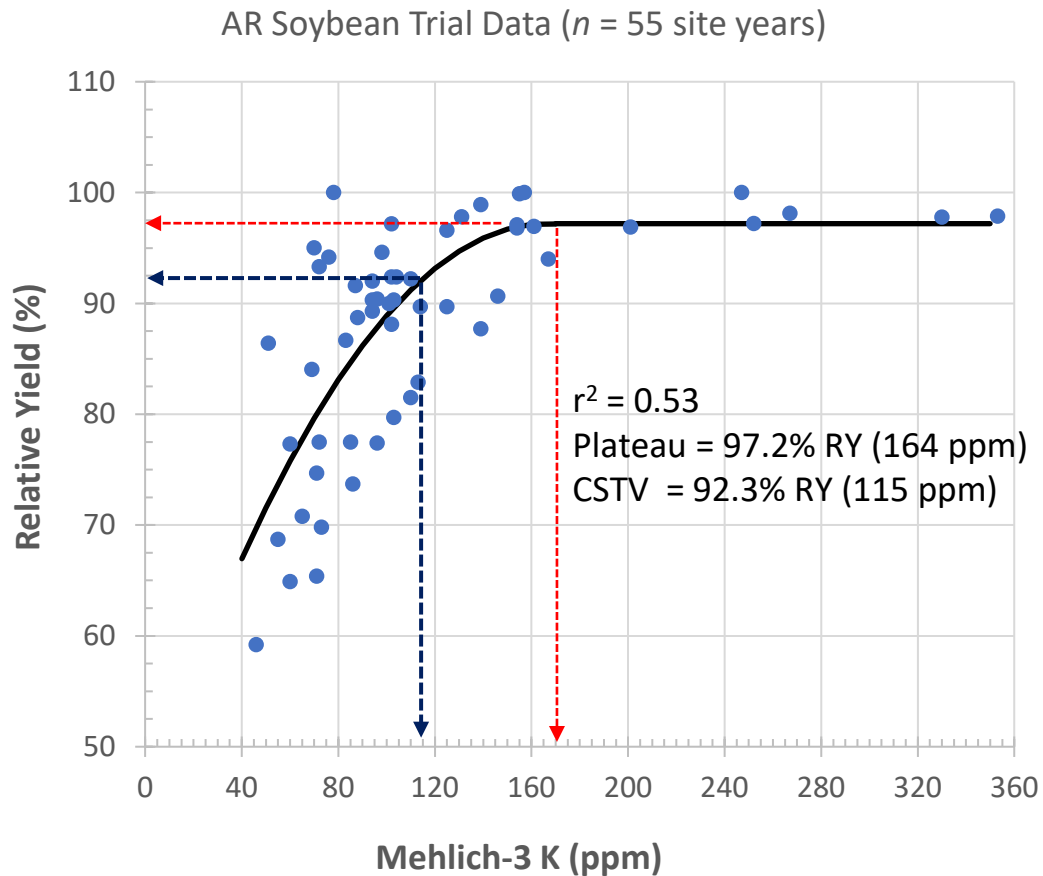


Mehlich-3 K, Irrigated Corn Data (6-inch depth, Arkansas with Iowa data)

