



Soil pH, Nutrient Management, Soil Health and Some Thoughts on Manure

Peter Tomlinson

Environmental Quality Specialist

Overview

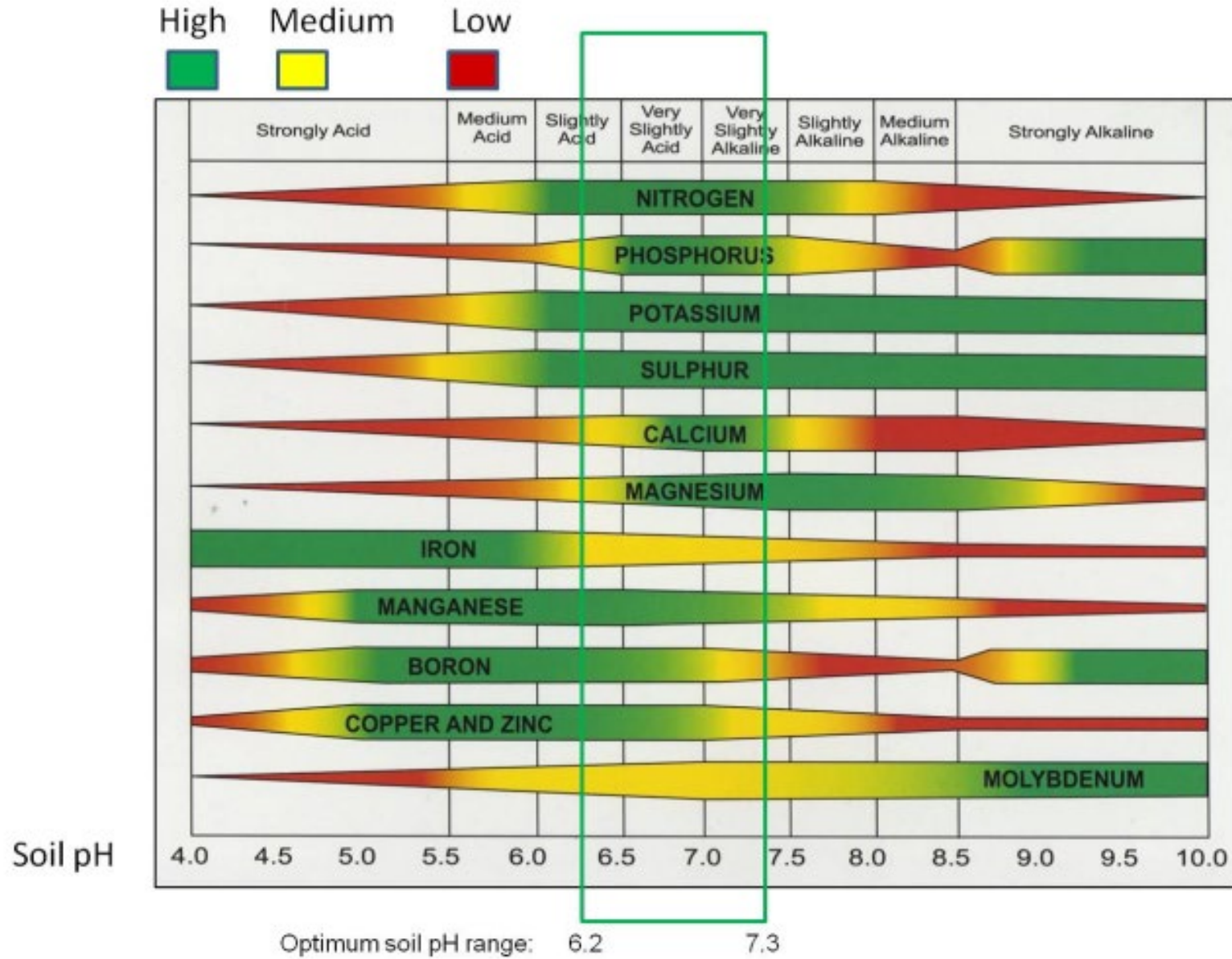
- Soil pH:
 - Fertilizer reactions
 - Nutrient availability
- Manure
 - Phosphorus
 - Nitrogen



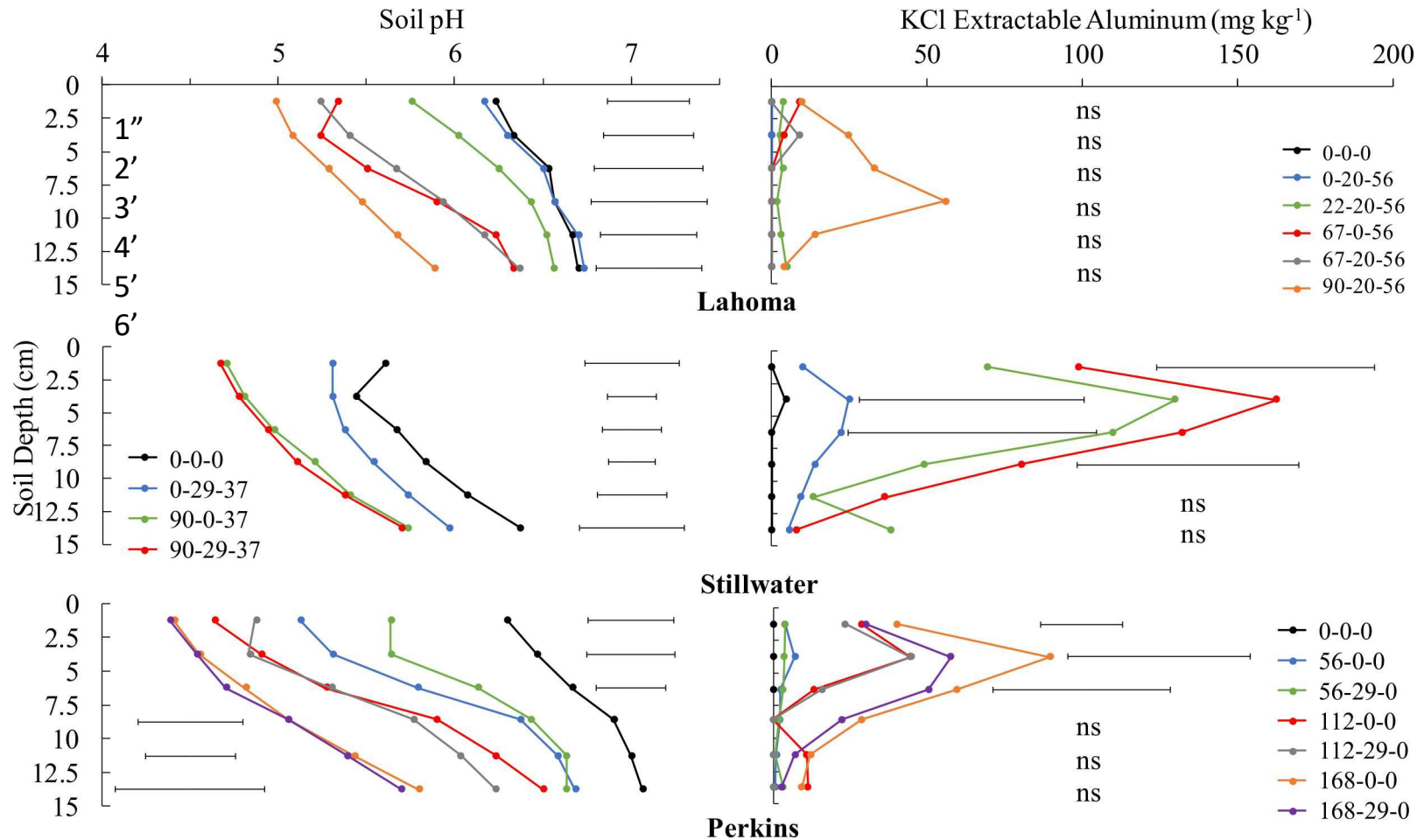
Crop	Soil pH				
	4.7	5	5.7	6.8	7.5
	Relative yield (100 is best; 0 is worst)				
Corn	34	73	83	100	85
Wheat	68	78	89	100	99
Soybeans	65	79	80	100	93
Oats	77	93	99	98	100
Barley	0	23	80	95	100
Alfalfa	2	9	42	100	100
Timothy (grass)	31	47	66	100	95

Methods for Assessing Soil Quality, page 173 (SSSA, 1996).

How soil pH affects availability of plant nutrients

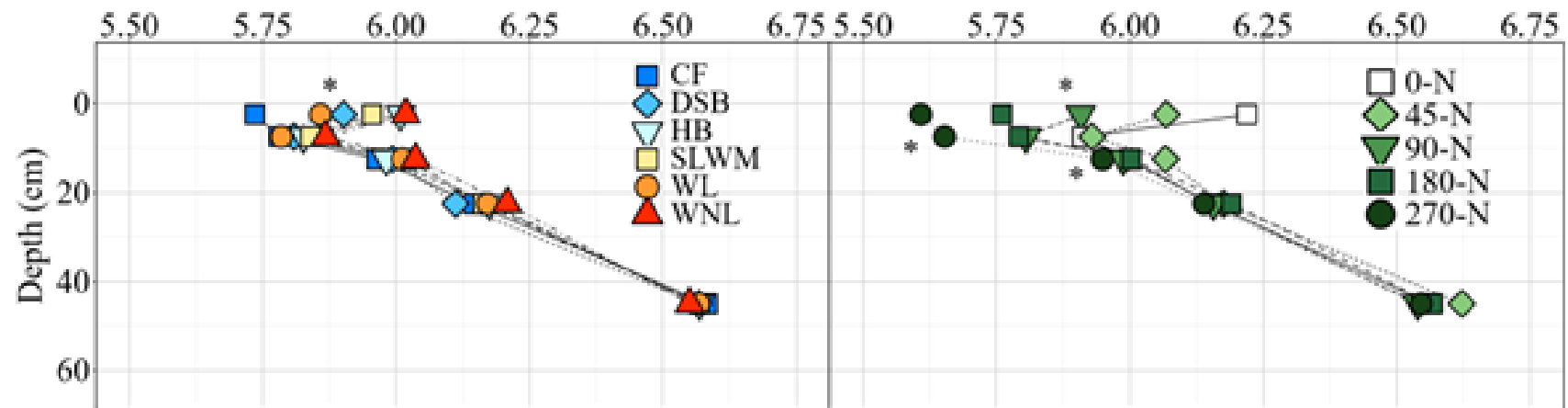
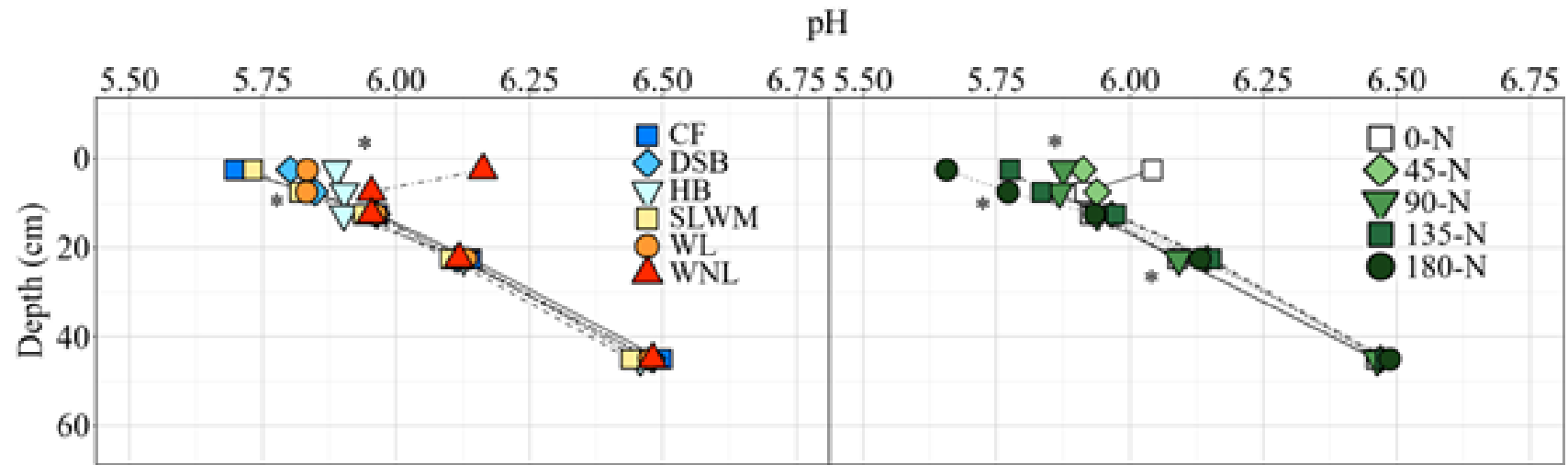


Long-term N trials - Oklahoma

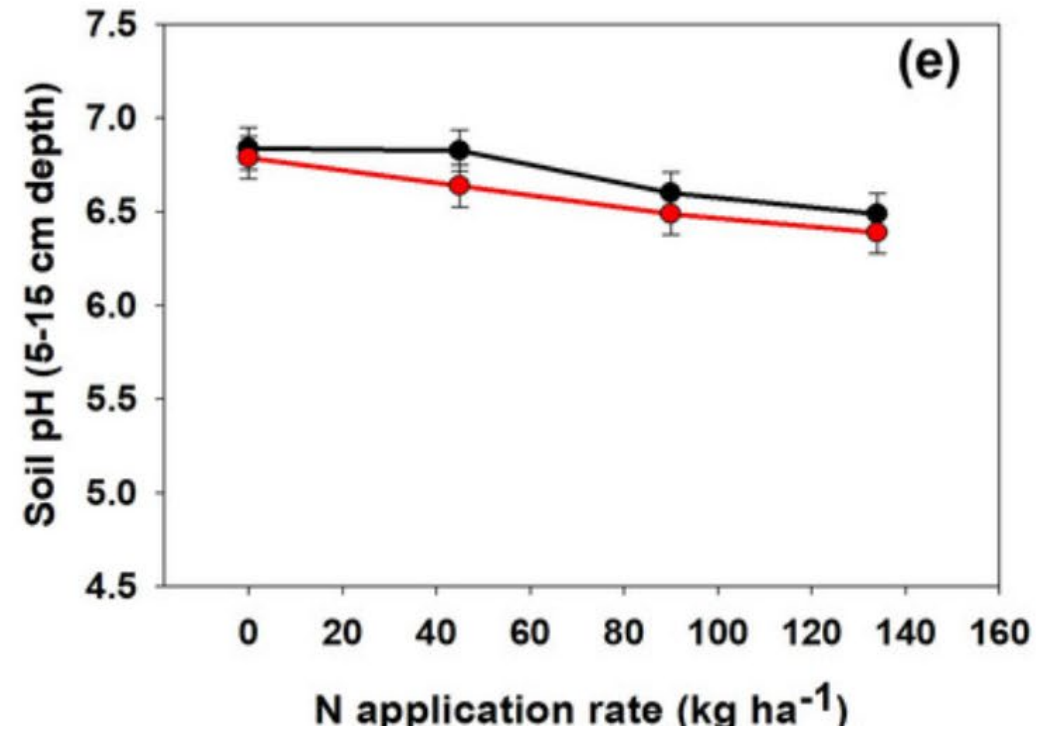
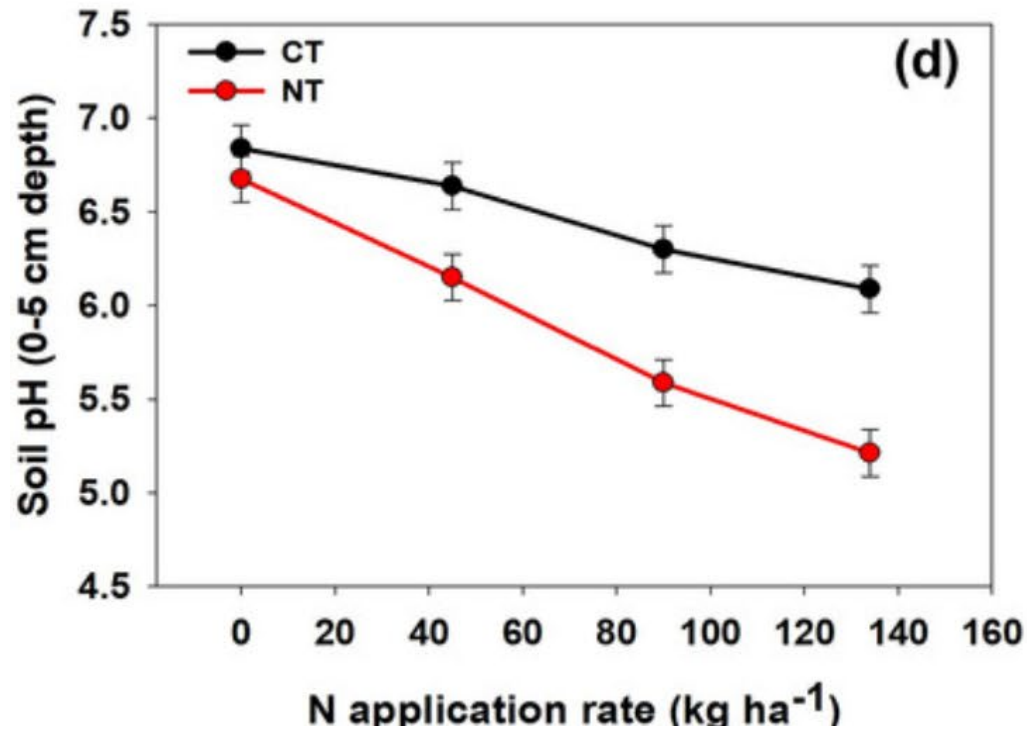


Joao Luis Bigatao Souza, Joao Arthur Antonangelo, Hailin Zhang, Vaughn Reed, Bronc Finch, Brian Arnall, Impact of long-term fertilization in no-till on the stratification of soil acidity and related parameters, Soil and Tillage Research, Volume 228, 2023, <https://doi.org/10.1016/j.still.2022.105624>.

