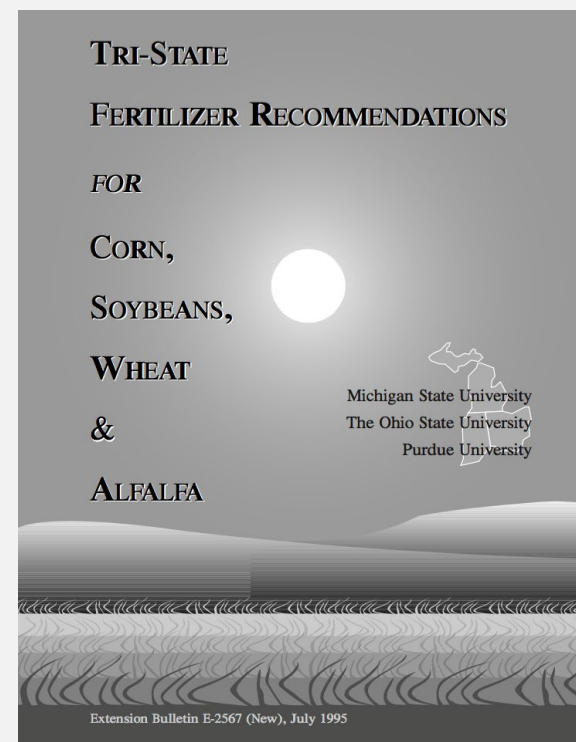


TRI-STATE FERTILIZER UPDATE

Steve Culman (and many, many others)
Ohio State University
School of Environment and Natural Resources
culman.2@osu.edu
soilfertility.osu.edu

Tri-State Recommendations

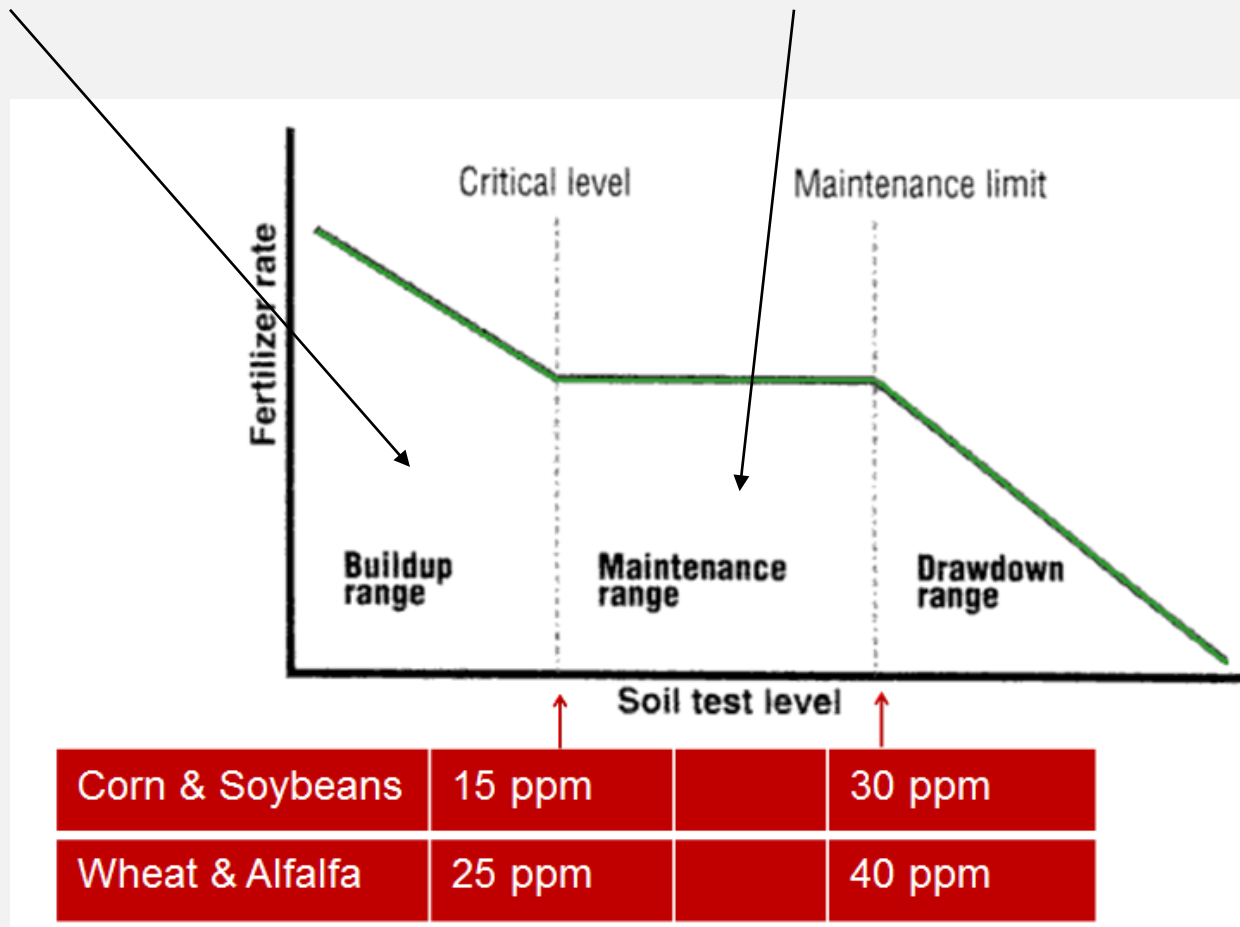
- Originally Published in 1995
- Unified N, P, K recommendations for corn, soybean, wheat and alfalfa across Ohio, Michigan and Indiana
- Served as a cornerstone of fertilizer management in this region



Build-Up and Maintenance

1) Build soils levels up to a maintenance level

2) Fertilize to replace nutrients lost with crop harvest



What's Wrong with the Tri-State Fertilizer Recs?

- Based on soil test extractants rarely used anymore
- Solely use Build-Up and Maintenance Approach
- Based on data from decades ago
- Over-sell the precision of soil testing
- Not transparent about data, trials that went into developing recommendations

Take Home Points

1. From 2014 – 2018, 300+ on-farm strip trials were conducted across Ohio evaluating corn, soybean and wheat response to N, P and K fertilizer.
2. Yield responses to P and K fertilizer in soils at or above the current maintenance range were very rare.
3. Long-term data from 3 sites show that when Ohio soils are in the current maintenance range, they can supply sufficient P and K to meet corn and soybean demand for many growing seasons without fertilization.
4. Recommended corn N rates were updated this spring and are based on maximizing farmer profitability, not maximizing yields.
5. Corn, soybean and wheat are yielding more grain with less nutrient: Grain nutrient removal per bushel of grain is lower than it was 20 years ago.

1. From 2014 – 2018, 300+ on-farm strip trials were conducted across Ohio evaluating corn, soybean and wheat response to N, P and K fertilizer.