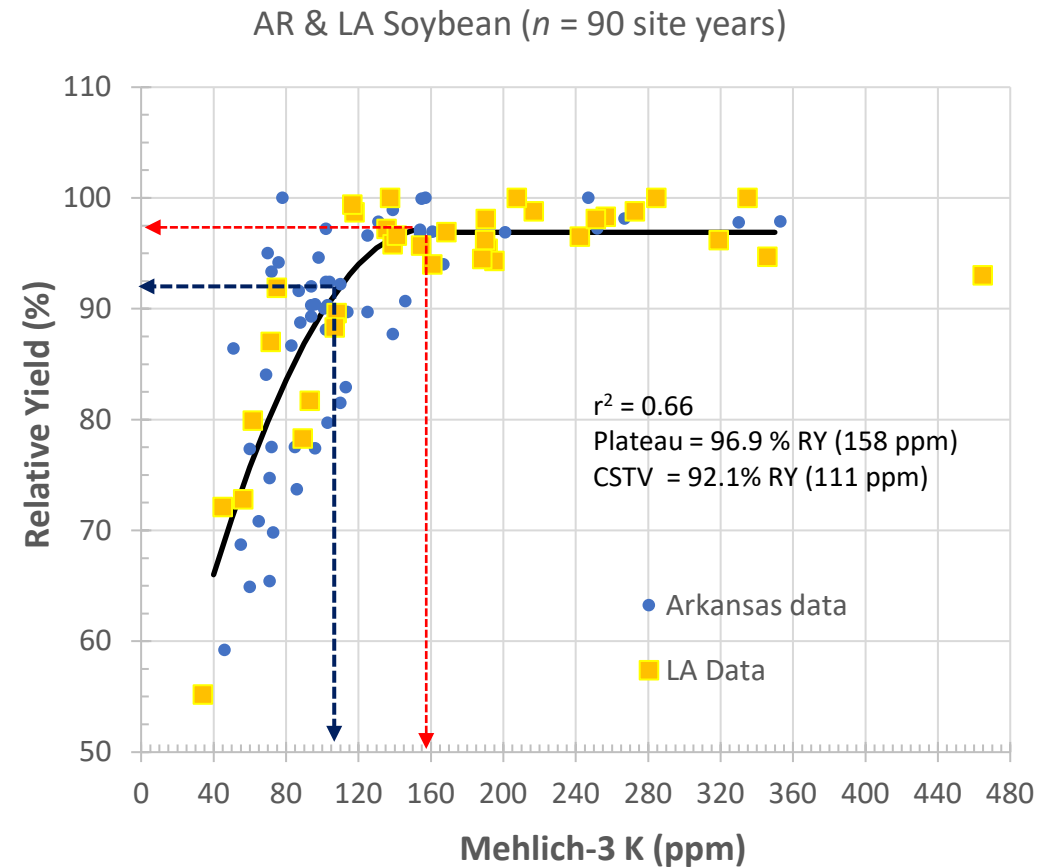
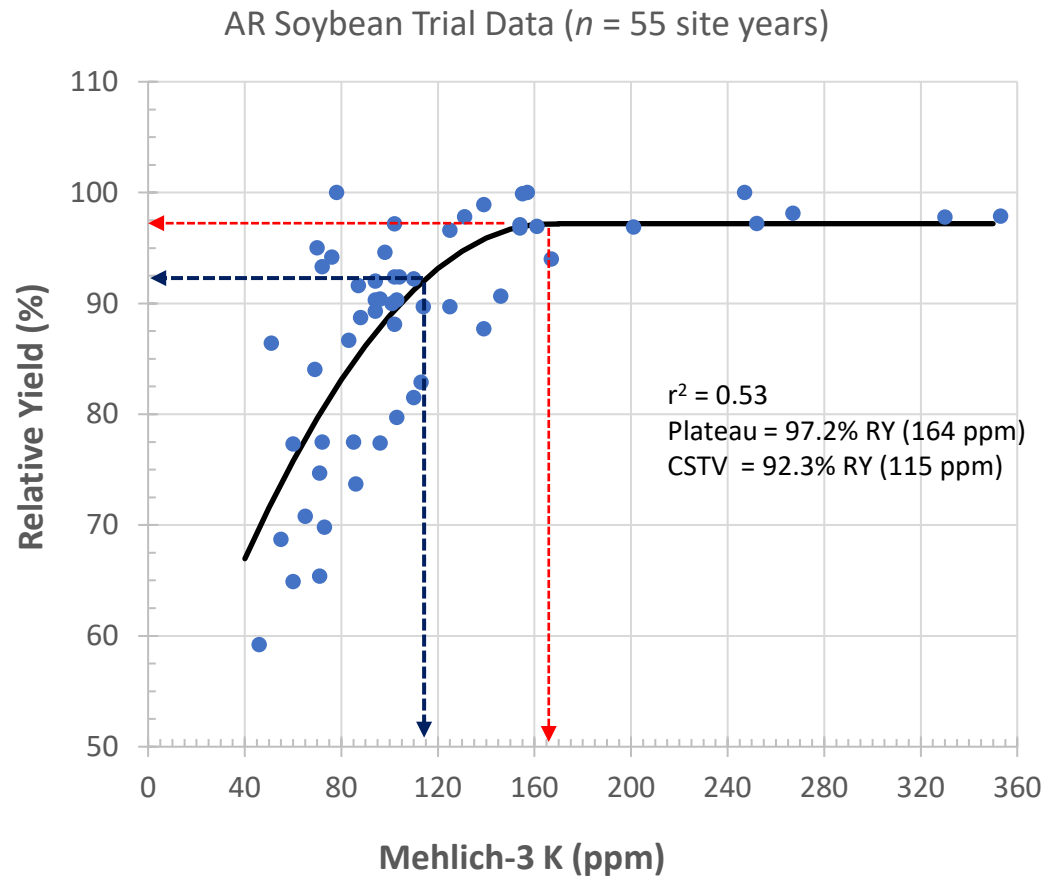


- Corn data, Mehlich-3 K
 - $n = 66$
 - Plateau = 93.2% RY & 111 ppm
 - 95% CI = 82-141 ppm
 - 95% of Max CSTV = 85 ppm
 - $r^2 = 0.40$
 - Arkansas data from *Drescher et al. (4 site years, 2022) & Crop Forage & Turfgrass Mgmt, 2021;7:e20120)*
 - [wileyonlinelibrary.com/journal/cft2](https://doi.org/10.1002/cft2.20120)
<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)



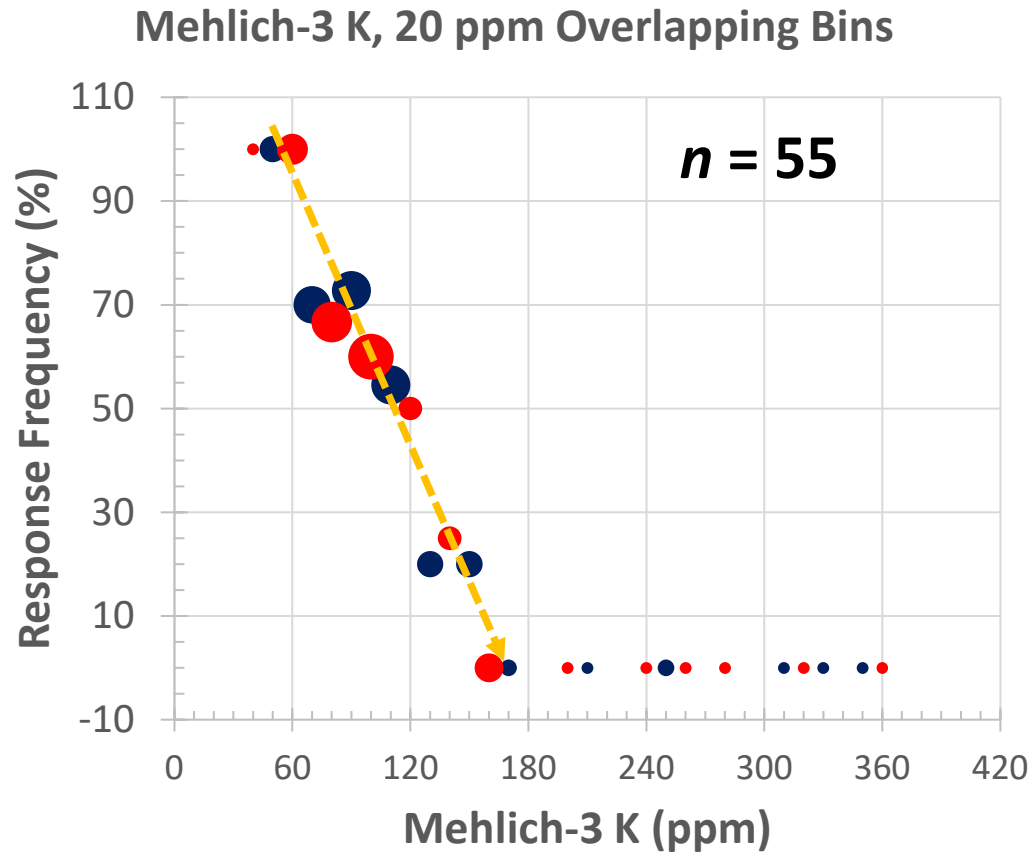
Representations of Mehlich-3 K Correlation Data for Soybean (Arkansas vs Ark+LA data)