Long-term Cover Crop Study – Manhattan



Hays



Obour, A. K., Holman, J. D., Simon, L. M., & Assefa, Y. (2023). No-tillage and nitrogen fertilization on soil chemical properties under dryland wheat–sorghum–fallow rotation. *Agrosystems, Geosciences & Environment*, 6, e20330. <https://doi.org/10.1002/agg2.20330>

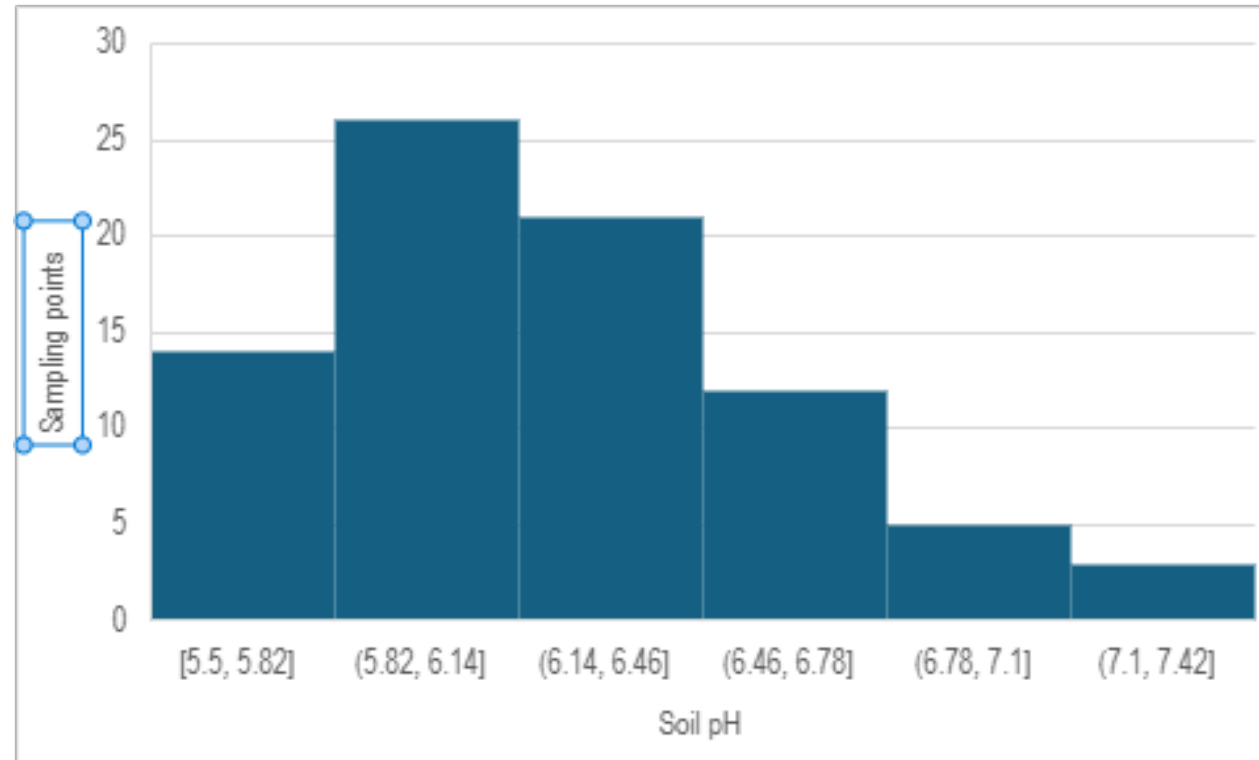
On-farm Wheat/Sorghum – Thomas Co, KS

No till

81, 1 acre grids

0-6' sampling depth

49% below pH 6.2

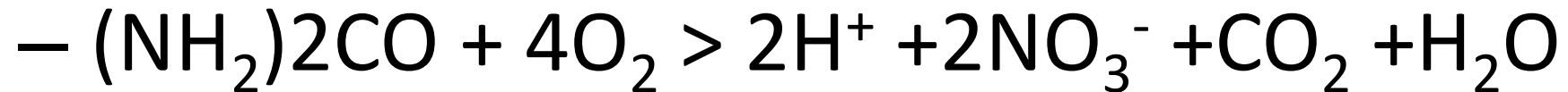


Nitrogen Fertilizer Reactions

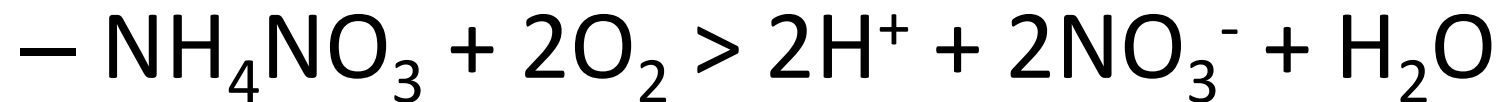
- Anhydrous Ammonia



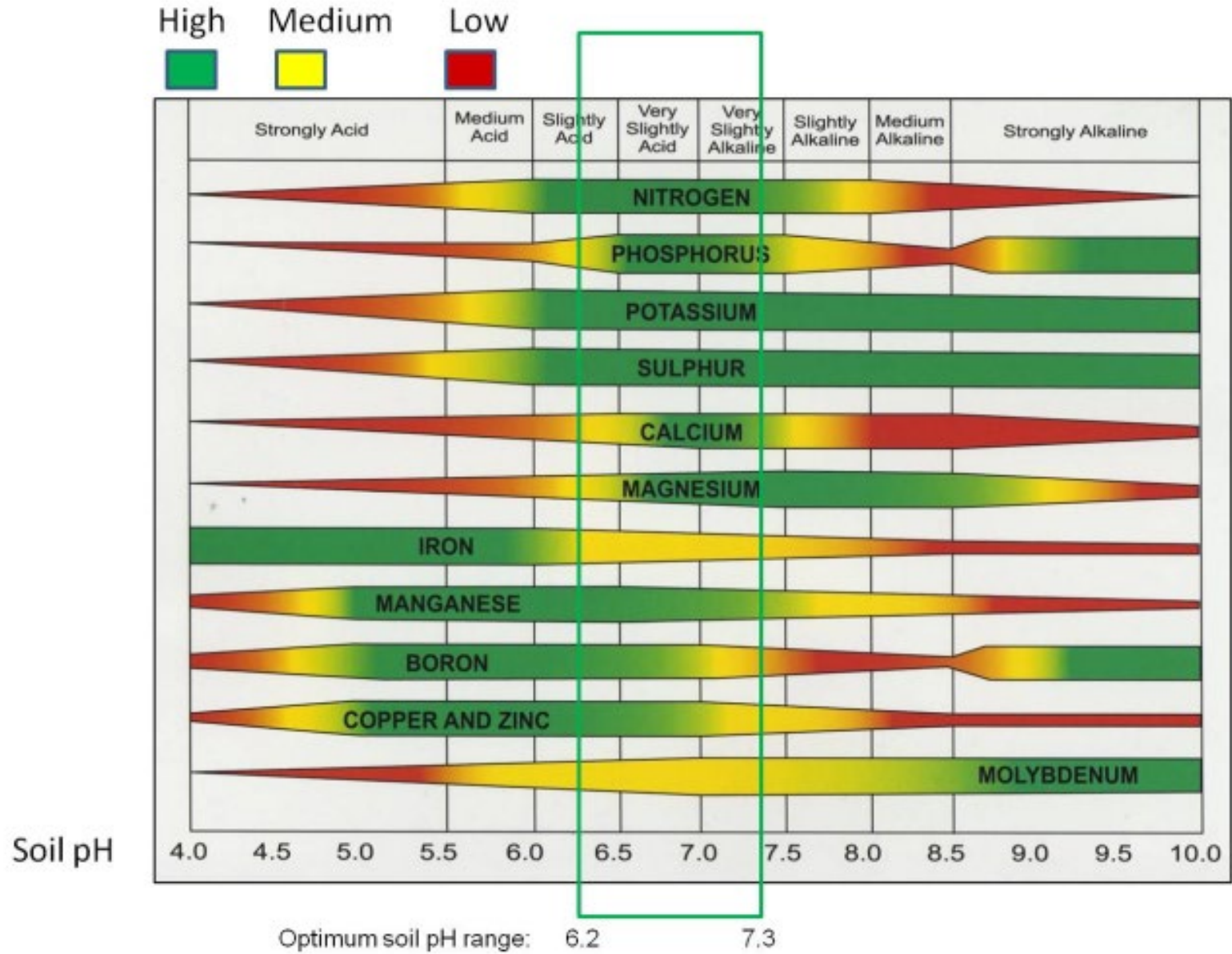
- Urea:



- Ammonium Nitrate



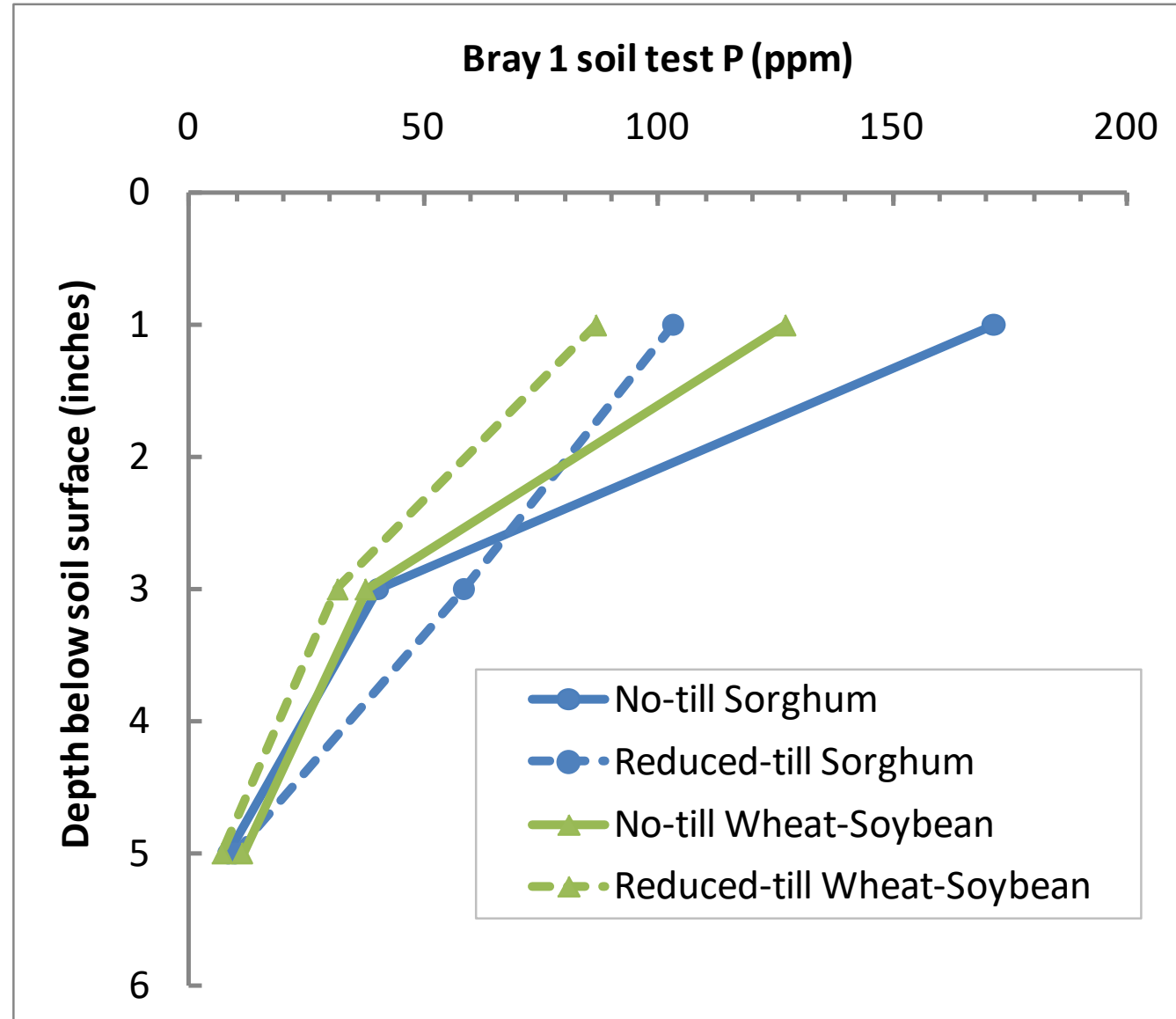
How soil pH affects availability of plant nutrients