Overview

- Corn, soybean and wheat on-farm trials
- N, P, K, S
- Many sites over diversity of soil types and regions in Ohio
- Worked directly with growers, crop consultants, educators, agronomists
- Let farmers choose source, rate, timing, placement

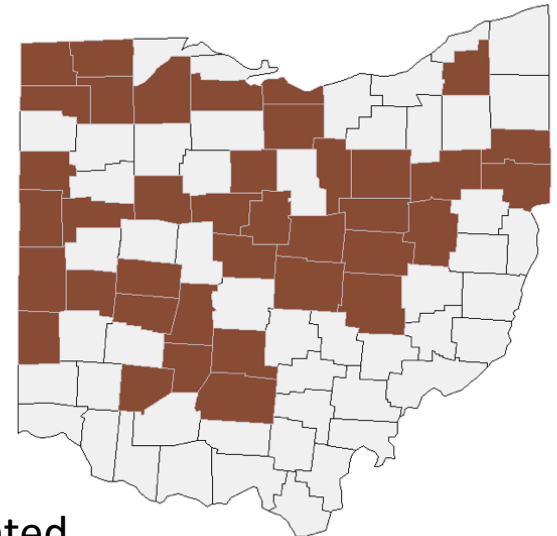


Each trial measured:

- Soil sampling (0-8")
- Leaf tissue (R1)
- Grain sample and yield
- Management survey

Trials in Ohio

Nutrient	Soybean	Corn	Wheat	Total
Nitrogen	--	60	8	68
Phosphorus	50	54	17	121
Potassium	50	40	17	107
Sulfur	15	18	10	43



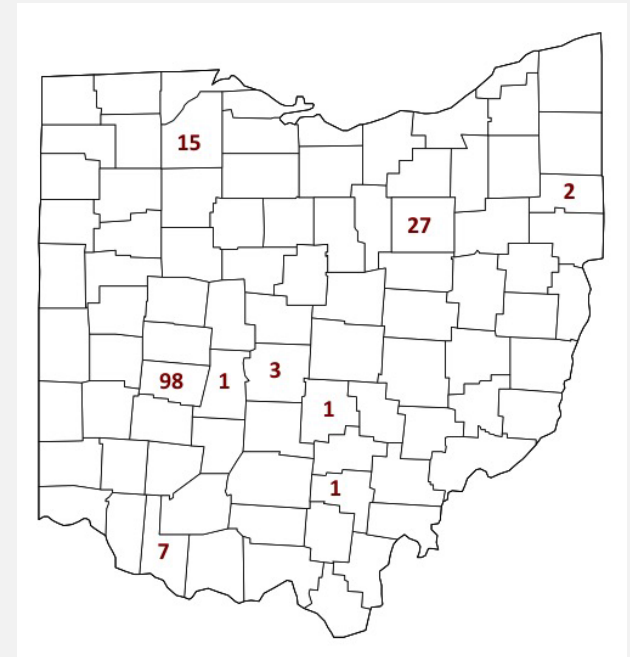
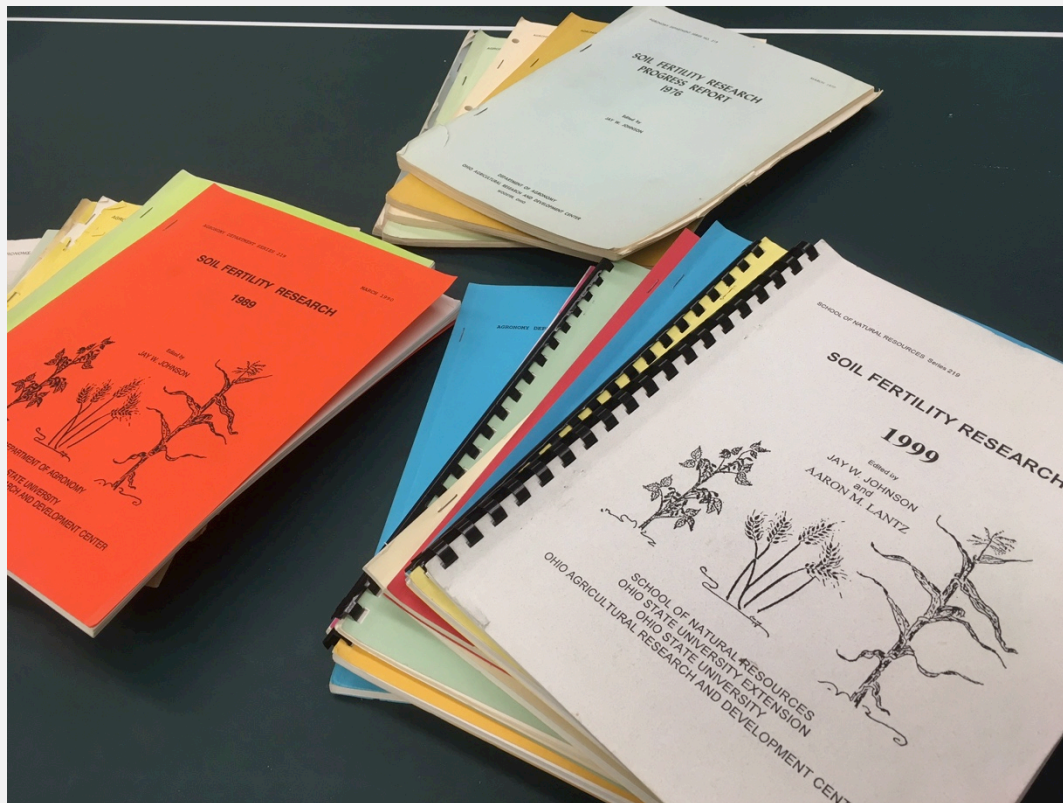
39 of 88 counties represented