0-to 4-inch sample depth

Louisiana data provided by Dr. Rasel Parvej, LSU AgCenter

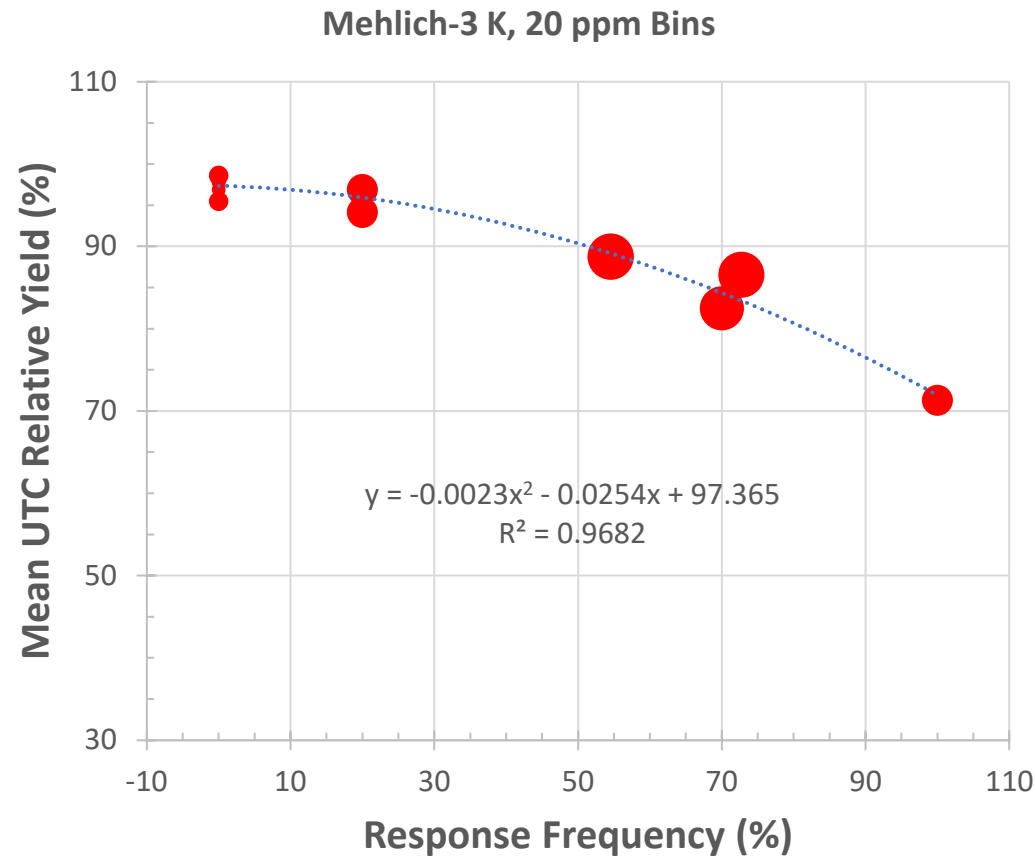
Mehlich-3 K for Soybean Overlapping 20 ppm Bins