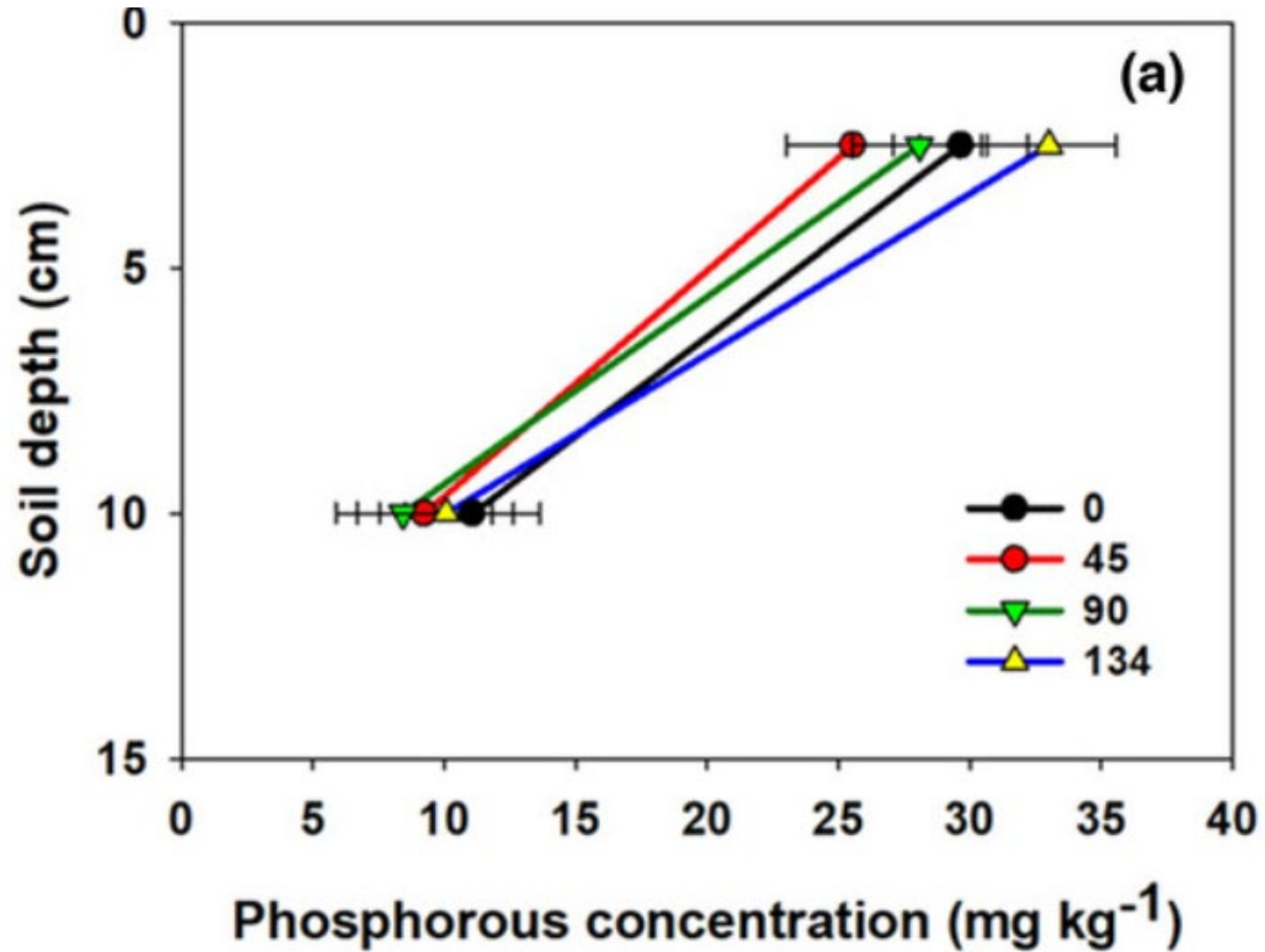
No-till induces P stratification

- Soil test P in long-term tillage plots at Hesston KS (20 years)

35 lbs P_2O_5 /ac/yr

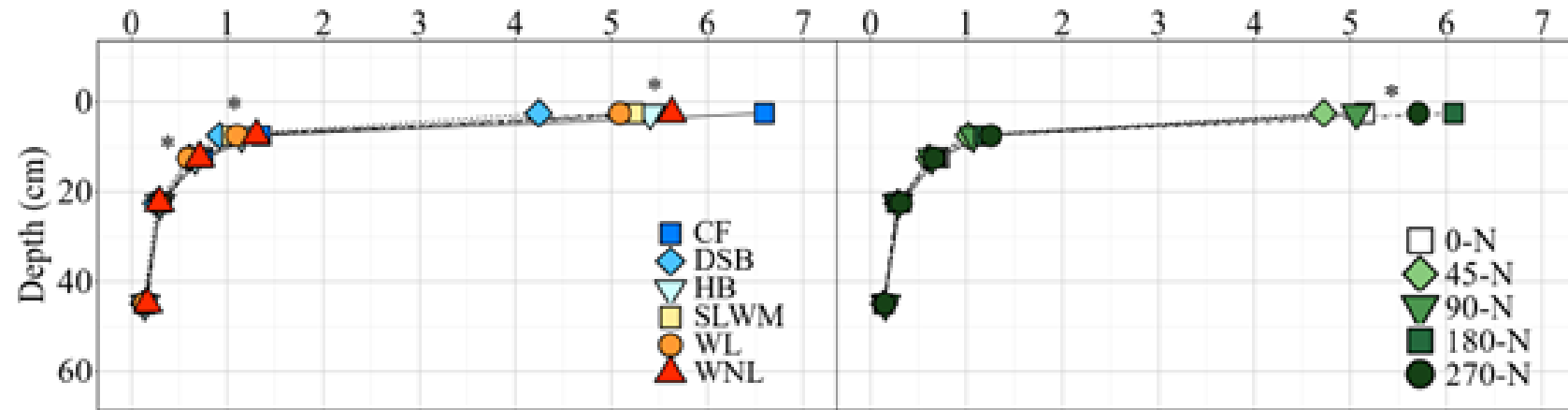
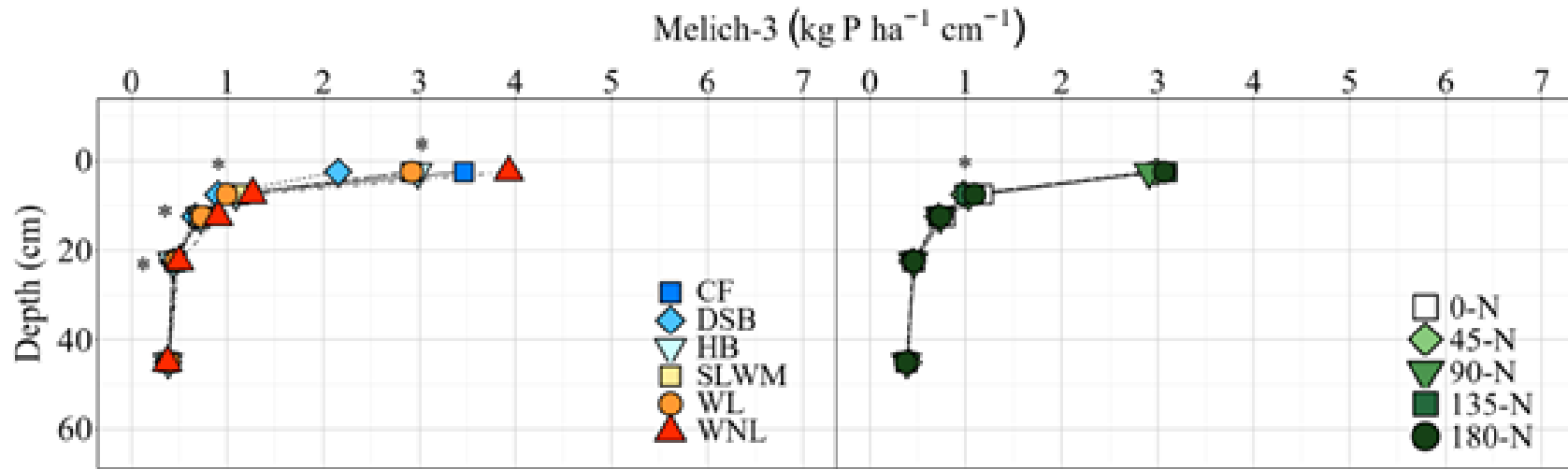


Hays



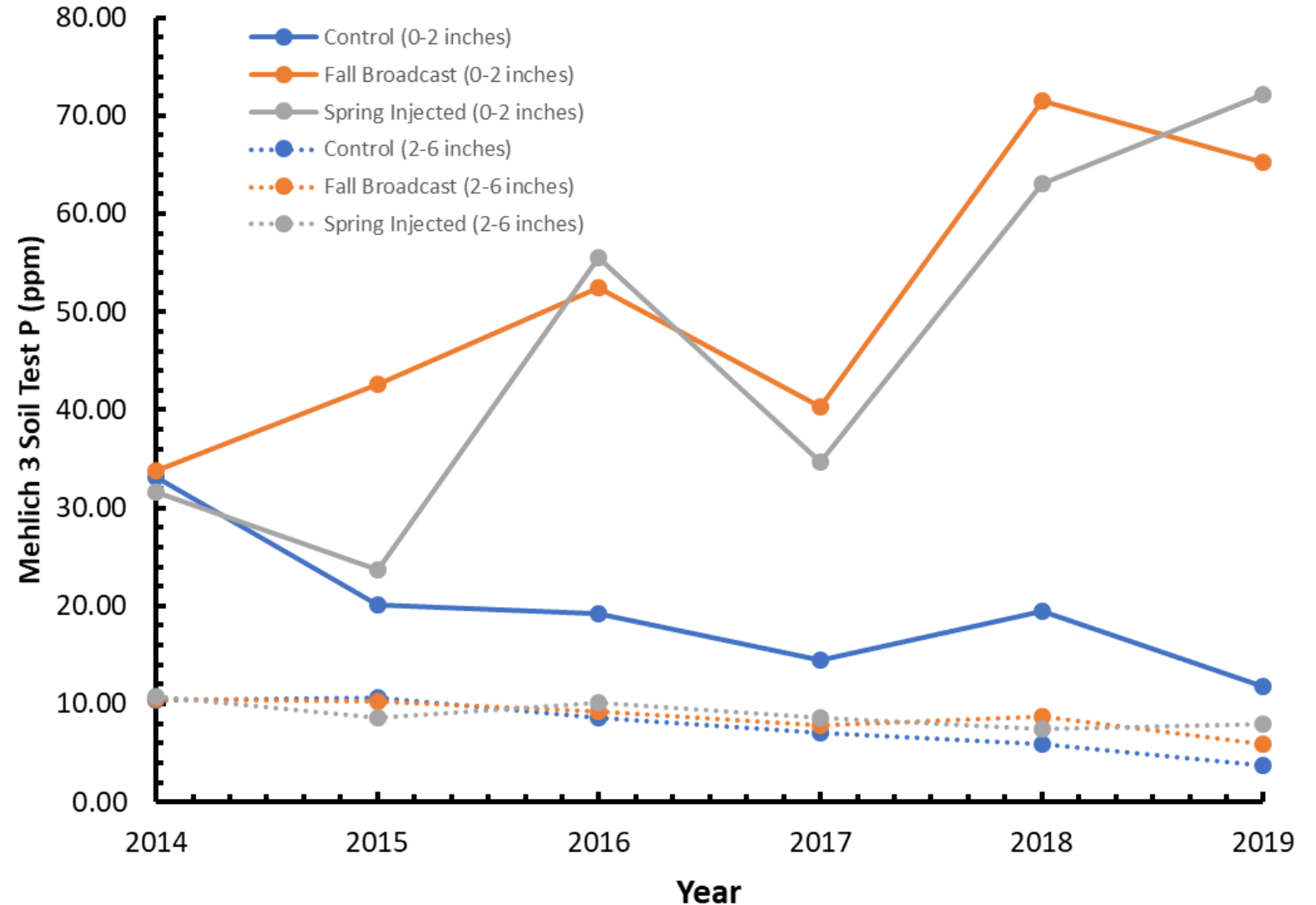
Obour, A. K., Holman, J. D., Simon, L. M., & Assefa, Y. (2023). No-tillage and nitrogen fertilization on soil chemical properties under dryland wheat–sorghum–fallow rotation. *Agrosystems, Geosciences & Environment*, 6, e20330. <https://doi.org/10.1002/agg2.20330>

Long-term Cover Crop Study – Manhattan



No-till induces P stratification

- Kansas Agricultural Watershed
 - No-till Corn-soybean rotation Starting in 2015
 - Spring Injected is 10-34-0 in a 2x2 at planting (55 lb P₂O₅/ac)
 - Fall broadcast is 18-46-0 broadcast in fall (55 lb P₂O₅/ac)



Soil pH and Soil Health

- As soil pH decreases (increase in acidity)
 - Microbial biomass (size) decreases
 - Microbial community diversity decreases
- Implications
 - Nutrient cycling efficiency
 - Herbicide effectiveness

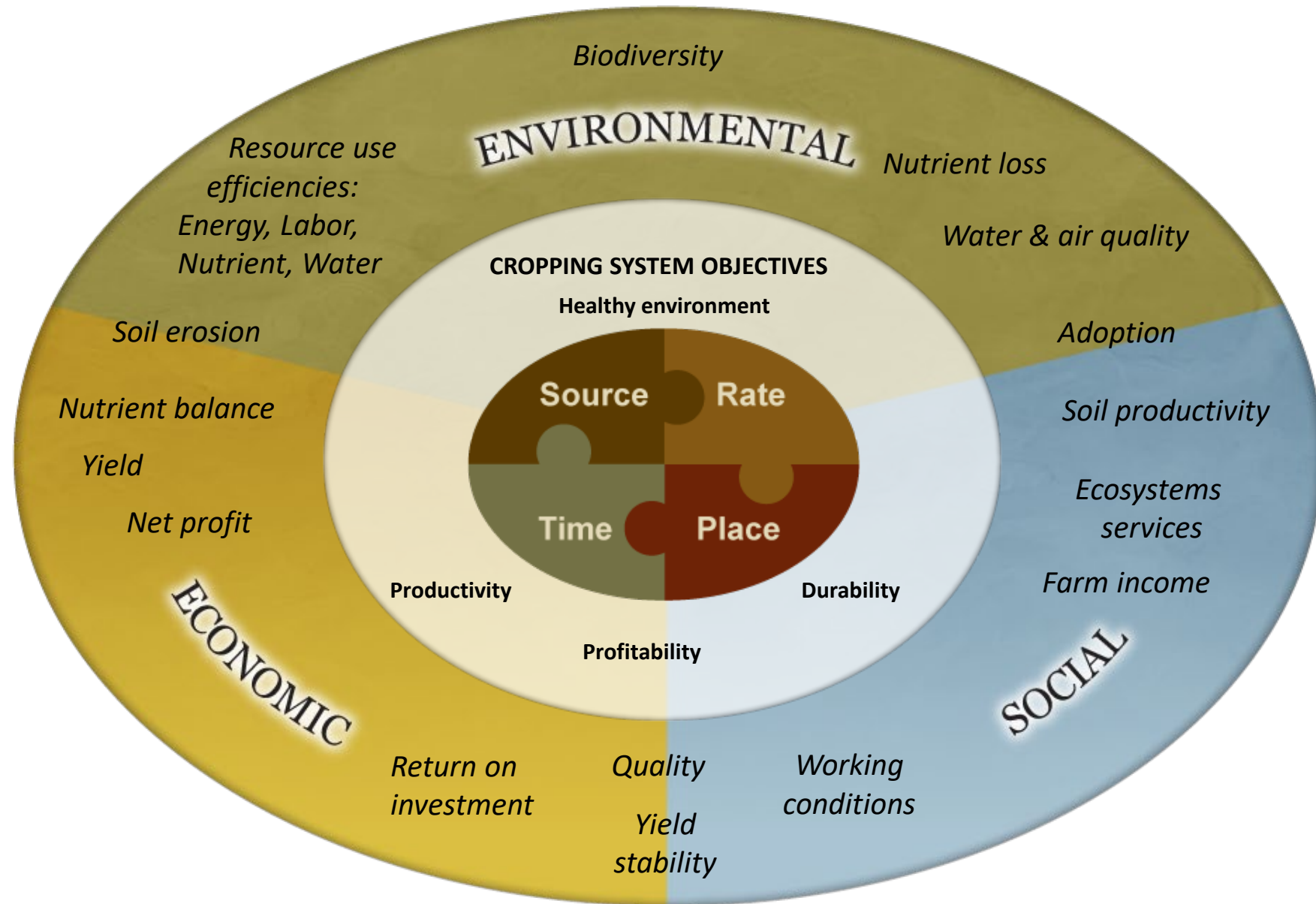


Manure and Your Fertility Program

K-STATE
Research and Extension



4R Nutrient Stewardship



Source: <http://www.ipni.net/4r>

Right Source

- Select the right fertilizer to achieve goals
- Factors to consider
 - Plant requirements
 - Soil conditions
 - Fertilizer delivery issues
 - Environmental risk
 - Price
 - Economic constraints