2. Yield responses to P and K fertilizer in soils at or above the current maintenance range were very rare.

Original Ohio Tri-State Data

Annual Soil Fertility Reports: 1976 – 1999

- 68 P trials (site-years) conducted
- 92 K trials conducted



9 sites total



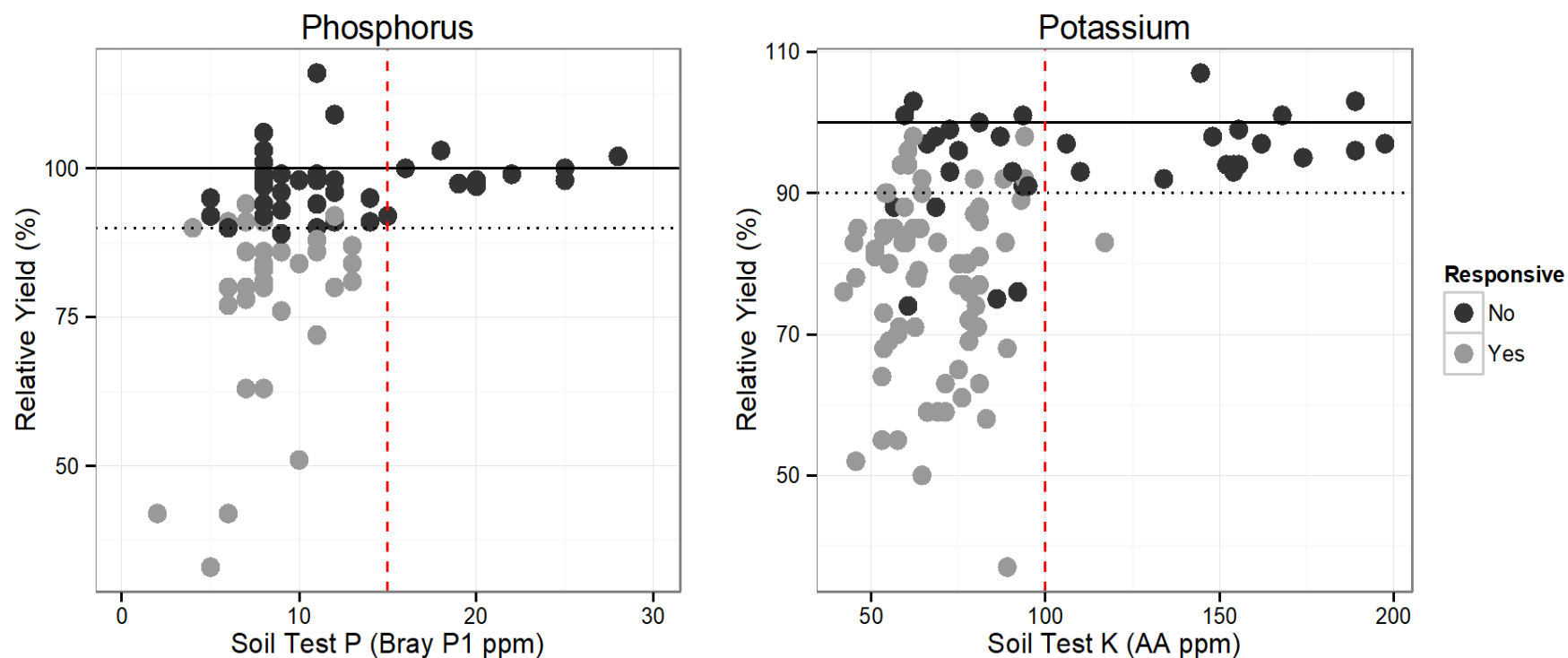
$$\text{Relative Yield} = \frac{\text{Unfertilized}}{\text{Fertilized}} \times 100$$

$$\text{Relative Yield} = \frac{45 \text{ bu/acre}}{50 \text{ bu/acre}} \times 100 = 90\%$$

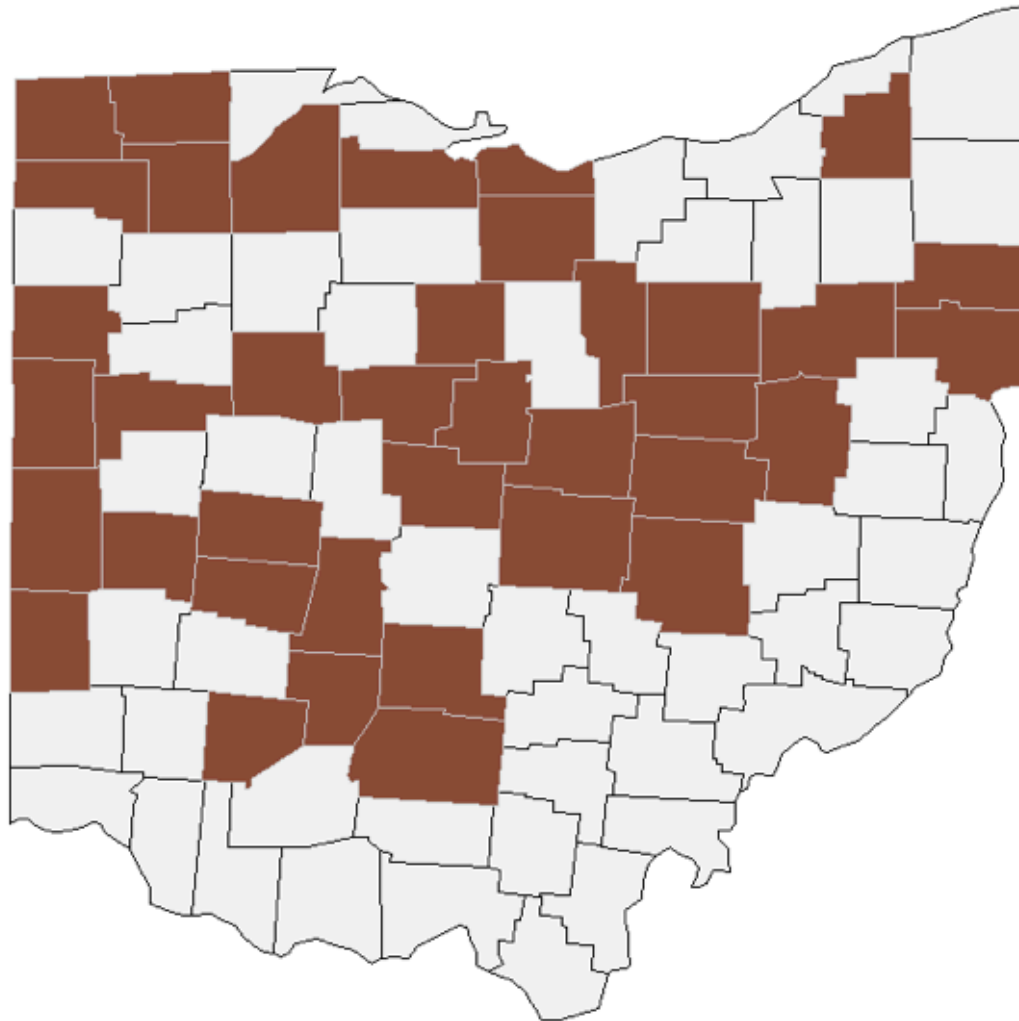
(10% reduction)

Original Ohio Tri-State Data (1976-1993)

(Corn, Soybean and Wheat)



Recent Work (2014-2018)