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

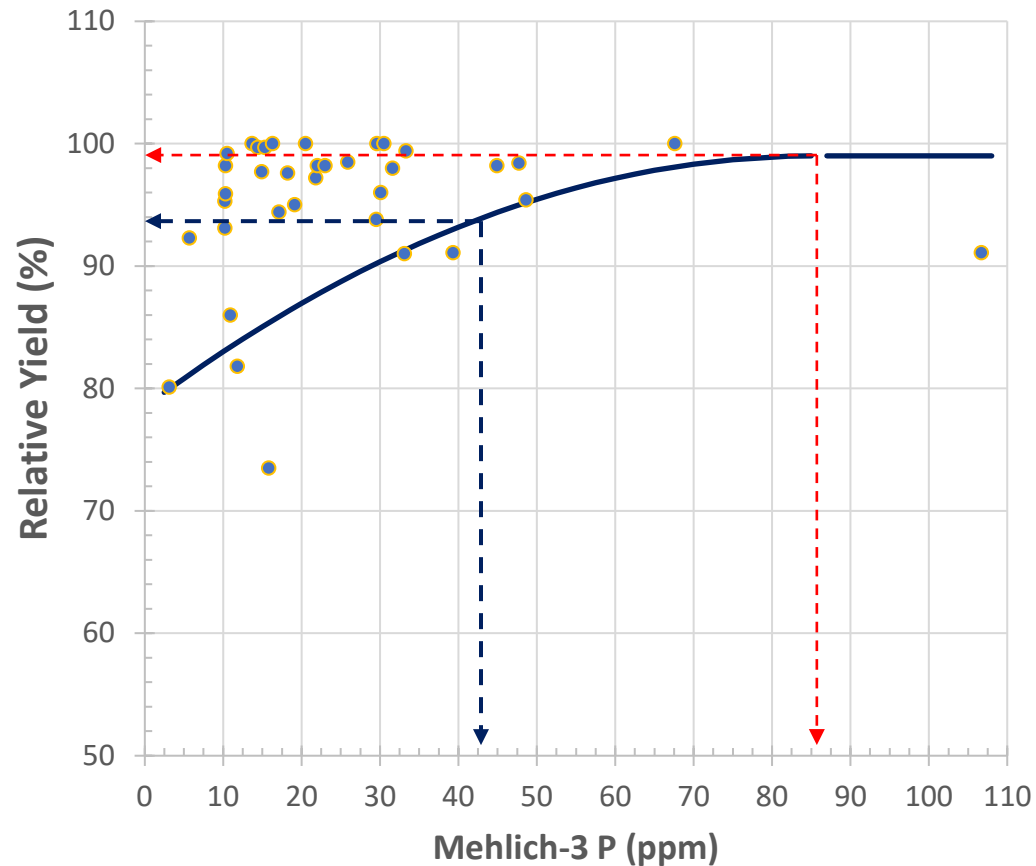
Relative Yield vs Response Frequency

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

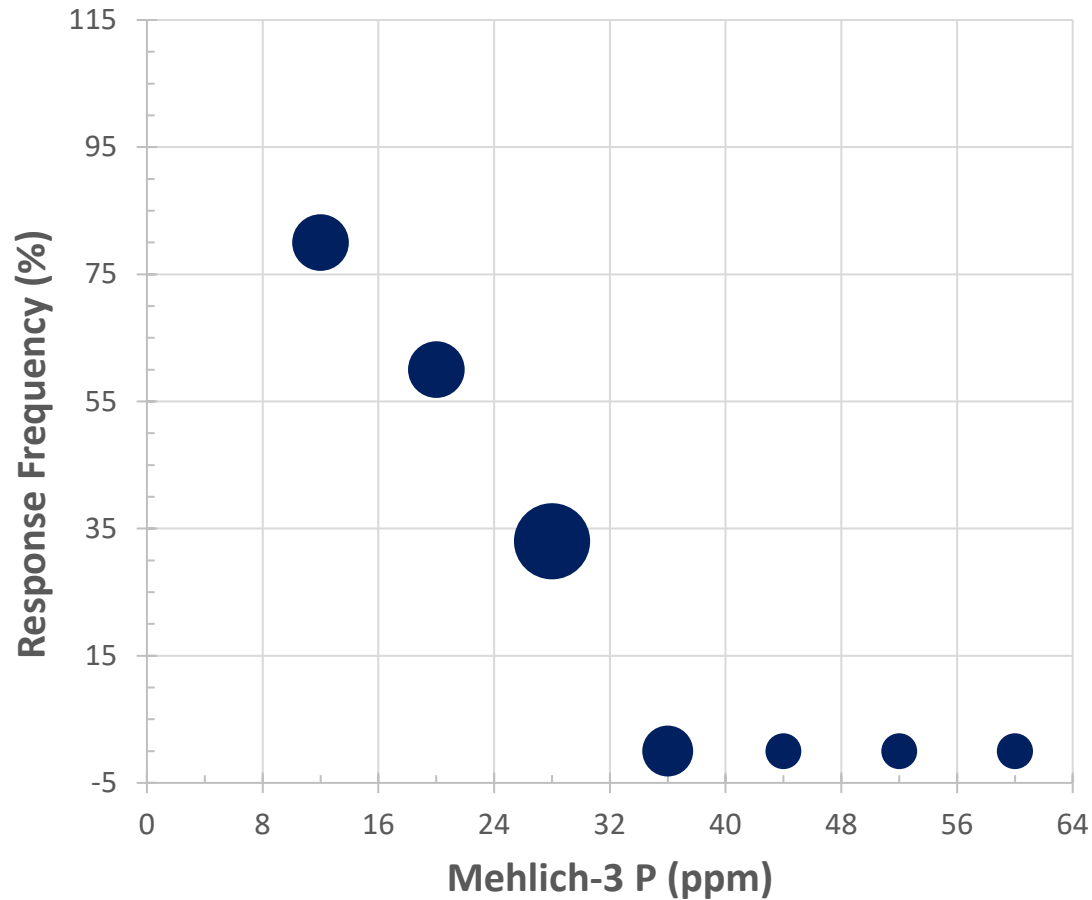
Mehlich-3 P, Irrigated Corn Data (Arkansas, 6-inch depth)