Source: [http://www.ipni.net/ppiweb/filelib.nsf/0/F3D85DDA3D489C418525762D004DA258/\\$file/4R-source-2009.pdf](http://www.ipni.net/ppiweb/filelib.nsf/0/F3D85DDA3D489C418525762D004DA258/$file/4R-source-2009.pdf)

Right Rate

- Select the right rate to achieve goals
 - Yield of a crop will be determined by most limited element. (Liebig's Law of the Minimum)
- Factors to consider
 - Deficiency of one can not be over come by excess of another element
 - All 17 essential nutrients must be present
 - Match nutrient supply with plant requirements
 - Soil sampling is the foundation

Source: [http://www.ipni.net/ppiweb/filelib.nsf/0/19BCE23CBD11AFE38525762D004DC16A/\\$file/4R-rate-2009.pdf](http://www.ipni.net/ppiweb/filelib.nsf/0/19BCE23CBD11AFE38525762D004DC16A/$file/4R-rate-2009.pdf)

Right Time

- Select the right time to achieve goals
- Factors to consider
 - Nutrient characteristics
 - Sight specific conditions
 - Plant nutrient uptake patterns
 - Soil characteristics
 - Weather and environment

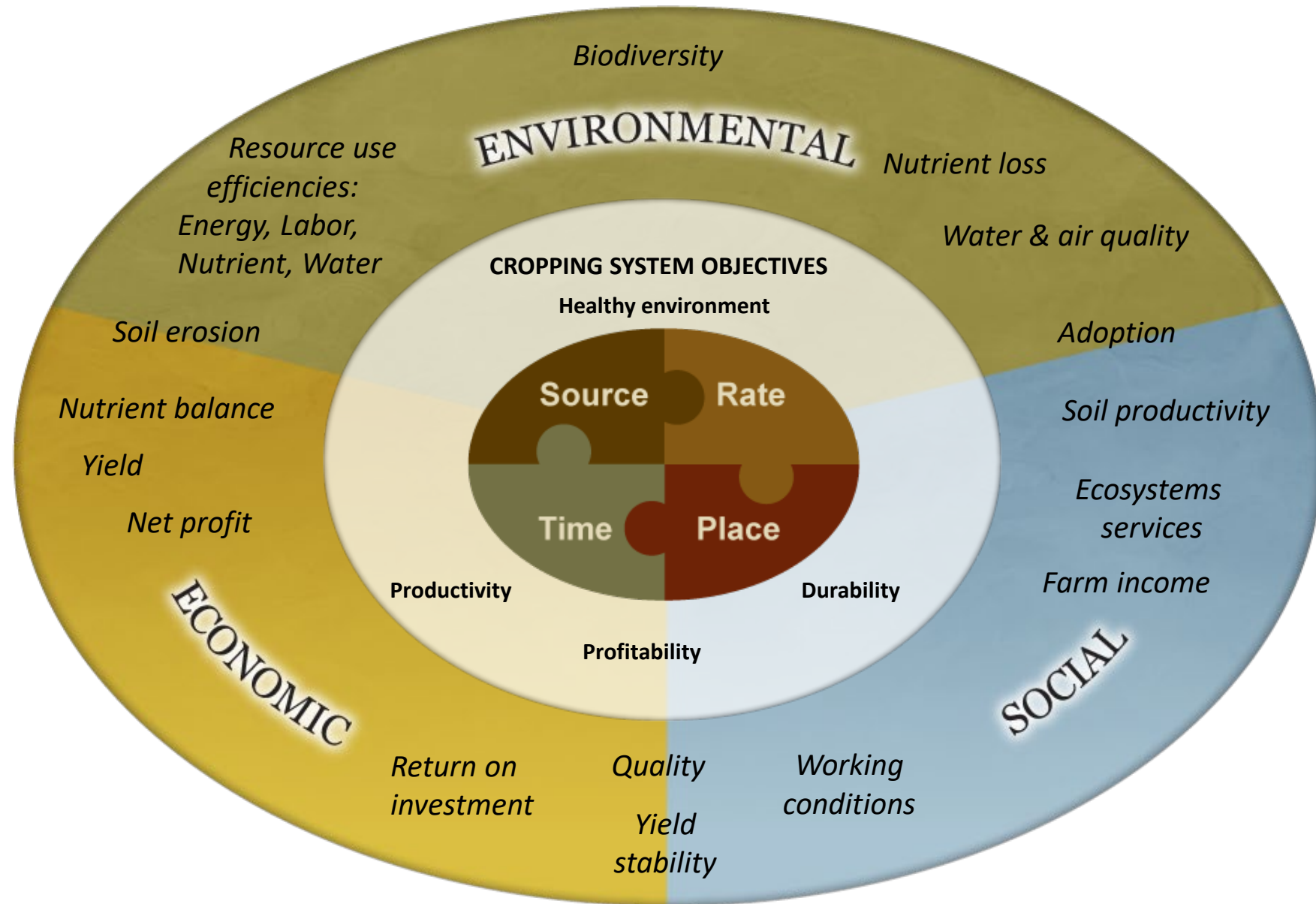
Source: [http://www.ipni.net/ppiweb/filelib.nsf/0/EF926099F1C56B4A8525762D004DD6D8/\\$file/4R-timing-2009.pdf](http://www.ipni.net/ppiweb/filelib.nsf/0/EF926099F1C56B4A8525762D004DD6D8/$file/4R-timing-2009.pdf)

Right Place

- Select the right place to achieve goals
 - Locating nutrients so they are accessible to the plant
- Factors to consider
 - Fertilized soil volume (concentration)
 - Relation to plant root system
 - P and K move to plant roots primarily by diffusion
 - Nutrient supply critical during rapid vegetative growth

Source: [http://www.ipni.net/ppiweb/filelib.nsf/0/0F716D45D3CFF2F18525766C006B7FEE/\\$file/4R-placement-2009.pdf](http://www.ipni.net/ppiweb/filelib.nsf/0/0F716D45D3CFF2F18525766C006B7FEE/$file/4R-placement-2009.pdf)

4R Nutrient Stewardship



Source: <http://www.ipni.net/4r>

Challenges for Agriculture

- Nutrient applications
 - Increase yields
 - Increase return of carbon to the soil
- Unmanaged nutrient applications
 - Increase nutrient losses
 - Potential to degrade water and air quality
 - Potential to increase gaseous N losses

Manure Management


- Production - Value as fertilizer
- Unbalanced fertilizer
 - Nutrient ratios (N, P, K, etc.) are fixed
 - Nitrogen based application exceed crop Phosphorus requirements.
 - Minimize impact on water quality
- **Fertility source** not manure disposal



Manure Math - Conversion

- Results in PPM
 - Solid manure lbs/ton = ppm x 0.002
 - Liquid manure lbs/1000 gal = ppm x 0.00834
- Results in %
 - Solid manure lbs/ton = % x 20
 - Liquid manure lbs/1000 gal = % x 83.4
- Other useful conversions
 - $P_2O_5 = P \times 2.3$
 - $K_2O = K \times 1.2$

Dollars and Cents

- Fertilizer prices  (prices as of Nov 10, 2021)
 - N = \$0.85 per lb. N
 - P = \$0.85 per lb. P
 - K = \$0.39 per lb. K
- Based on nutrients N, P, and K value
 - Poultry litter:
 - \$65 per ton (first yr.)
 - \$110 per ton (first yr. + residual)
 - Feedlot manure:
 - \$16 per ton (first yr.)
 - \$28 per ton (first yr. + residual)
 - Actual value greater

Nitrogen Based Plan

Crop	Yield	N Uptake	Manure Needed
	--ton/acre--	--lb/acre--	--ton/acre--
Corn silage (Feedlot)	20	165	
Corn silage (Poultry litter)	20	165	

Nitrogen Based Plan

Crop	Yield	N Uptake	Manure Needed
	--ton/acre--	--lb/acre--	--ton/acre--
Corn silage (Feedlot)	20	165	10
Corn silage (Poultry litter)	20	165	2.5

Phosphorus Based Plan

Crop	Yield	P₂O₅ Uptake	Manure Needed
	--ton/acre--	--lb/acre--	--ton/acre--
Corn silage (Feedlot)	20	64	
Corn silage (Poultry litter)	20	64	

Phosphorus Based Plan

Crop	Yield	P₂O₅ Uptake	Manure Needed
	--ton/acre--	--lb/acre--	--ton/acre--
Corn silage (Feedlot)	20	64	5.2
Corn silage (Poultry litter)	20	64	1.3

Phosphorus Over-Application

Crop	N – Manure Needed	P – Manure Needed	OVER APPLICATION N-BASIS
	--ton/acre--	--ton/acre--	--ton/acre--
Corn silage (Feedlot)	10.0	5.3	4.7
Corn silage (Poultry litter)	2.5	1.3	1.2

Phosphorus

- Manage nutrients based on phosphorous
- Nutrient over application impacts bottom line

~~IN~~ P

Nitrogen Deficit

Crop	Phosphorus	Nitrogen Applied	Nitrogen Fertilizer Needed	Nitrogen Fertilizer Costs
	Manure Applied			
	--ton/acre--		-----lbs/acre-----	--\$/acre--
Corn silage (Feedlot)	5.3		87.5	
Corn silage (Poultry litter)	1.3		85.8	

Nitrogen Deficit

Crop	Phosphorus Manure Applied	Nitrogen Applied	Nitrogen Fertilizer Needed	Nitrogen Fertilizer Costs
	--ton/acre--	-----lbs/acre-----		--\$/acre--
Corn silage (Feedlot)	5.3	87.5	77	
Corn silage (Poultry litter)	1.3	85.8	79	

Nitrogen Deficit

Crop	Phosphorus	Nitrogen Applied	Nitrogen	Nitrogen
	Manure Applied		Fertilizer Needed	Fertilizer Costs
	--ton/acre--		-----lbs/acre-----	--\$/acre--
Corn silage (Feedlot)	5.3	88	77	65
Corn silage (Poultry litter)	1.3	86	79	67

Set Backs

- Minimum distance between water bodies and manure application
- Recommended Distances
 - 100 feet for perennial stream, well, pond or sinkhole
 - 50 feet for intermittent stream
- Distance can be reduced with established buffers

Key Management Considerations

- Storage Site Evaluation
 - Access
 - Distances to water and residences
 - Soil type (infiltration)
 - Sensitive ground water
- Agronomics
 - Soil test and manage soil phosphorus
 - Mehlich-3 or Bray-1 <50 ppm
 - Observe set back recommendations
 - Incorporate within 24hr