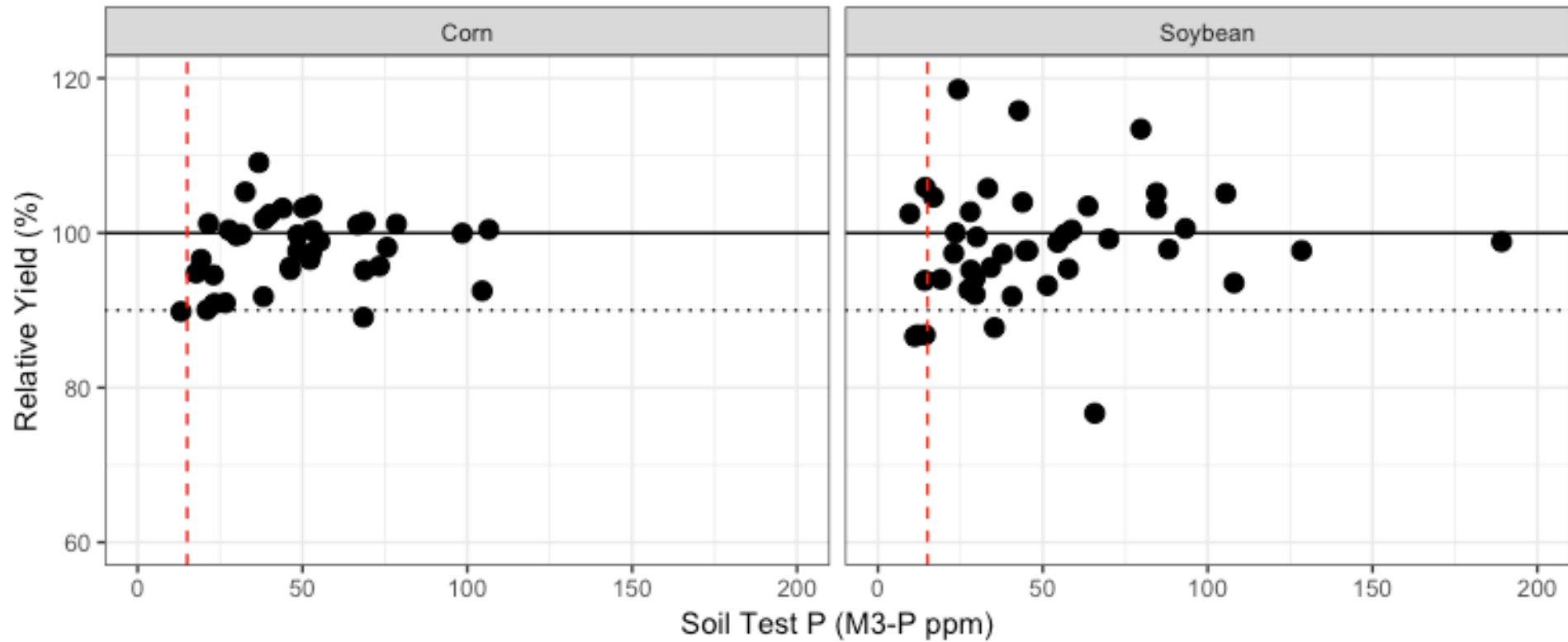


Soil Test P & K Distributions Across Trials

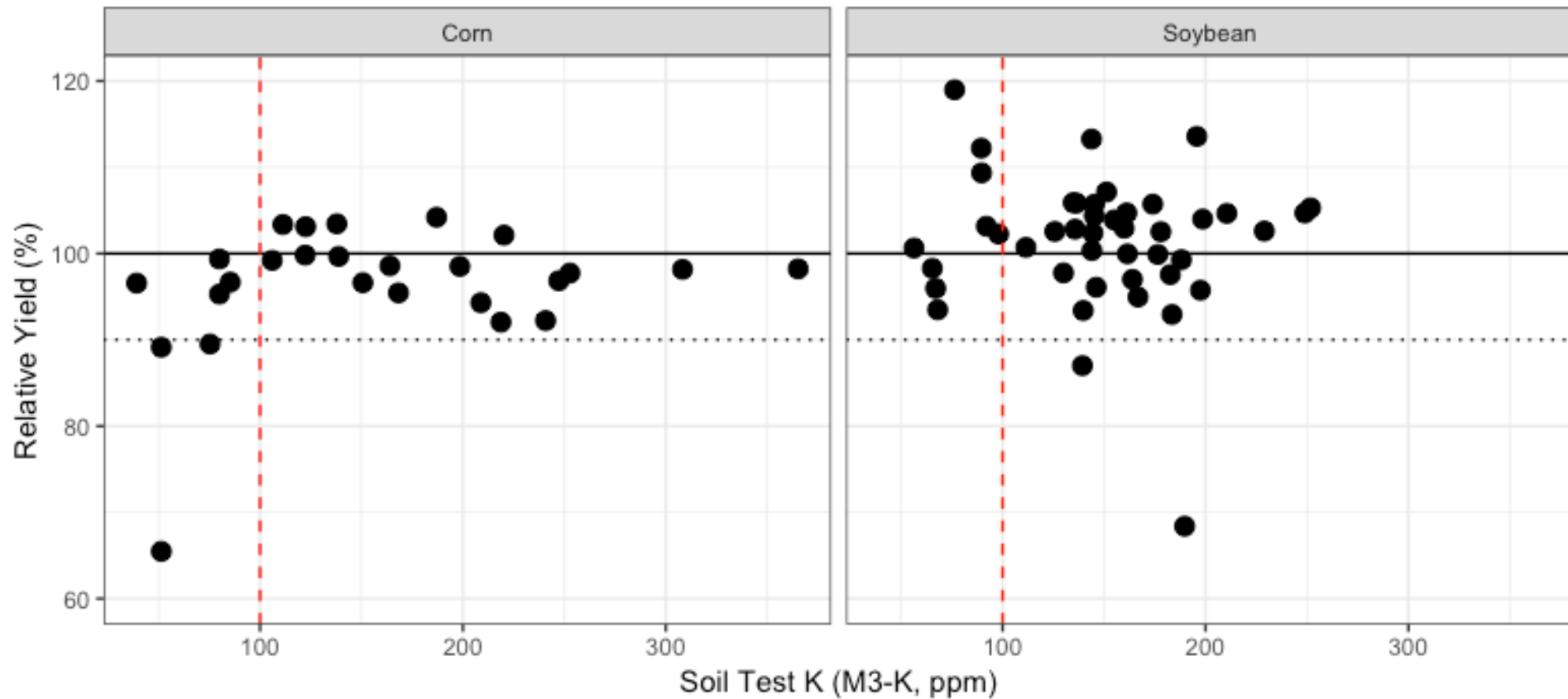
	pH	CEC ($\text{cmol}_c \text{ kg}^{-1}$)	OM (%)	Mehlich 3 P (ppm)	Mehlich 3 K (ppm)
Average	6.4	11.3	2.3	57	161
Range	(4.9-7.4)	(1.0-25.6)	(0.4-6.1)	(8-299)	(34-421)

- Phosphorus
 - 12% of samples below critical level
 - 55% above maintenance limit
- Potassium
 - 15% of samples below critical level
 - 53% above maintenance limit