• Corn data, Mehlich-3 P

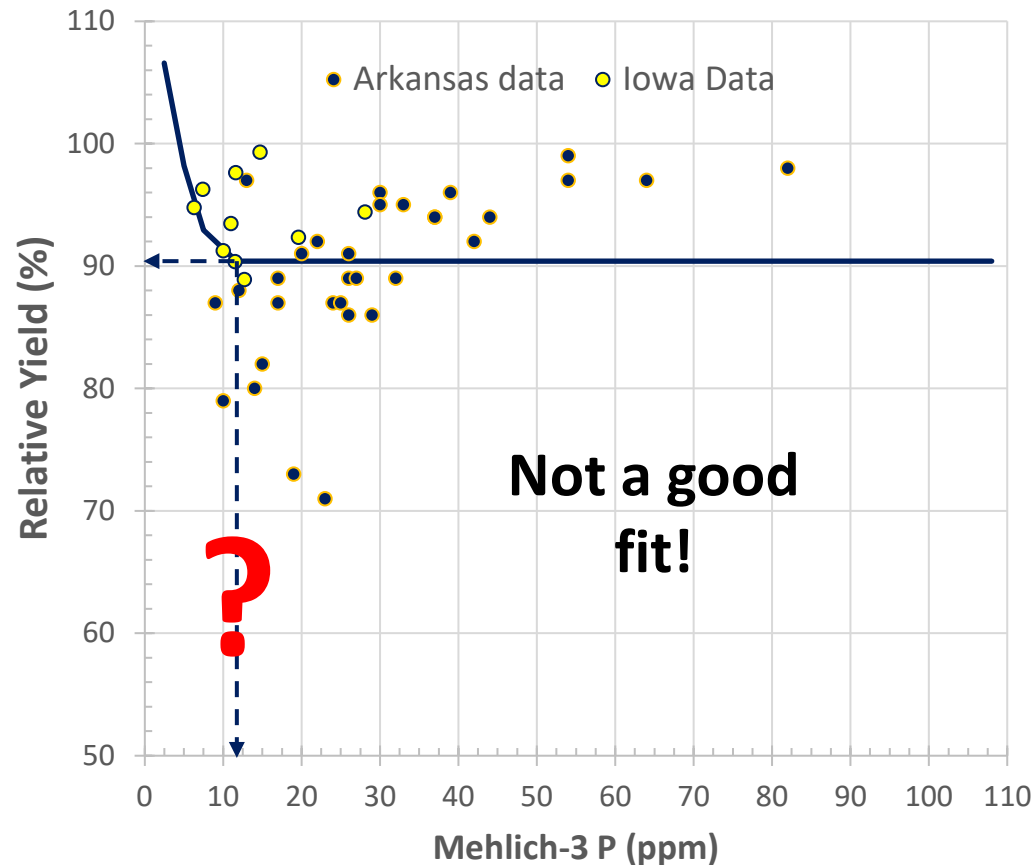
- $n = 33$
- CSTV = 43 ppm
- $r^2 = 0.39$
- Arkansas Data from *Crop Forage & Turfgrass Mgmt.* 2021;7:e20120
 - [wileyonlinelibrary.com/journal/cft2](https://doi.org/10.1002/cft2)
<https://doi.org/10.1002/cft2.20120>

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

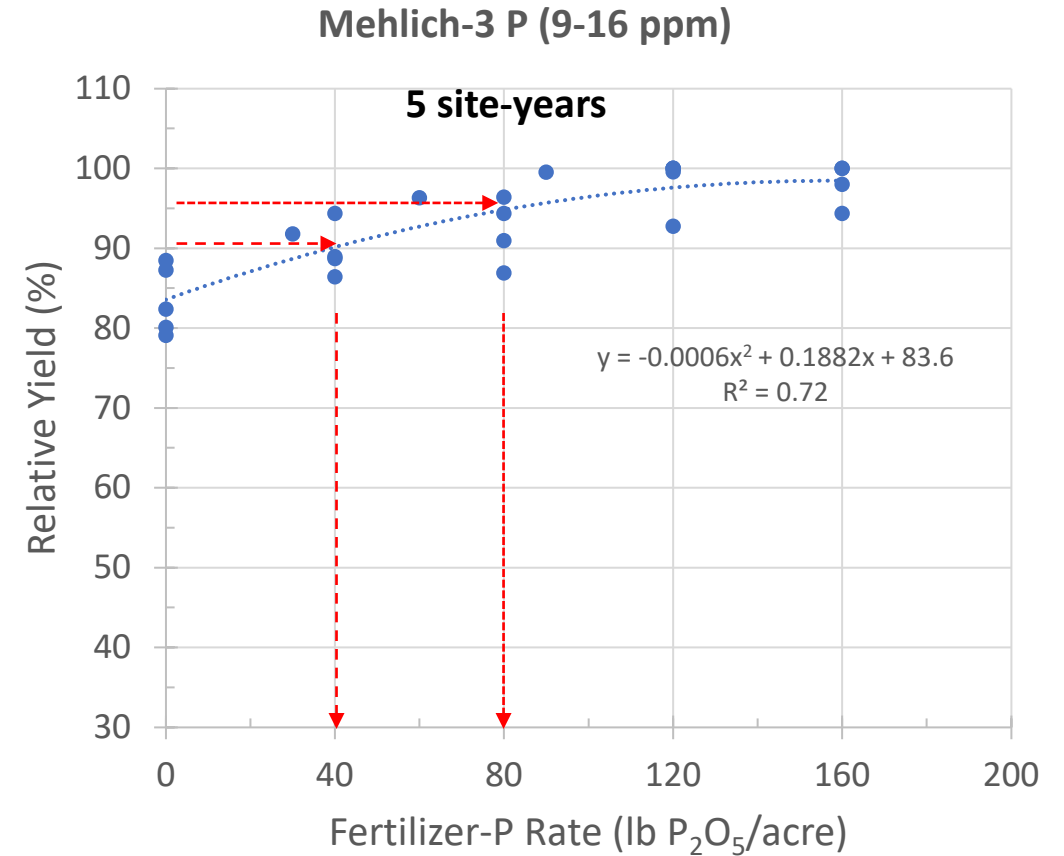
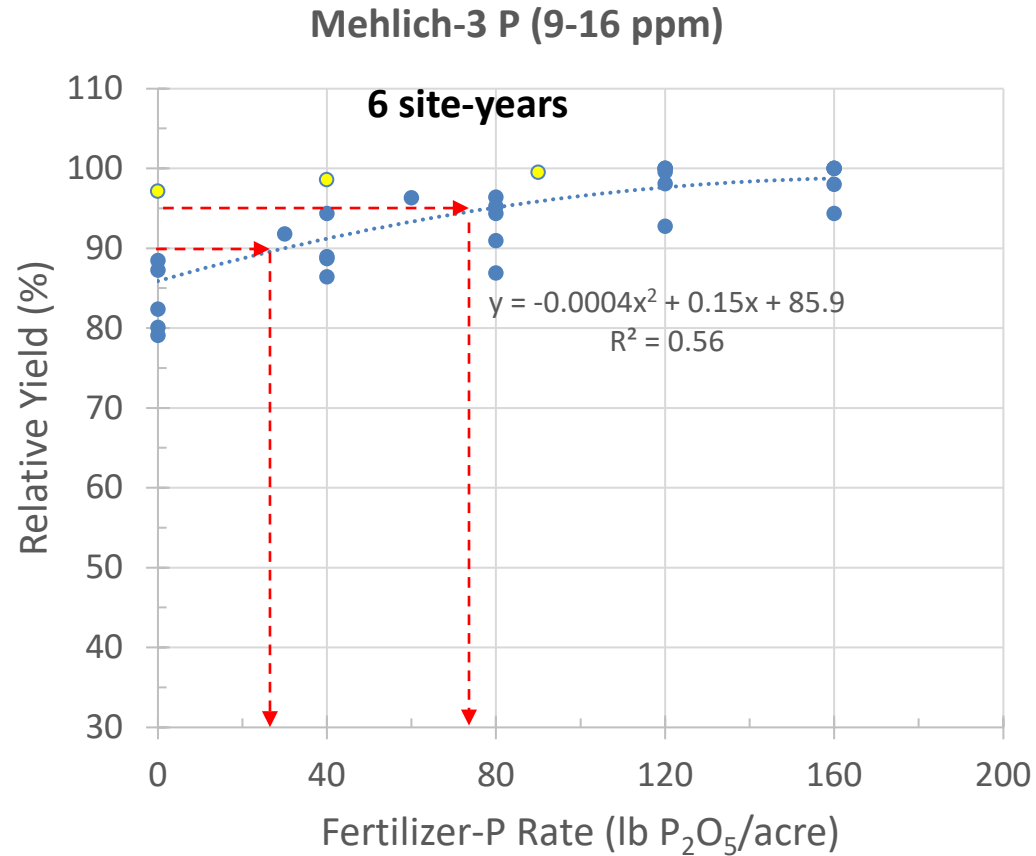
Mehlich-3 P, Irrigated Corn Data (Arkansas + Iowa Data, 6-inch depth)