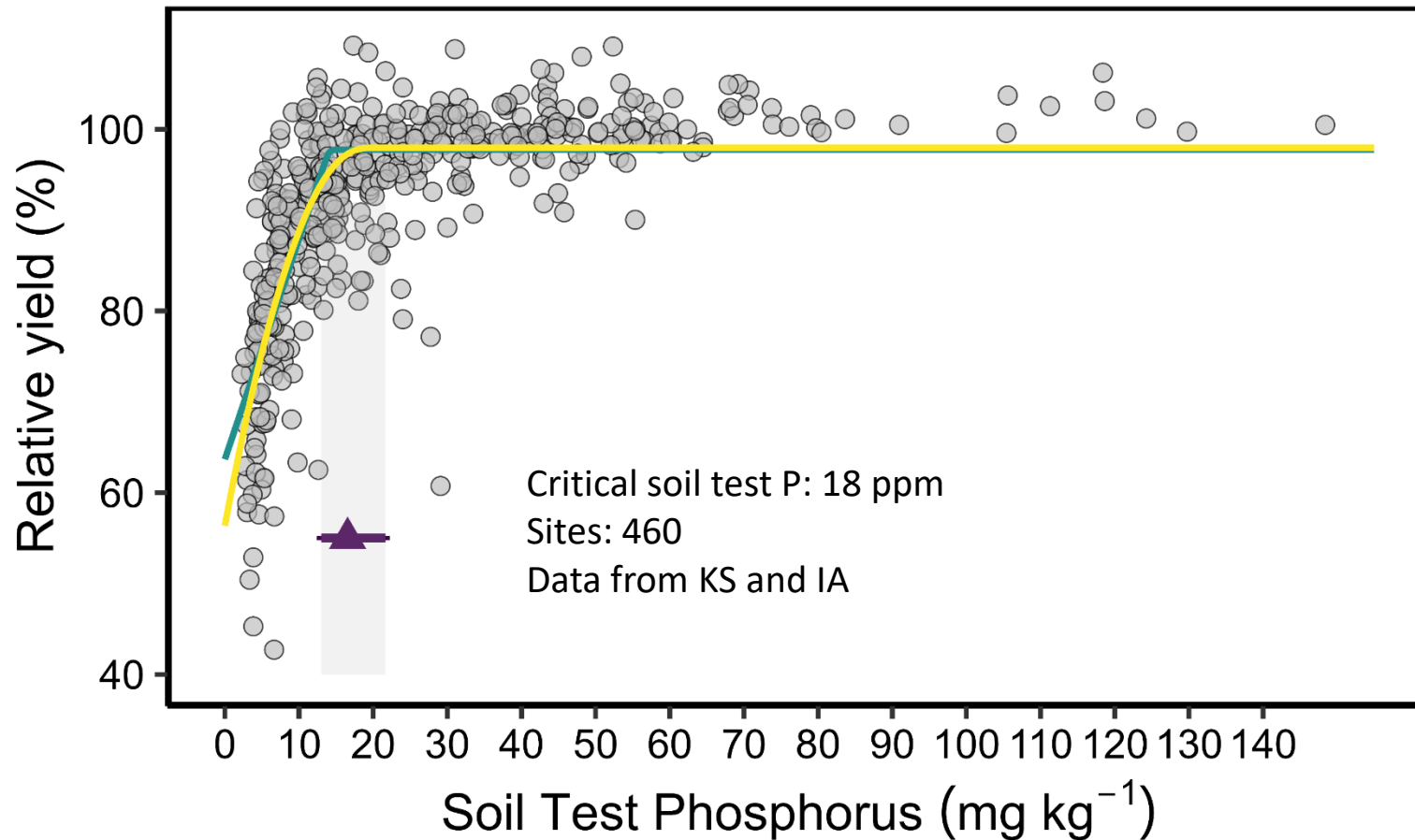


Thank you

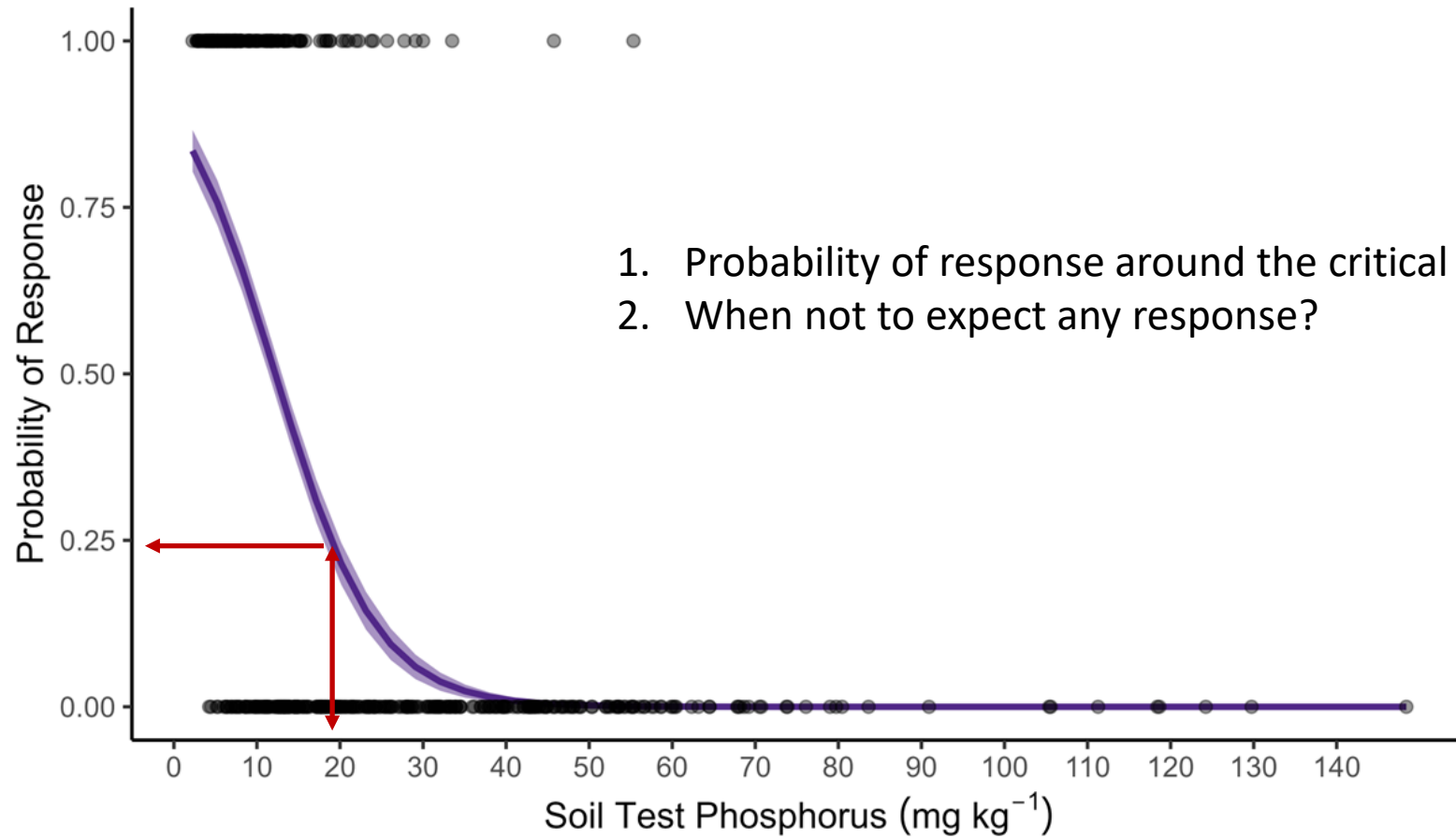
Peter Tomlinson - Environmental Quality
(ptomlin@ksu.edu)

Department of Agronomy, Kansas State University

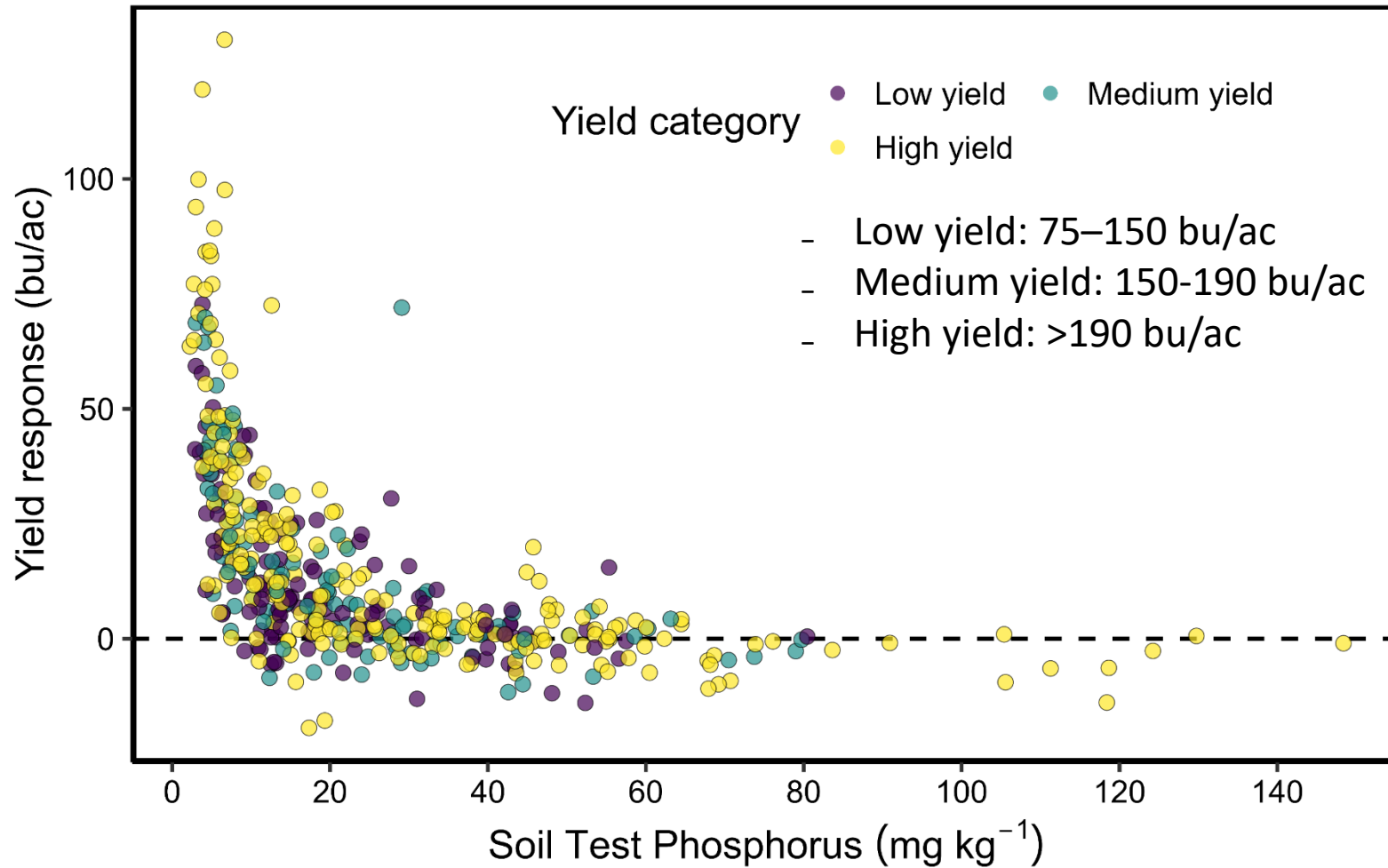
Corn: Critical soil test P using Mehlich-3 colorimetric



Probability of yield response vs Soil Test phosphorus in corn

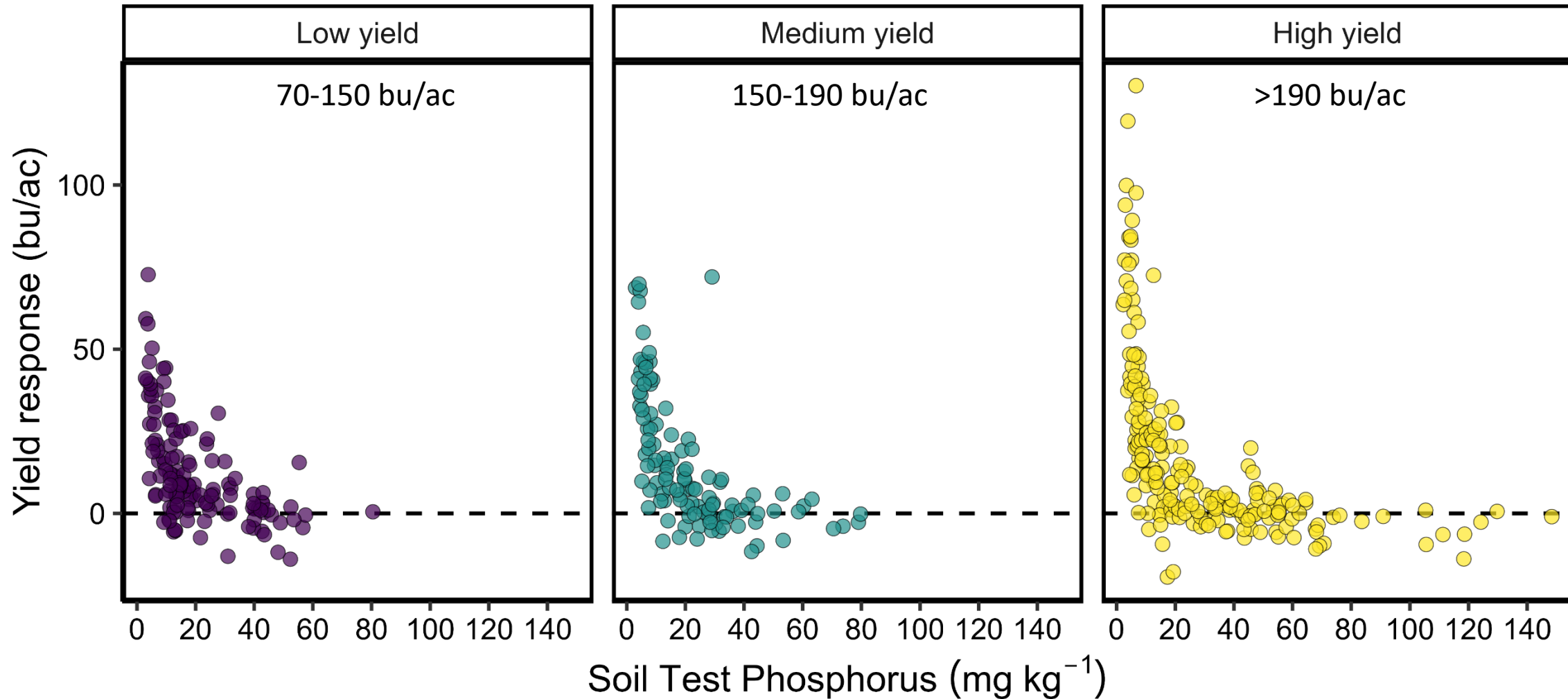


Yield potential and magnitude of yield response to P fertilizer in corn?



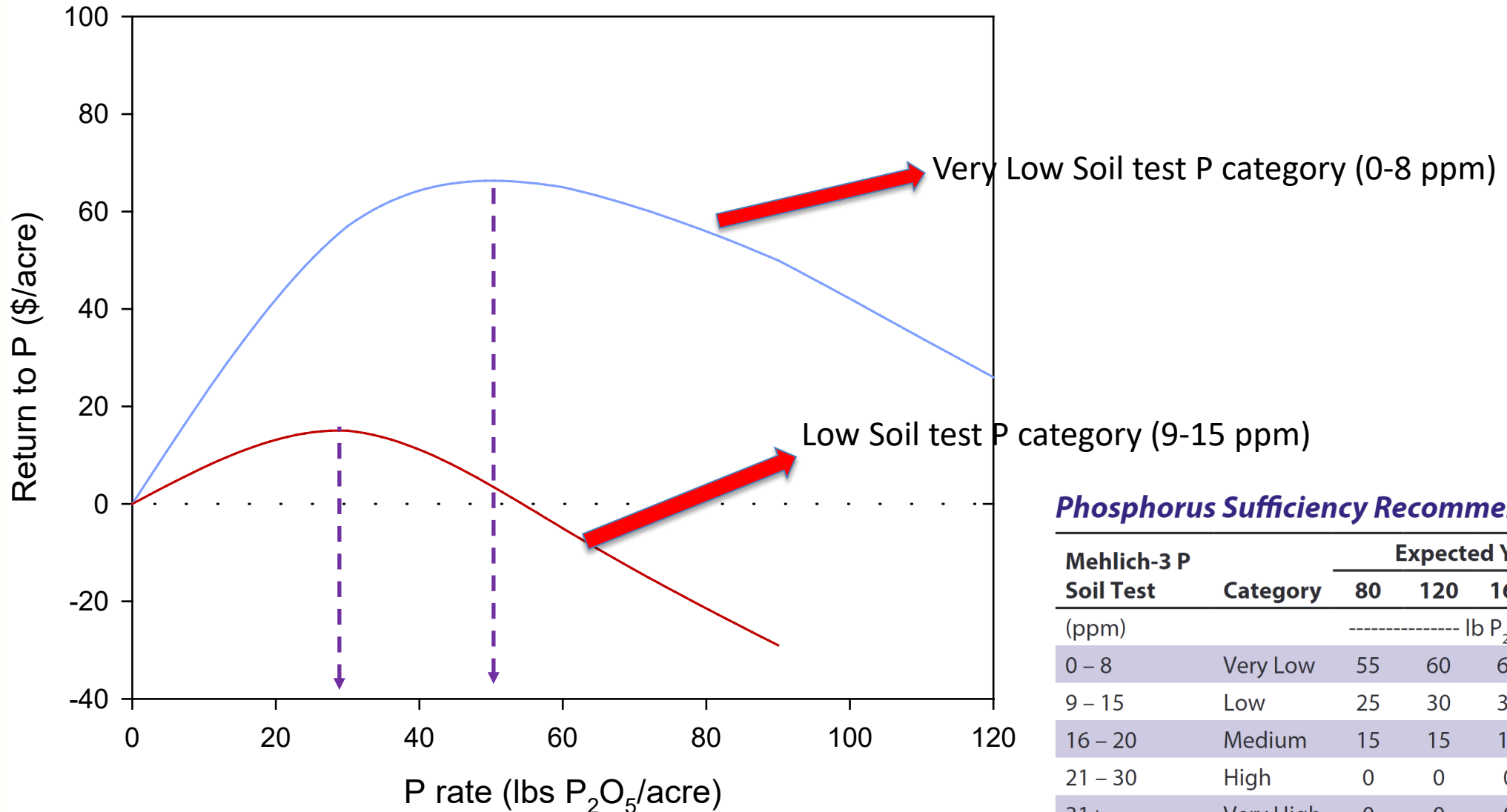
~ 60 lbs P_2O_5 /acre rate

Yield potential and magnitude of yield response to P fertilizer in corn?