Soil Test Phosphorus



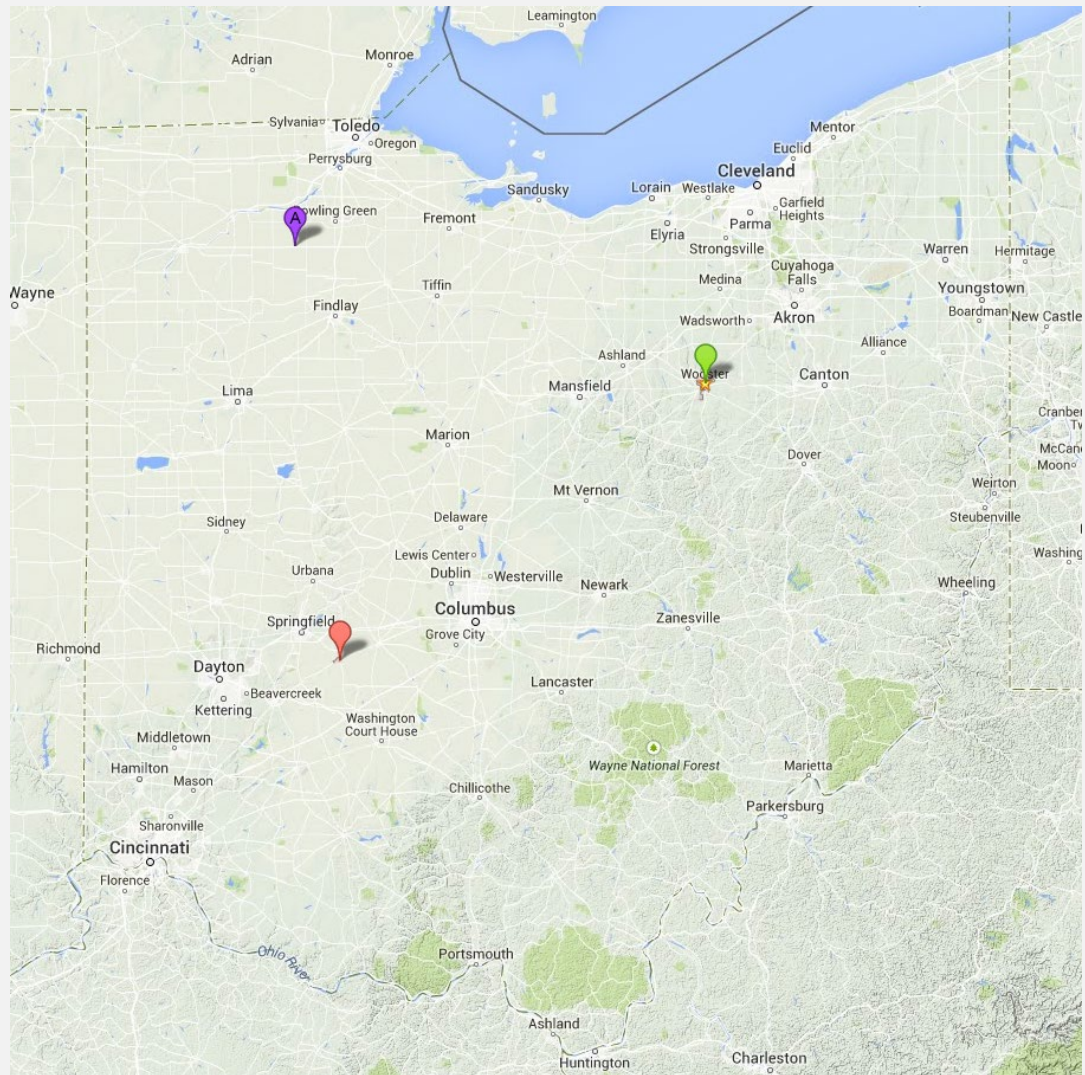
Soil Test Potassium



3. Long-term data from 3 sites show that when Ohio soils are in the current maintenance range, they can supply sufficient P and K to meet corn and soybean demand for many growing seasons without fertilization.

Long-term P & K Plots

- Clark County
- Wayne County
- Wood County
- Started in 2005
 - P & K Fertilization
 - 3 rates (0, 1x, 2x)
 - Corn and soybean



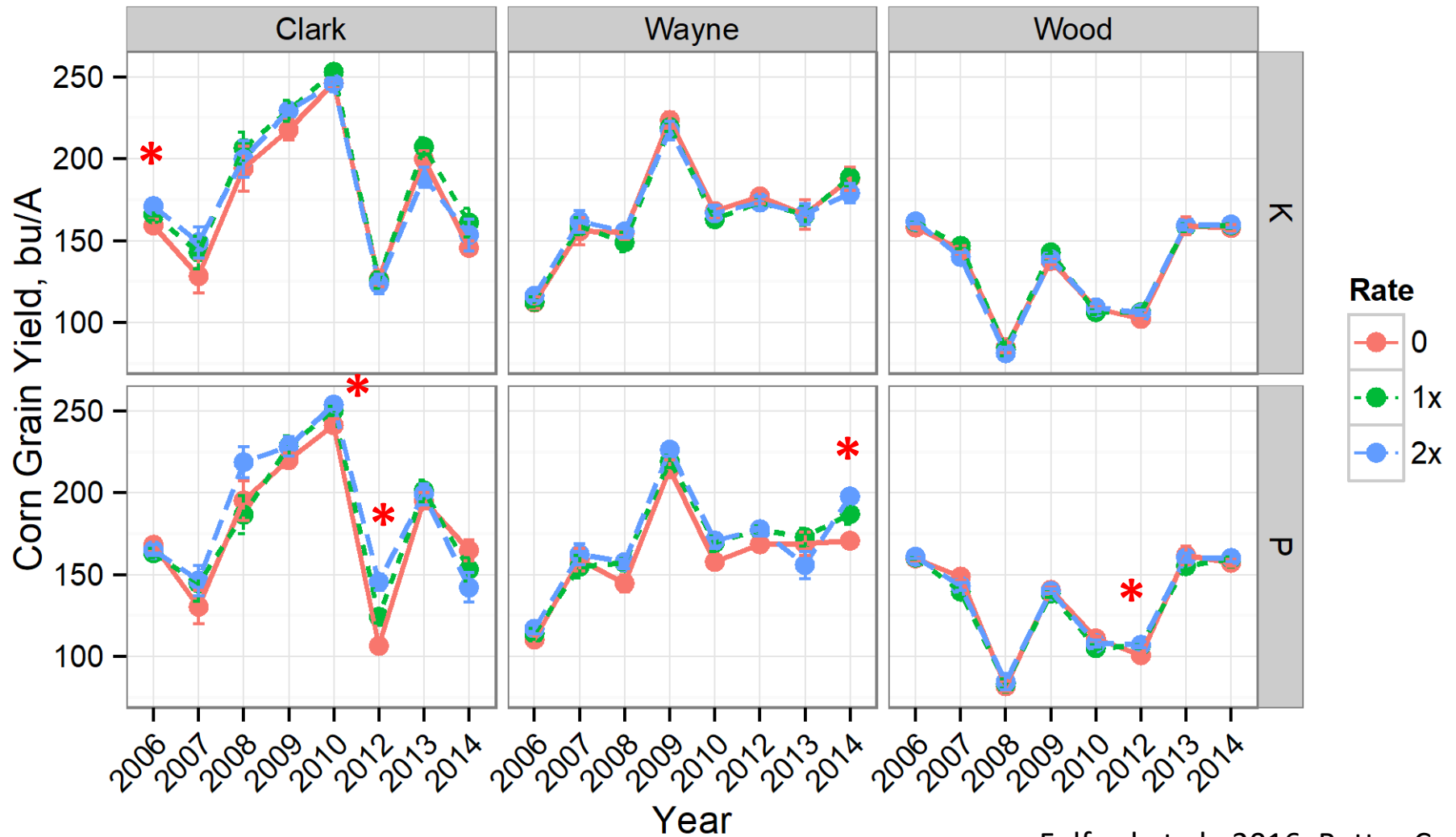
Baseline Soil Data

Soil Property	Clark	Wayne	Wood
pH	6.8	5.9	6.1
CEC (meq/100g)	13	11	22
OM (%)	1.7	1.5	2.9
Bray P (ppm)	29	28	22
K (ppm)	113	113	198