• Corn data, Mehlich-3 P

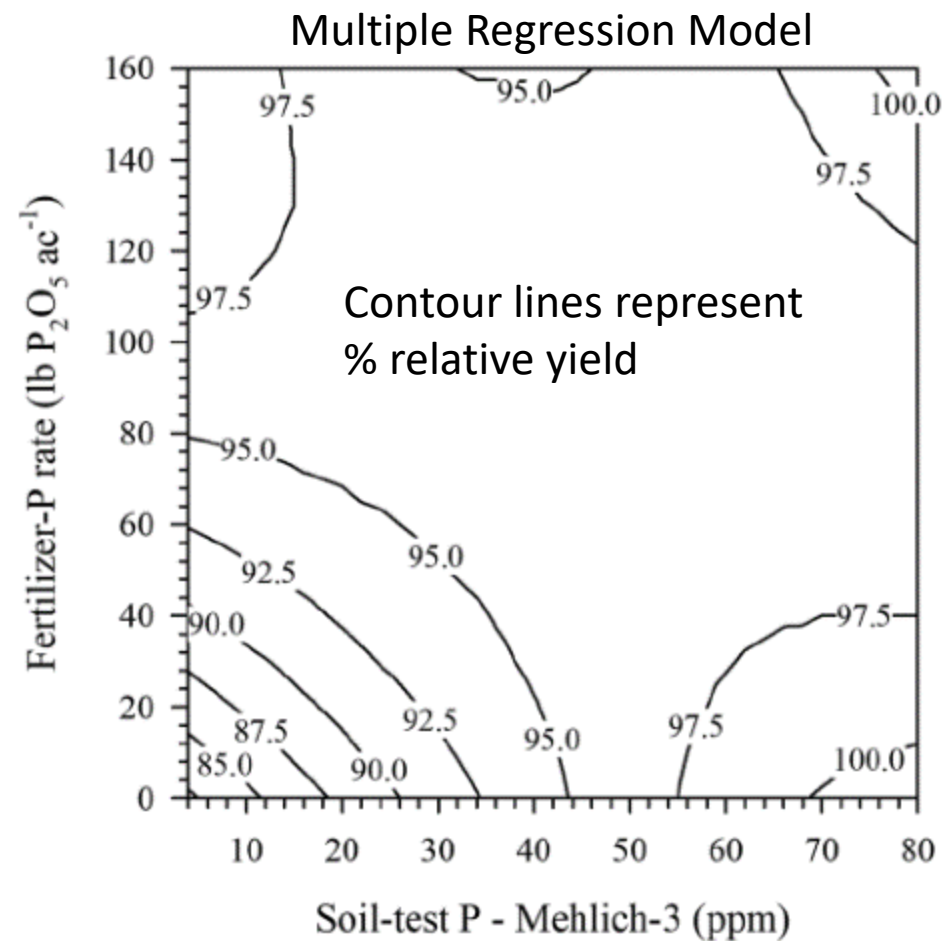
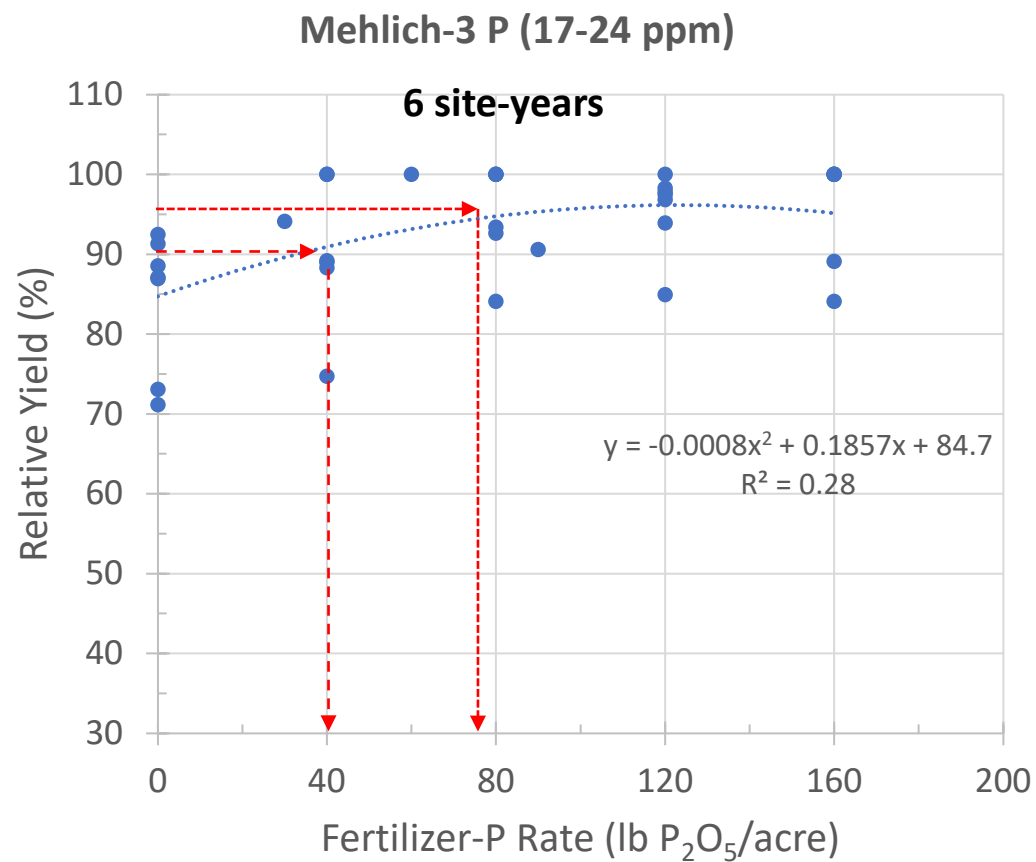
- $n = 42$
- CSTV = ?? ppm
- $r^2 = 0.02$
- Arkansas data from *Crop Forage & Turfgrass Mgmt.* 2021;7:e20120
 - [wileyonlinelibrary.com/journal/cft2](https://doi.org/10.1002/cft2.20120)
<https://doi.org/10.1002/cft2.20120>
- Iowa Data from Mallarino et al. (*Soil Sci. Soc. Am. J.* 73:2143-2150)
 - doi:10.2136/sssaj2008.0383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