~ 60 lbs P₂O₅/acre rate

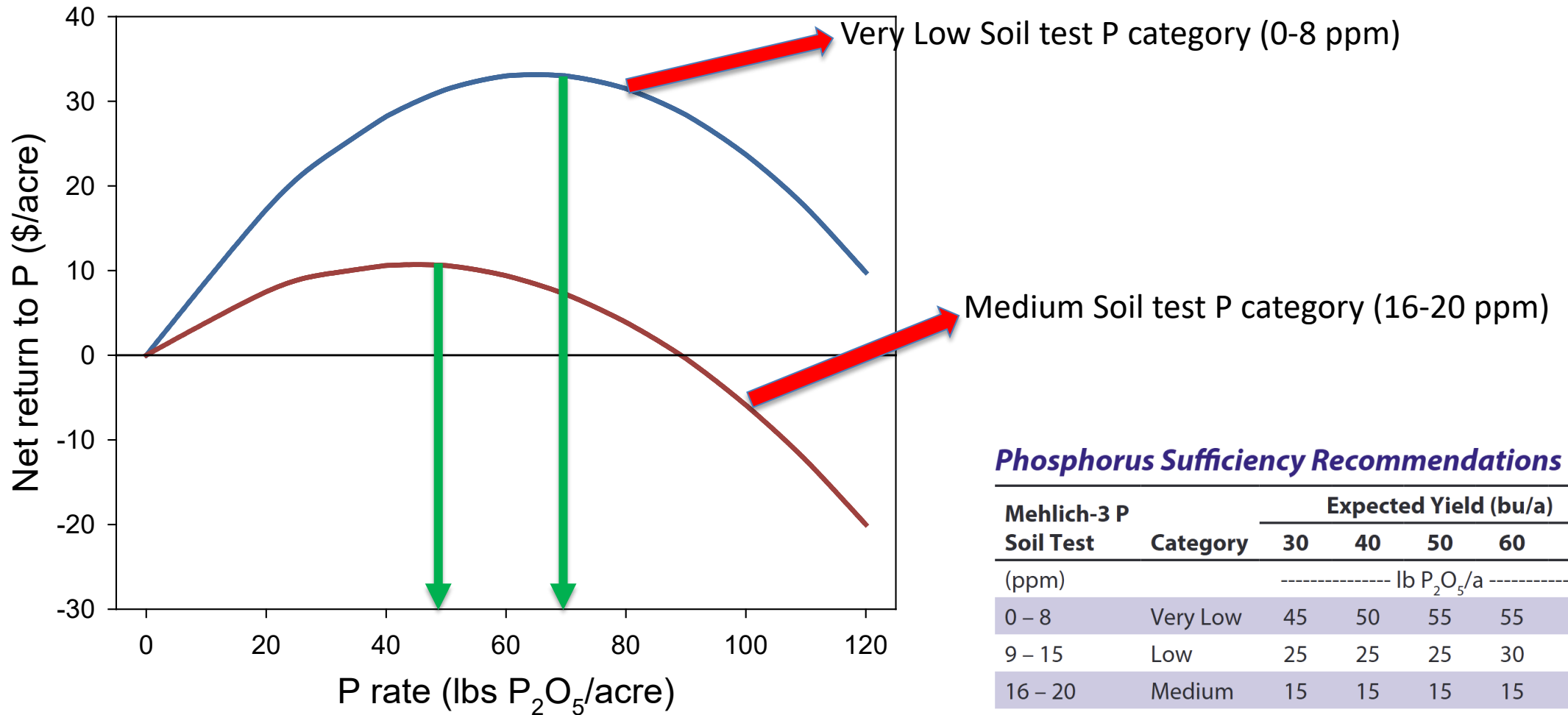
Corn: Return to P fertilizer (\$0.8 P & \$4 corn) for one growing season



Phosphorus Sufficiency Recommendations

Mehlich-3 P Soil Test (ppm)	Category	Expected Yield (bu/a)				
		80	120	160	200	240
0 – 8	Very Low	55	60	65	70	80
9 – 15	Low	25	30	35	35	40
16 – 20	Medium	15	15	15	15	15
21 – 30	High	0	0	0	0	0
31+	Very High	0	0	0	0	0

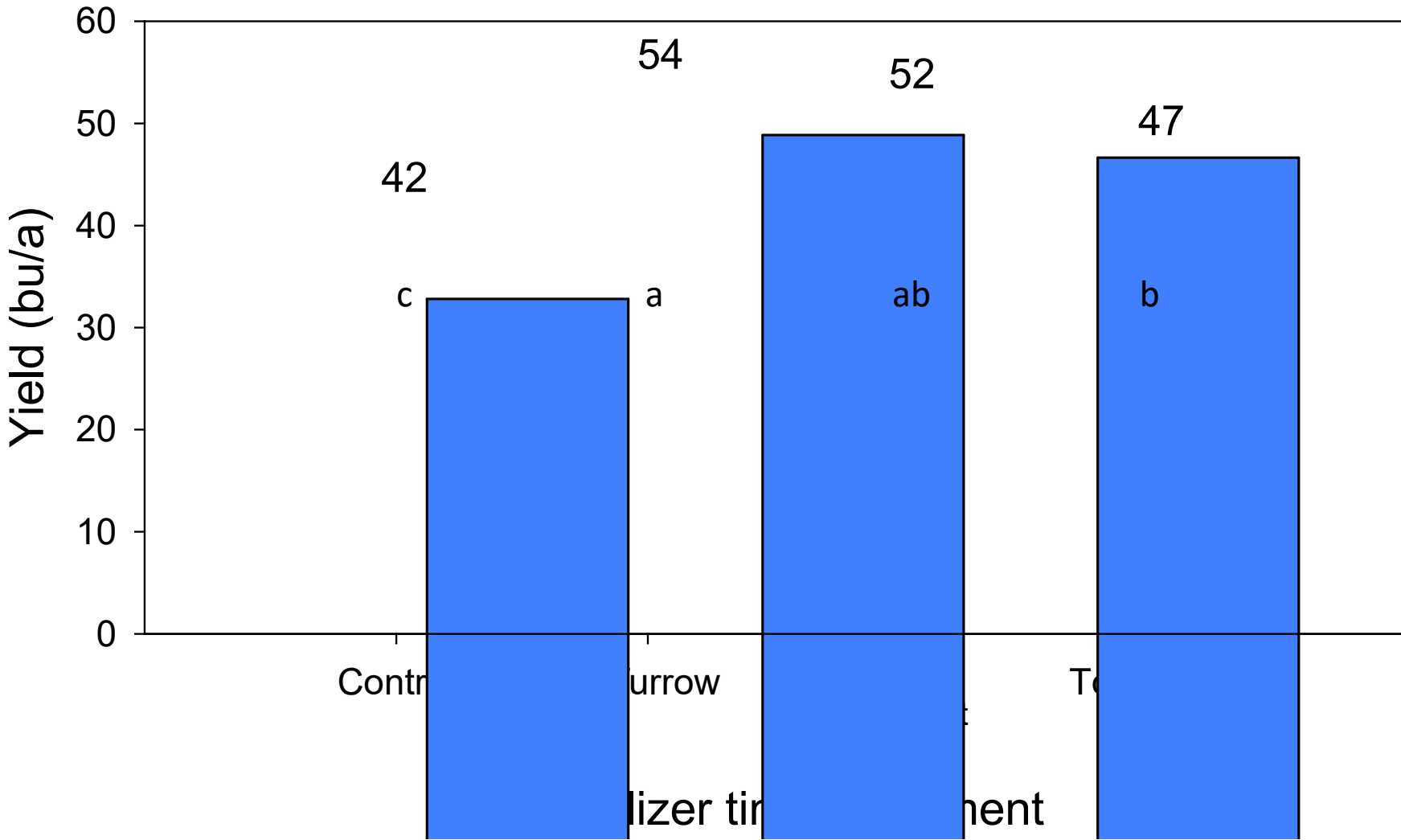
Wheat: Return to P fertilizer (\$0.8 P & \$5 wheat) for one growing season



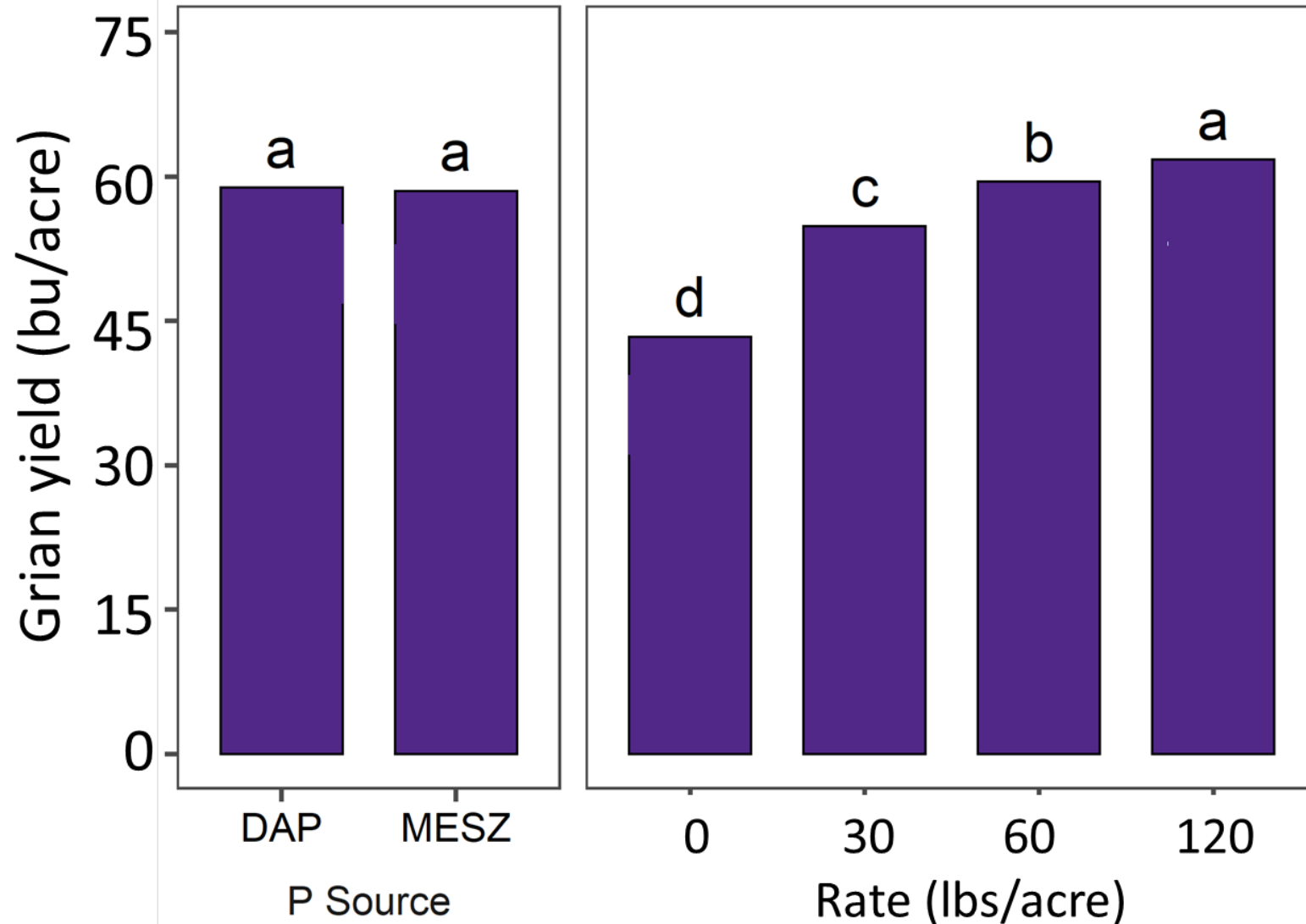
Phosphorus Sufficiency Recommendations

Mehlich-3 P Soil Test (ppm)	Category	Expected Yield (bu/a)				
		30	40	50	60	70
0 – 8	Very Low	45	50	55	55	60
9 – 15	Low	25	25	25	30	30
16 – 20	Medium	15	15	15	15	15
21 – 30	High	0	0	0	0	0
31+	Very High	0	0	0	0	0

Increase efficiency: Phosphorus placement and time for wheat, 40 lbs of P₂O₅ using TSP



P fertilizer with the seed (MAP and MESZ): Yield response



Skip a year of P application ? effect on soil test P

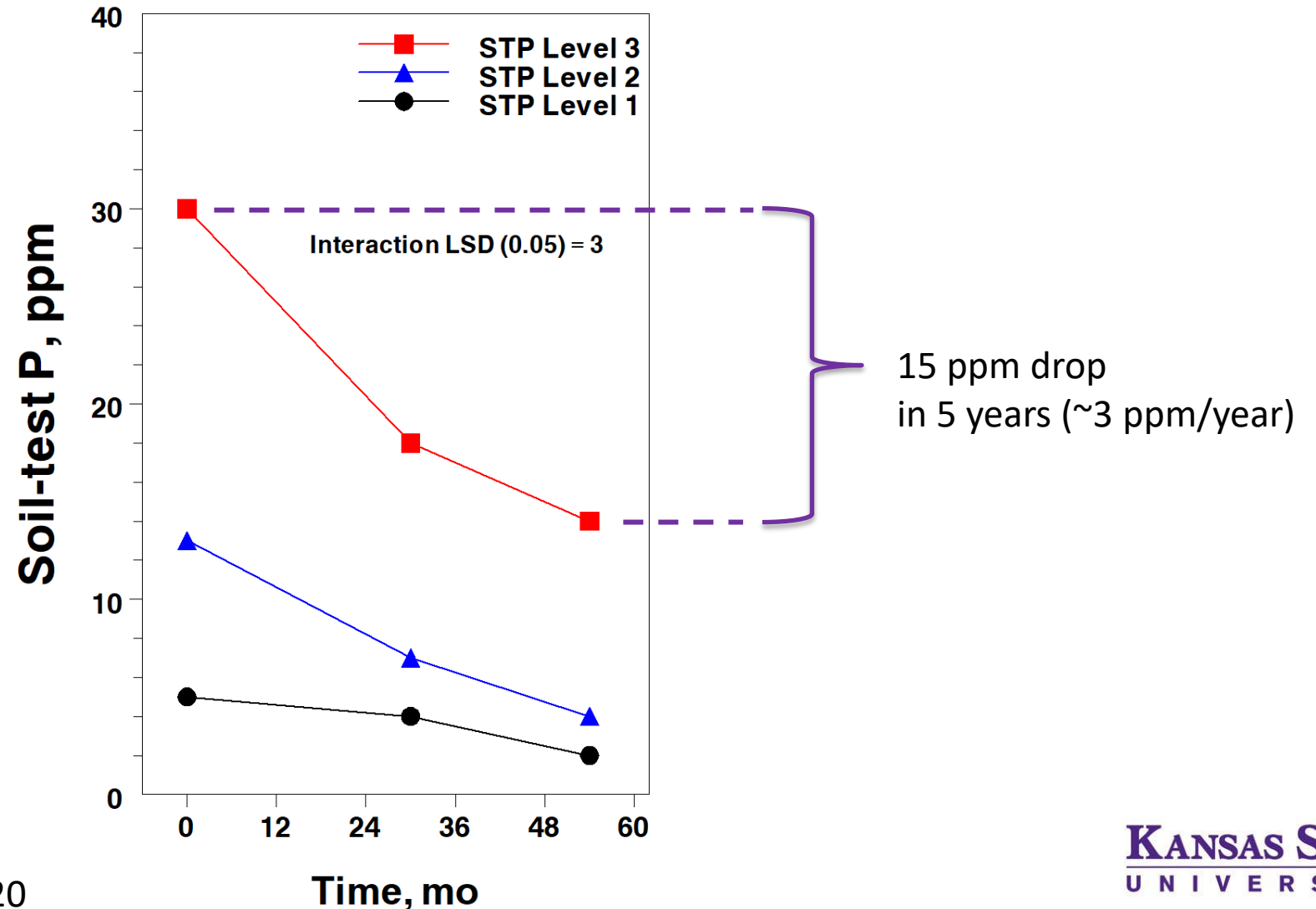
Crop	P ₂ O ₅ (lb)/bu
Corn	0.33
Grain Sorghum	0.40
Wheat	0.50
Soybeans	0.80