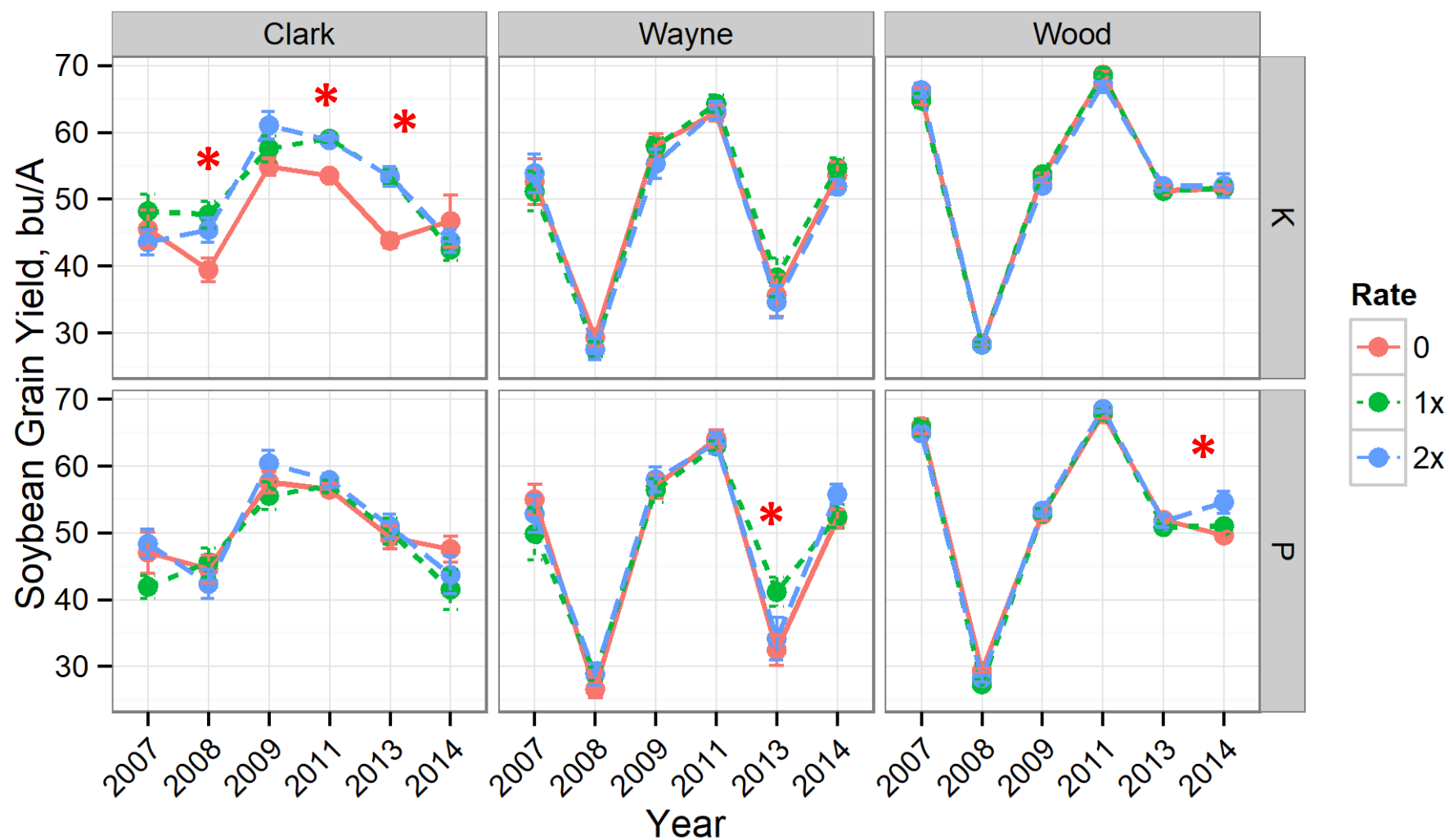
Tri-State Rec Corn and Soybean Maintenance Range

- Phosphorous: 15-30 ppm Bray P
- Potassium: 100-155 ppm AA

Corn Grain Yield



Soybean Grain Yield



Long Term P & K Trial Findings

- Fertilization increased grain yields in 9 out of 42 comparisons
 - 9 yrs
 - Soil test P and K started in maintenance range
 - No indication that recommendations are too low
- Soil test levels fertilized at 2x removal rate failed to build substantially

4. Recommended corn N rates were updated this spring and are based on maximizing farmer profitability, not maximizing yields.

CORN NITROGEN RATE CALCULATOR

Finding the Maximum Return To N and Most Profitable N Rate
A Regional (Corn Belt) Approach to Nitrogen Rate Guidelines

This web site provides a process to calculate economic return to N application with different nitrogen and corn prices and to find profitable N rates directly from recent N rate research data. The method used follows a regional approach for determining corn N rate guidelines that is implemented in several Corn Belt states.

START HERE

Choose how you want to calculate N rates, using one set of prices or using multiple prices.

SINGLE PRICE

MULTIPLE PRICE

In association with these Universities

IOWA STATE
UNIVERSITY
Extension and Outreach

PURDUE
UNIVERSITY

UNIVERSITY OF MINNESOTA
EXTENSION

MICHIGAN STATE
UNIVERSITY
EXTENSION

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

WISCONSIN
UNIVERSITY OF WISCONSIN - MADISON

THE OHIO STATE
UNIVERSITY

go.osu.edu/corn-n-rate

SINGLE PRICE

MULTIPLE PRICE

V 1.8

Select State

Ohio

Select Rotation

Corn following soybean

Set Corn and Nitrogen Prices

Anhydrous Ammonia (82% N)

820

...

(\$/Ton)

Nitrogen Price

0.40

(\$/lb N)

Corn Price

4.00

(\$/bu)