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

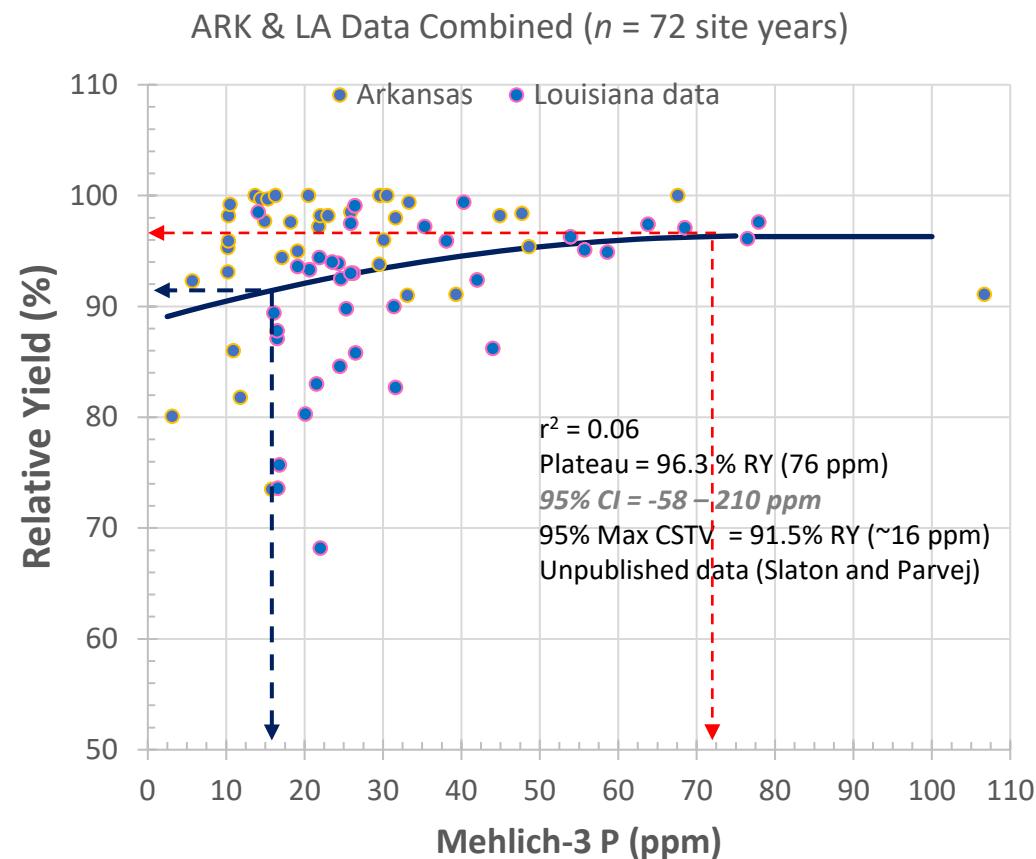
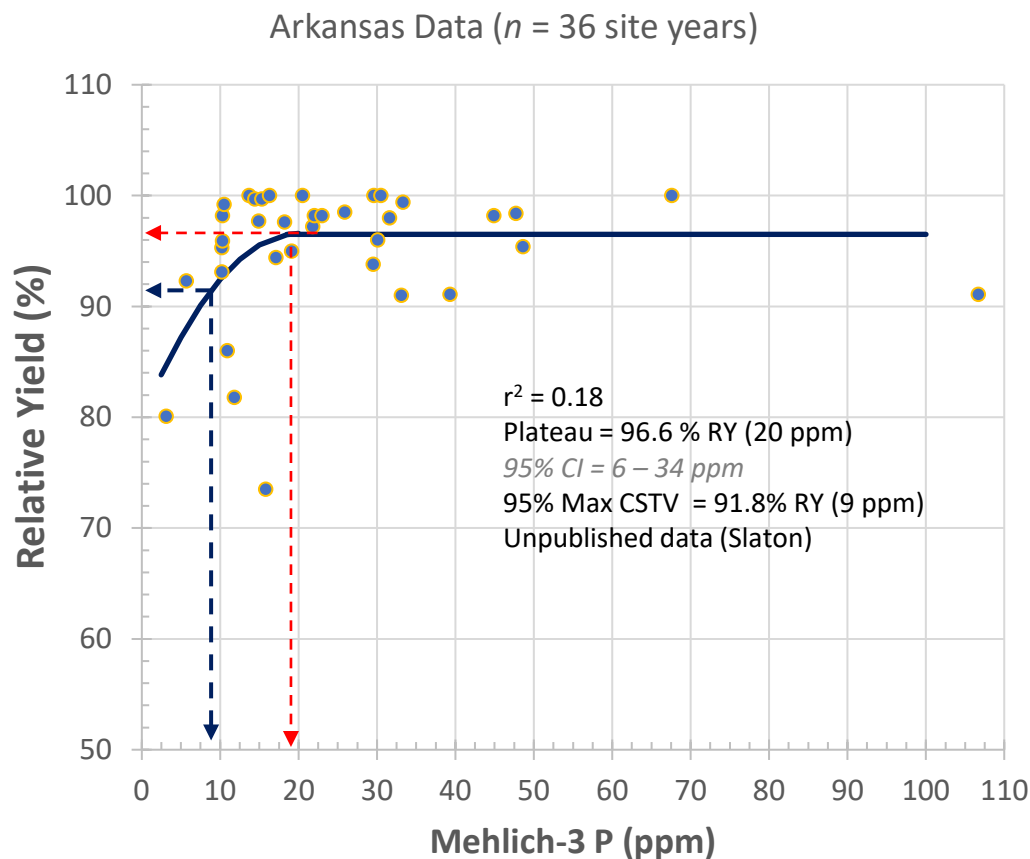