Assuming ~18 lbs of P₂O₅ =
change 1 ppm soil test P

200 bu corn = 66 lbs of P₂O₅
= change of ~3.5 ppm STP

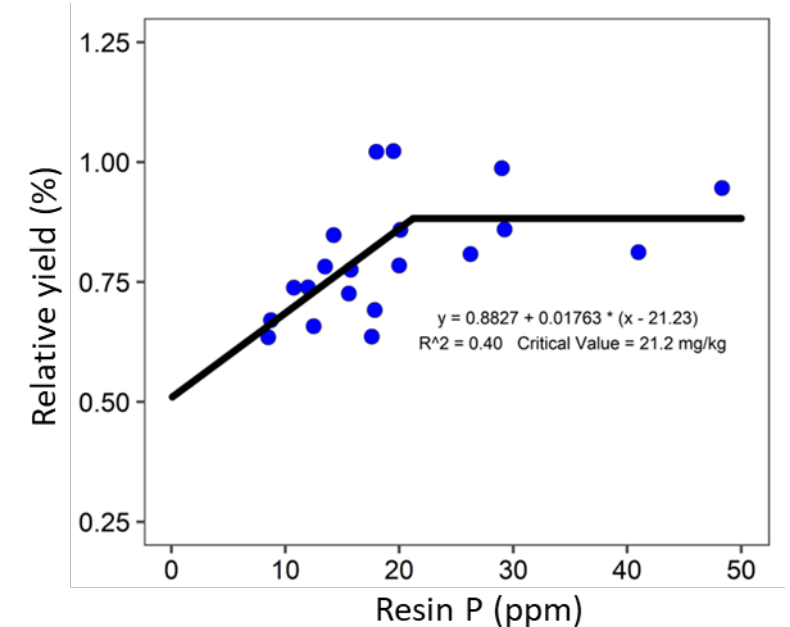
Soil test every 2-4 years

Change in soil test P (5-years with soybean)

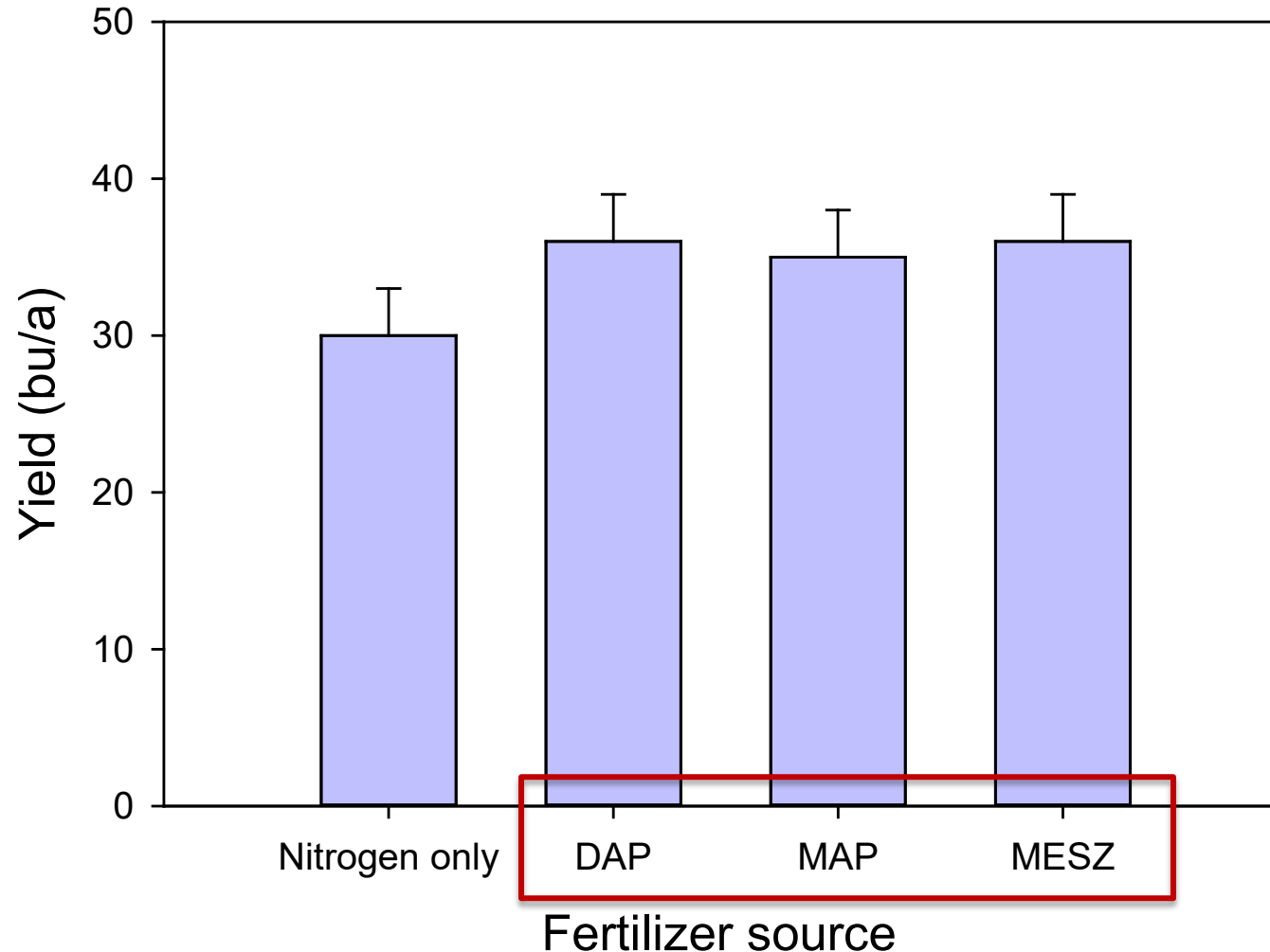


Different soil test methods and critical soil test levels (wheat)

STP Method	Critical value (ppm)
Mehlich-3 COL	25
Bray-1	26
Olsen	12
Mehlich-3 ICP	35
H3A	26
Resin	20



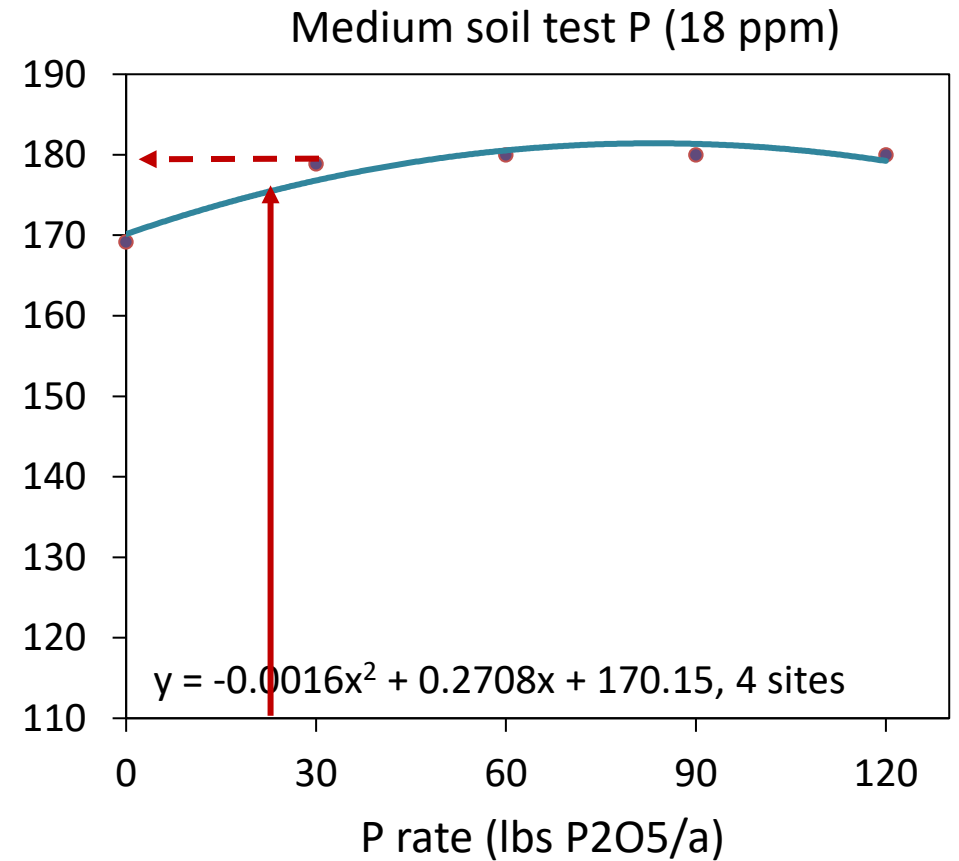
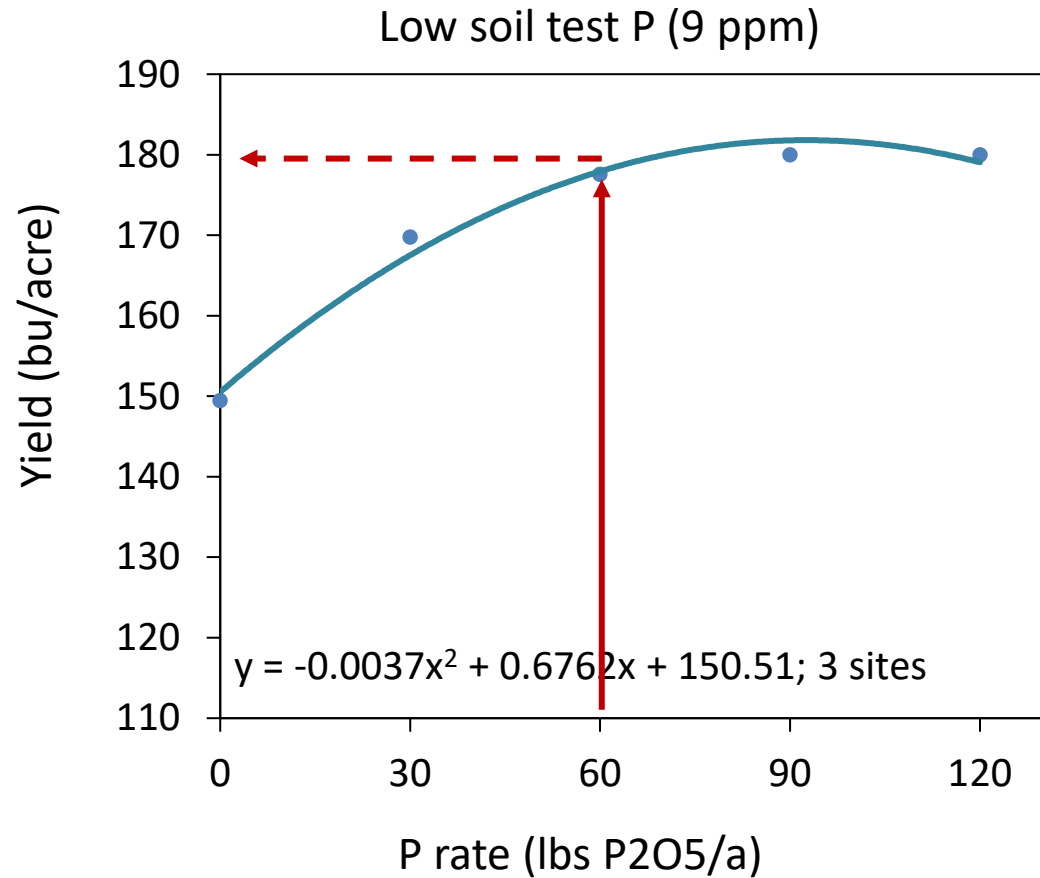
Phosphorus fertilizer source make any difference?



All these decisions are based on soil test information!

- What is the cost of a soil test?
- Cost of over-application vs under-application of P fertilizer
 - Yield losses
 - Unnecessary P fertilizer (for this year)

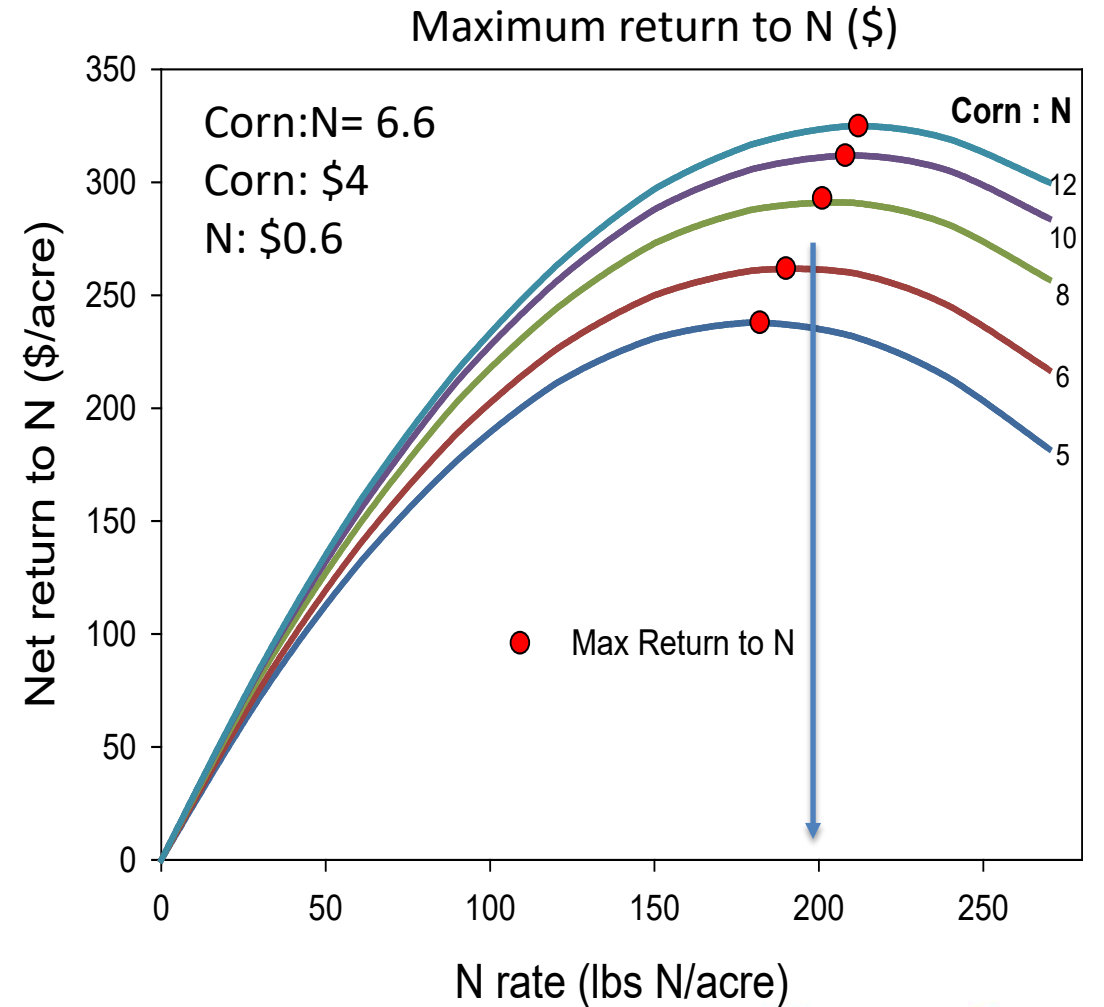
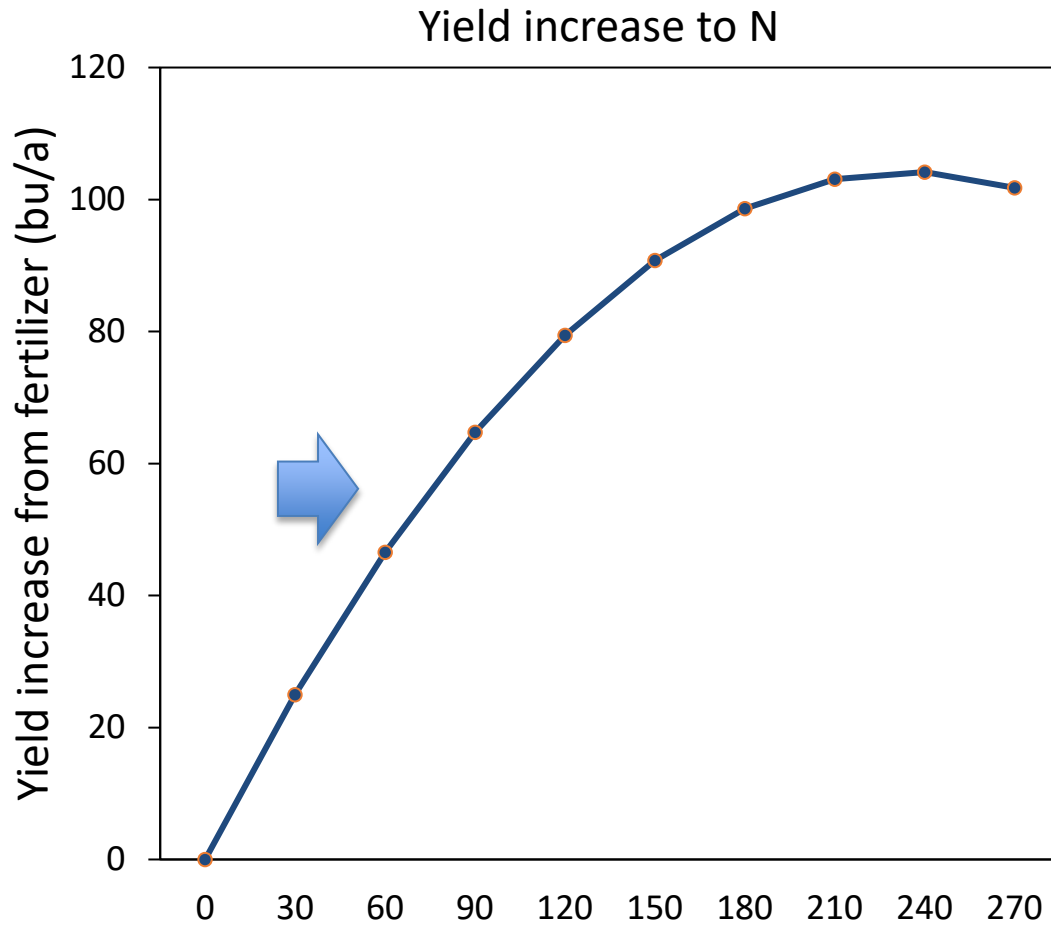
All these decisions are based on soil test information!