CALCULATE

RESET

Crop Rotation

Corn price

Nitrogen source
and cost

State

Rates and Charts

State: Ohio

Number of sites: 228

Rotation: Corn Following Soybean

Nitrogen Price (\$/lb): 0.40

Corn Price (\$/bu): 4.00

Price Ratio: 0.10

MRTN Rate (lb N/acre): 180

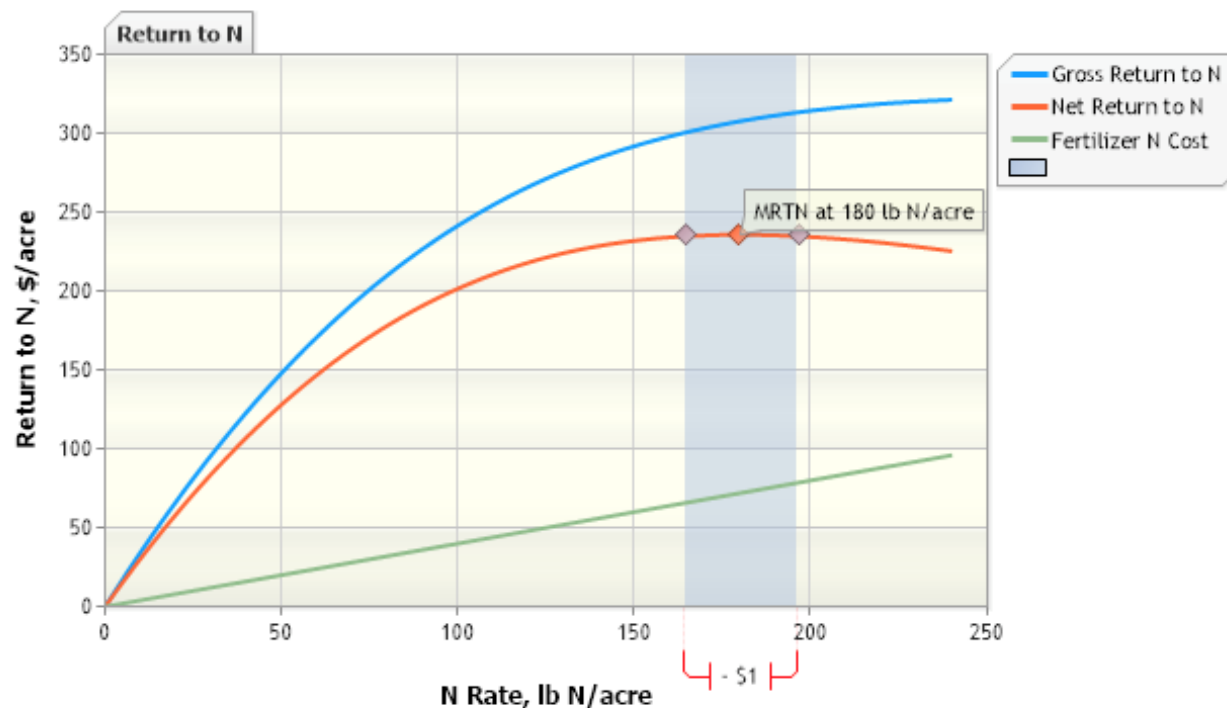
Profitable N Rate Range (lb N/acre): 164 - 196

Net Return to N at MRTN Rate (\$/acre): \$235.72

Percent of Maximum Yield at MRTN Rate: 98%

Anhydrous Ammonia (82% N) at MRTN Rate (lb product/acre): 219

Anhydrous Ammonia (82% N) Cost at MRTN Rate (\$/acre): \$72.00



Ohio New Corn N Rates

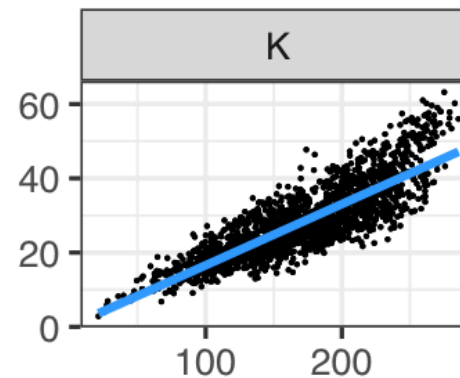
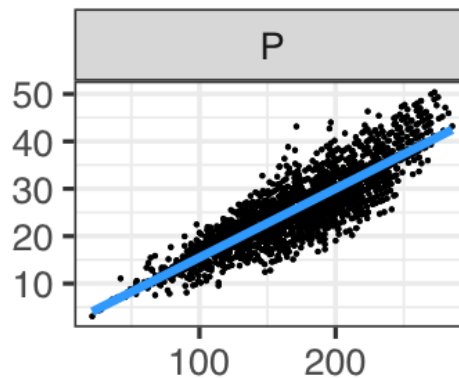
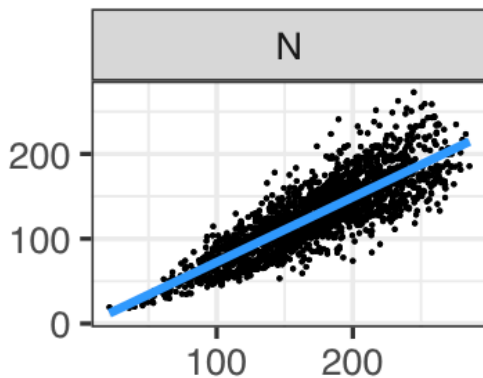
go.osu.edu/corn-n-rate

	Price of Nitrogen Fertilizer (\$/ lb)				
Price/ bushel corn	\$0.30	\$0.35	\$0.40	\$0.45	\$0.50
\$3.25	185	176	168	162	155
\$3.50	187	180	173	166	160
\$3.75	191	184	176	170	164
\$4.00	195	186	180	174	168
\$4.25	199	190	184	177	171
\$4.50	200	193	185	180	175

5. Corn, soybean and wheat are yielding more grain with less nutrient: Grain nutrient removal per bushel of grain is lower than it was 20 years ago.

Grain Nutrient Removal (lb/bu)

Grain Removal (lbs)



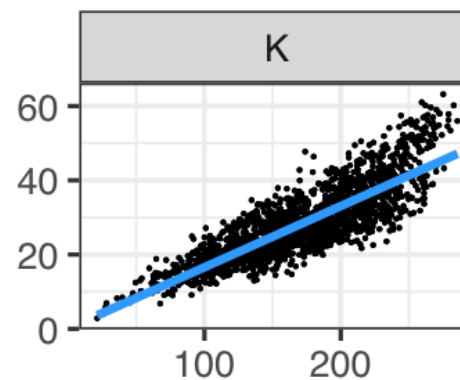
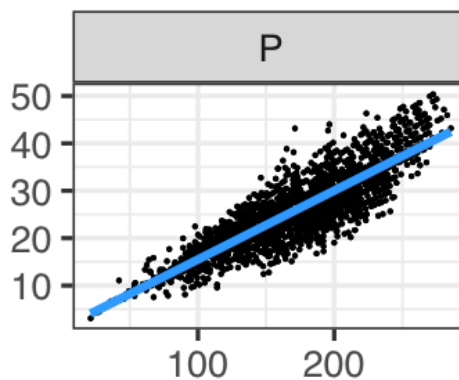
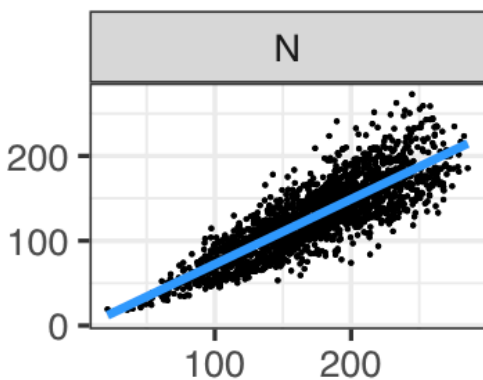
Corn Yield (bushel/ acre)