No data site-years with Mehlich-3 P < 9 ppm

Calibration of Fertilizer-P Rate for Corn



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



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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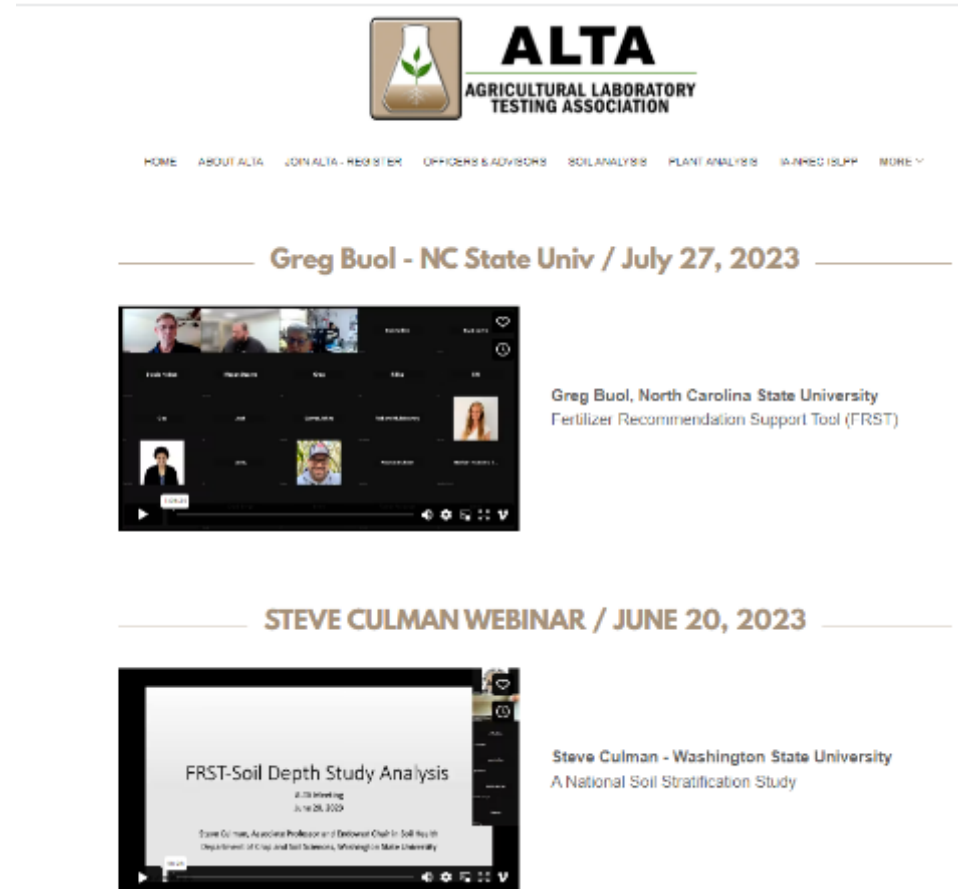
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