	Grain nutrient removal rates			Total grain nutrient removed at harvest		
	Corn	Soybean	Wheat	Corn (180 bu)	Soybean (60 bu)	Wheat (80 bu)
	(lb of nutrient/ bushel grain)			(lbs of nutrient/ acre)		
N	0.74	3.55	0.96	134	213	77
P ₂ O ₅	0.35	0.79	0.49	62	47	39
K ₂ O	0.20	1.14	0.24	36	68	19
Ca	0.06	0.22	0.08	11	13	6
Mg	0.05	0.14	0.07	9	8	6
S	0.05	0.18	0.07	9	11	6
B	0.0003	0.0023	0.0003	0.05	0.14	0.03
Cu	0.0001	0.0008	0.0003	0.02	0.05	0.02
Fe	0.0013	0.0054	0.0025	0.24	0.32	0.20
Mn	0.0002	0.0017	0.0022	0.04	0.10	0.18
Zn	0.0010	0.0023	0.0015	0.17	0.14	0.12
Na	0.0003	0.0008	0.0003	0.06	0.05	0.03

Grain Nutrient Removal (lb/bu)

Crop	Nutrient	Tri-State (1995) (lbs/ bushel)	New Data (lbs/ bushel)	Percent Decrease
Corn	P ₂ O ₅	0.37	0.34	8%
	K ₂ O	0.27	0.19	30%
Soybean	P ₂ O ₅	0.80	0.80	0
	K ₂ O	1.40	1.08	23%

Grain Removal (lbs)



Corn Yield (bushel/ acre)

Take Home Points

1. From 2014 – 2018, 300+ on-farm strip trials were conducted across Ohio evaluating corn, soybean and wheat response to N, P and K fertilizer.
2. Yield responses to P and K fertilizer in soils at or above the current maintenance range were very rare.
3. Long-term data from 3 sites show that when Ohio soils are in the current maintenance range, they can supply sufficient P and K to meet corn and soybean demand for many growing seasons without fertilization.
4. Recommended corn N rates were updated this spring and are based on maximizing farmer profitability, not maximizing yields.
5. Corn, soybean and wheat are yielding more grain with less nutrient: Grain nutrient removal per bushel of grain is lower than it was 20 years ago.

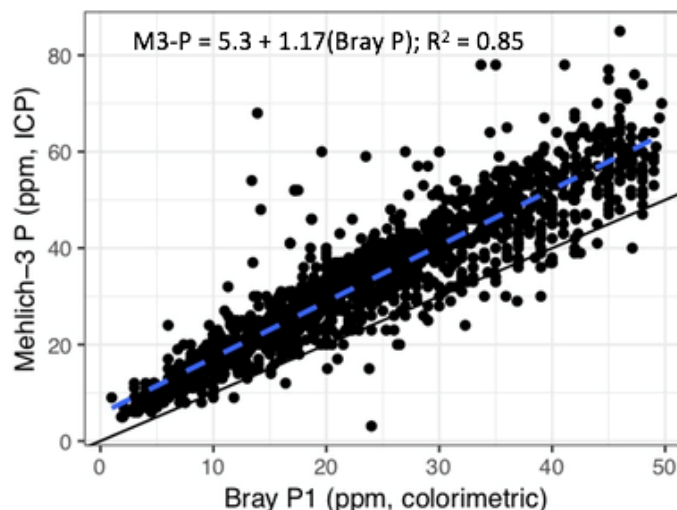
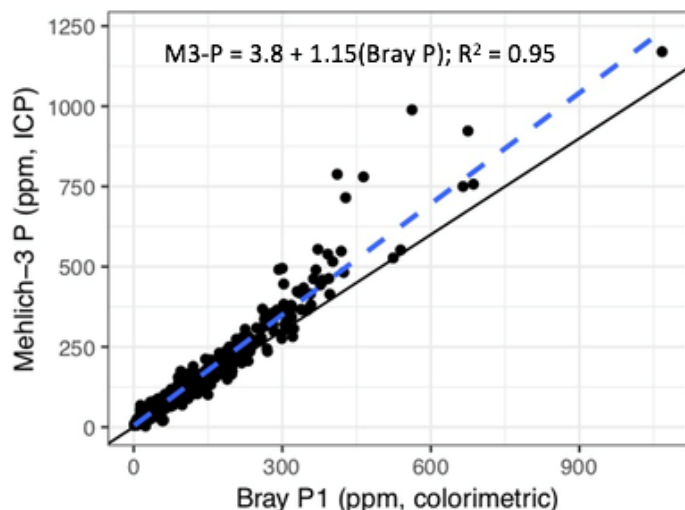
Timeline

- Release in early 2019
- More dynamic, living document, than a static work revisited every 20 years
- Transparency to give growers confidence in the recommendations to make better fertilizer decisions
- Need to develop tools to use this information

Thank You

Steve Culman
Soil Fertility
Ohio State University
Wooster, Ohio
culman.2@osu.edu
330-822-3787
soilfertility.osu.edu

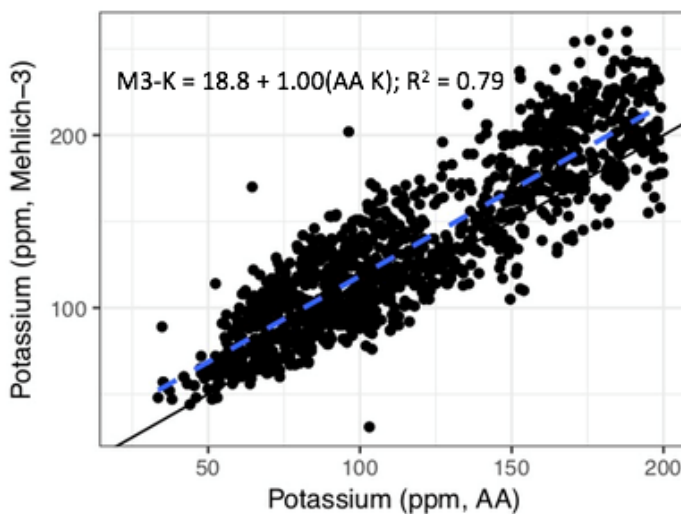
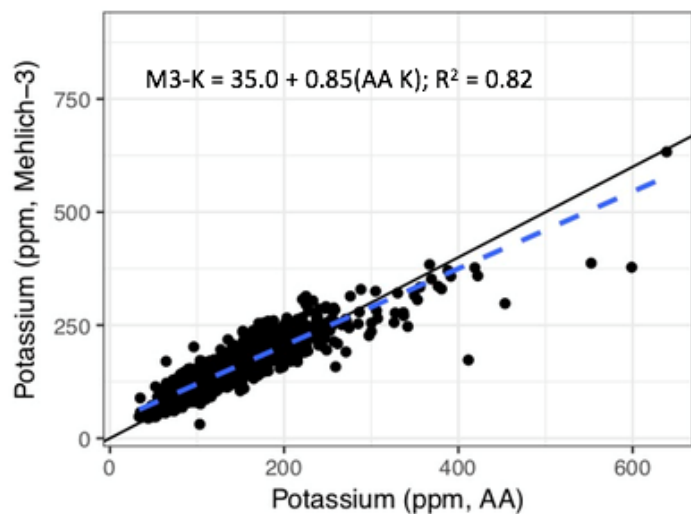
Converting Soil Test Extractants



*Bray P to Mehlich-3 P:
multiply by 1.35*

*Mehlich-3 P to Bray P:
divide by 1.35.*

*This conversion should
not be used above 300
ppm.*



*No conversion is
necessary for Mehlich-3
and ammonium acetate
K, Ca or Mg*

Soil Test Trends