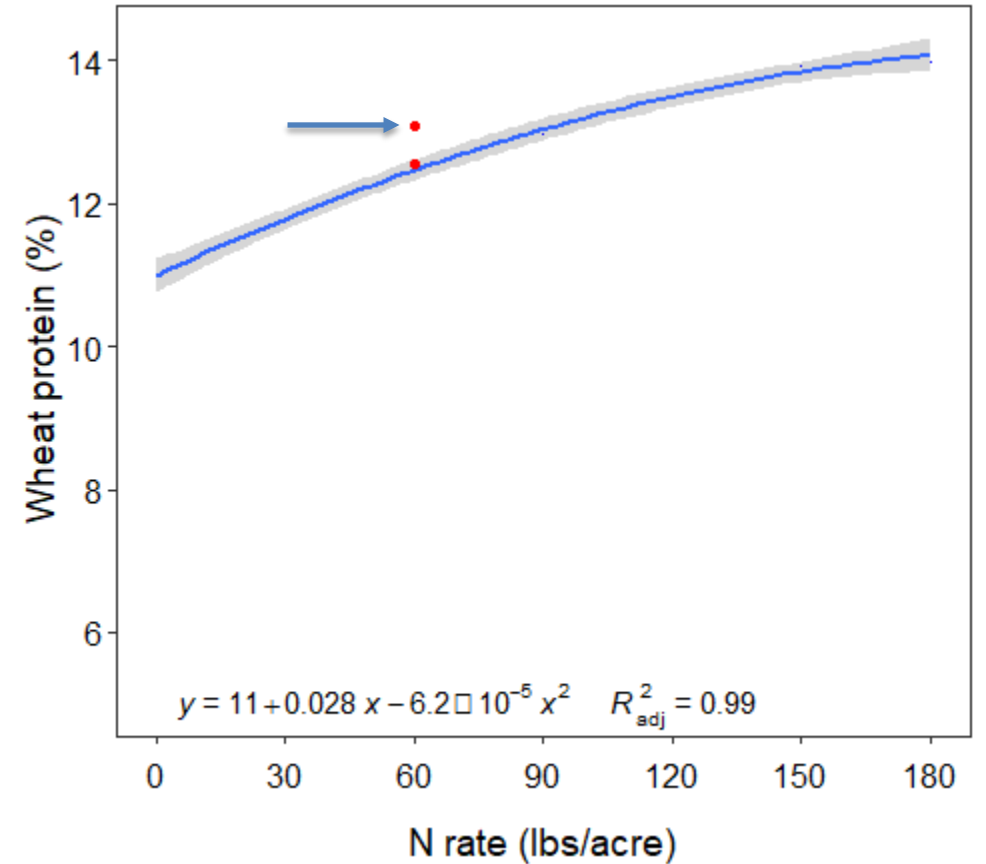
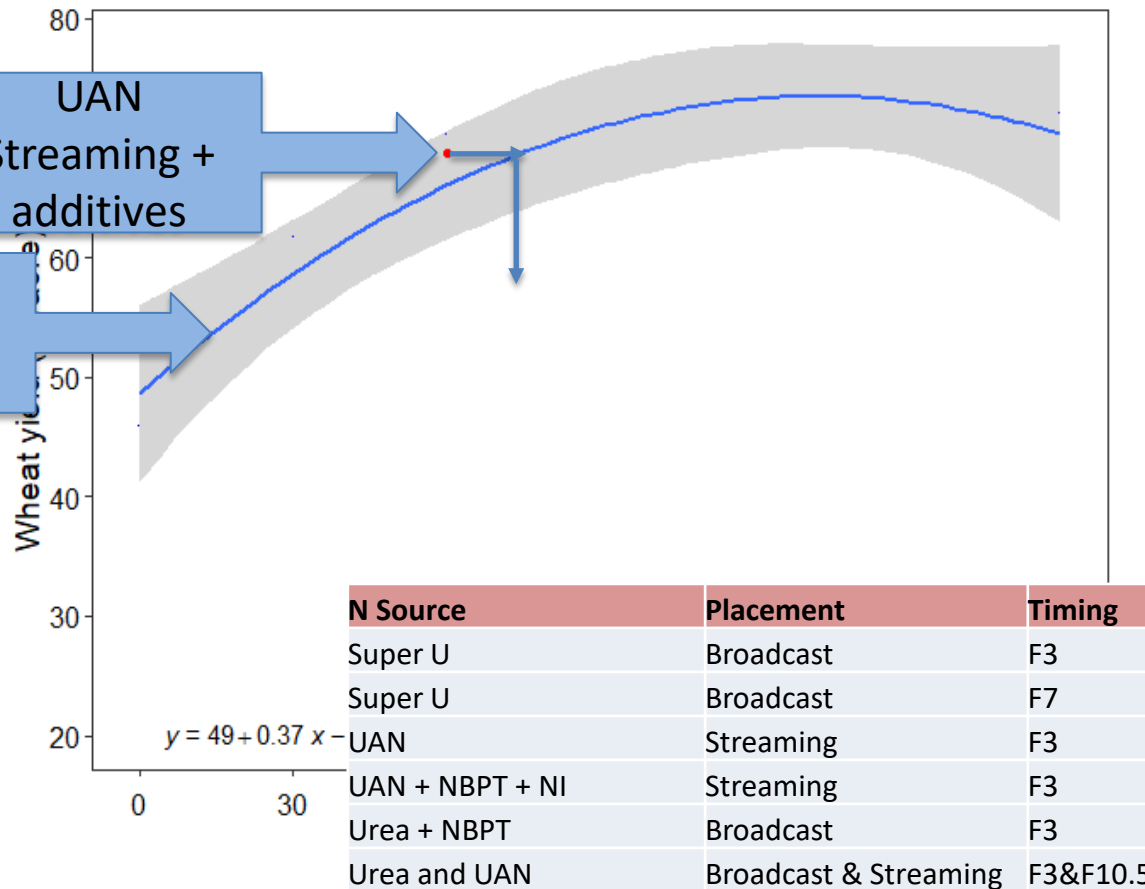
Summary

- Phosphorus can provide flexibility during tight budget years
 - High soil test levels
 - Manure application
- Use good soil test information
- Don't reduce P in low testing fields, profits are very likely

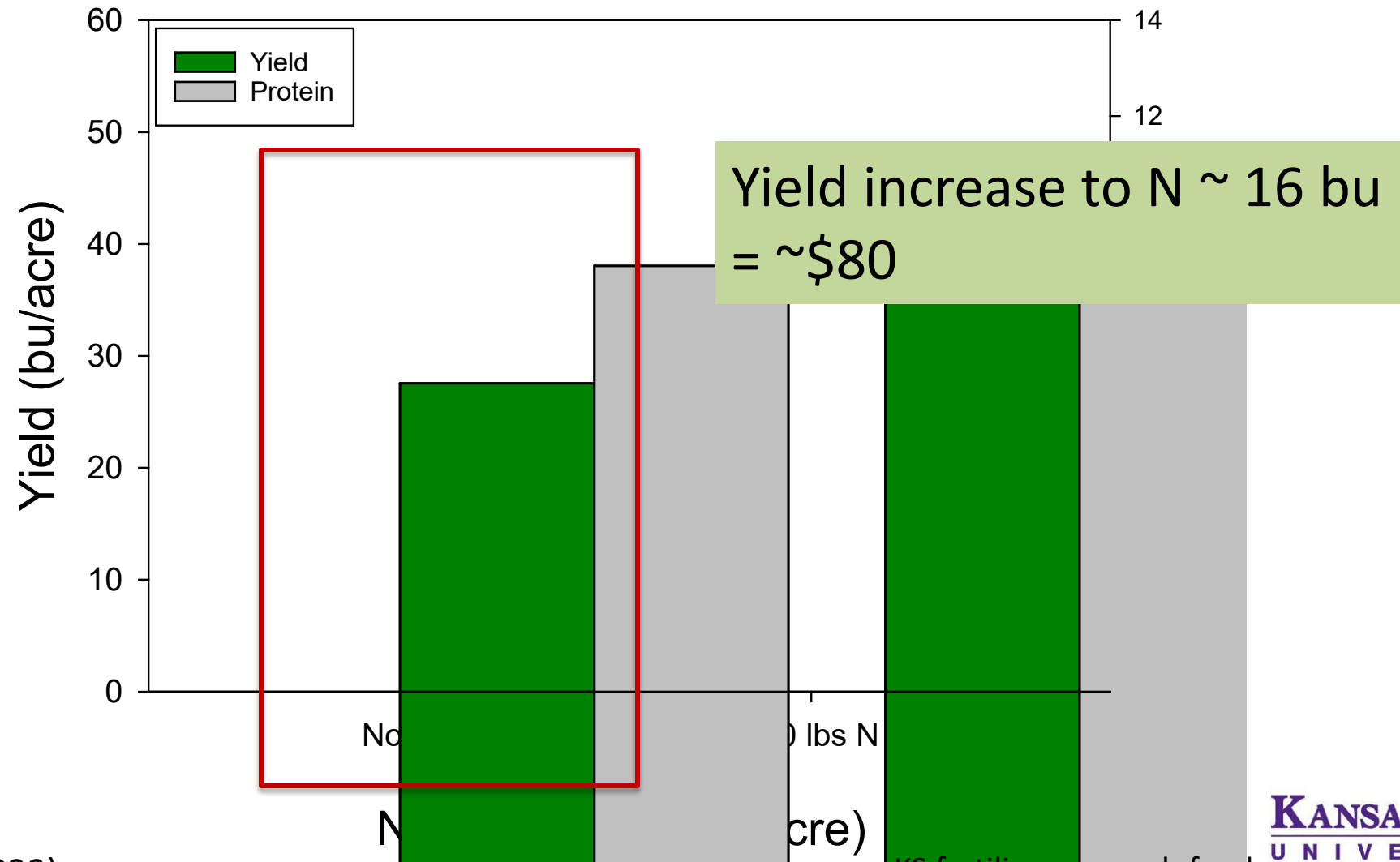
Corn response to N fertilizer



Wheat: Nitrogen management options in: Yield and protein



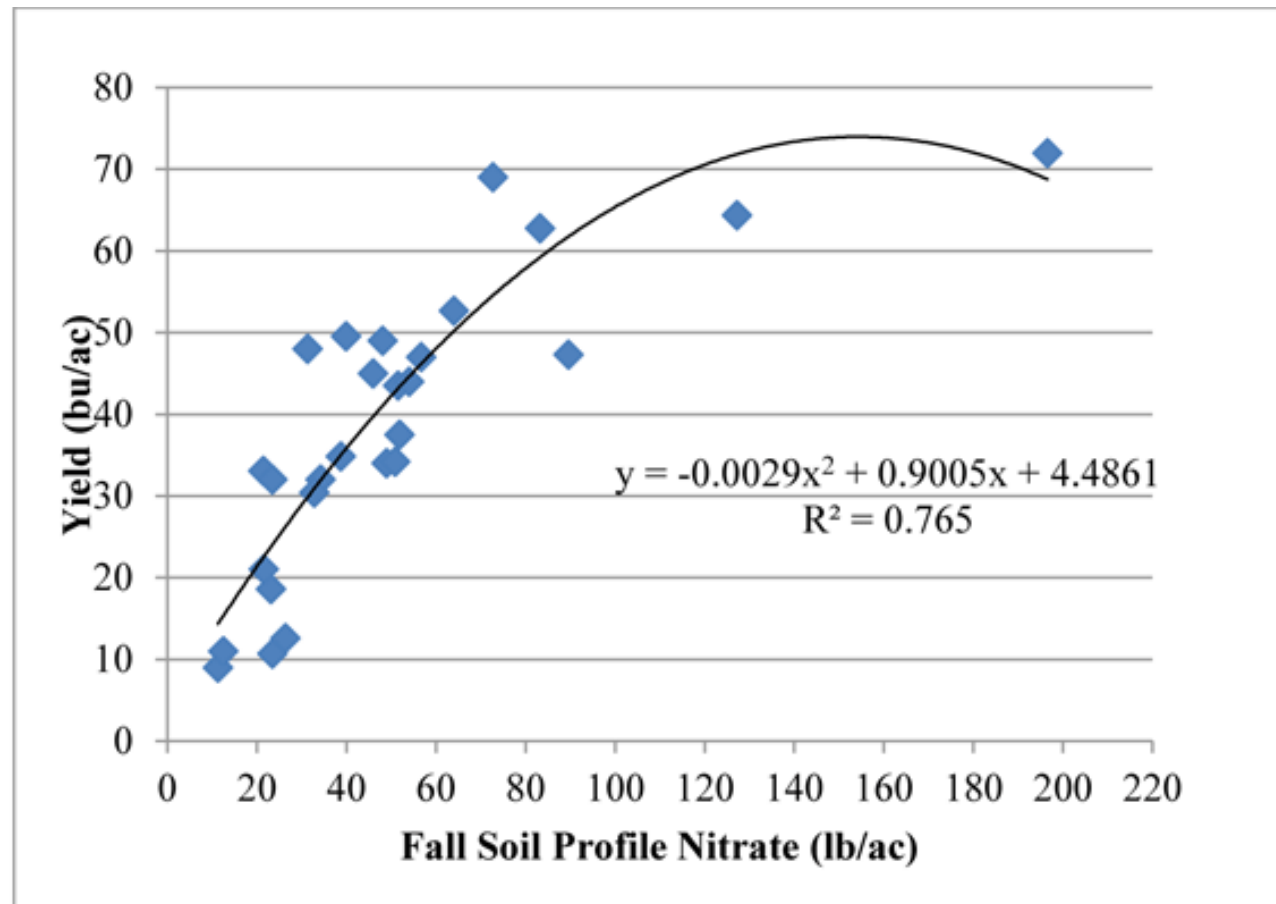
Nitrogen deficiency effect on yield and protein (average of 21 sites)



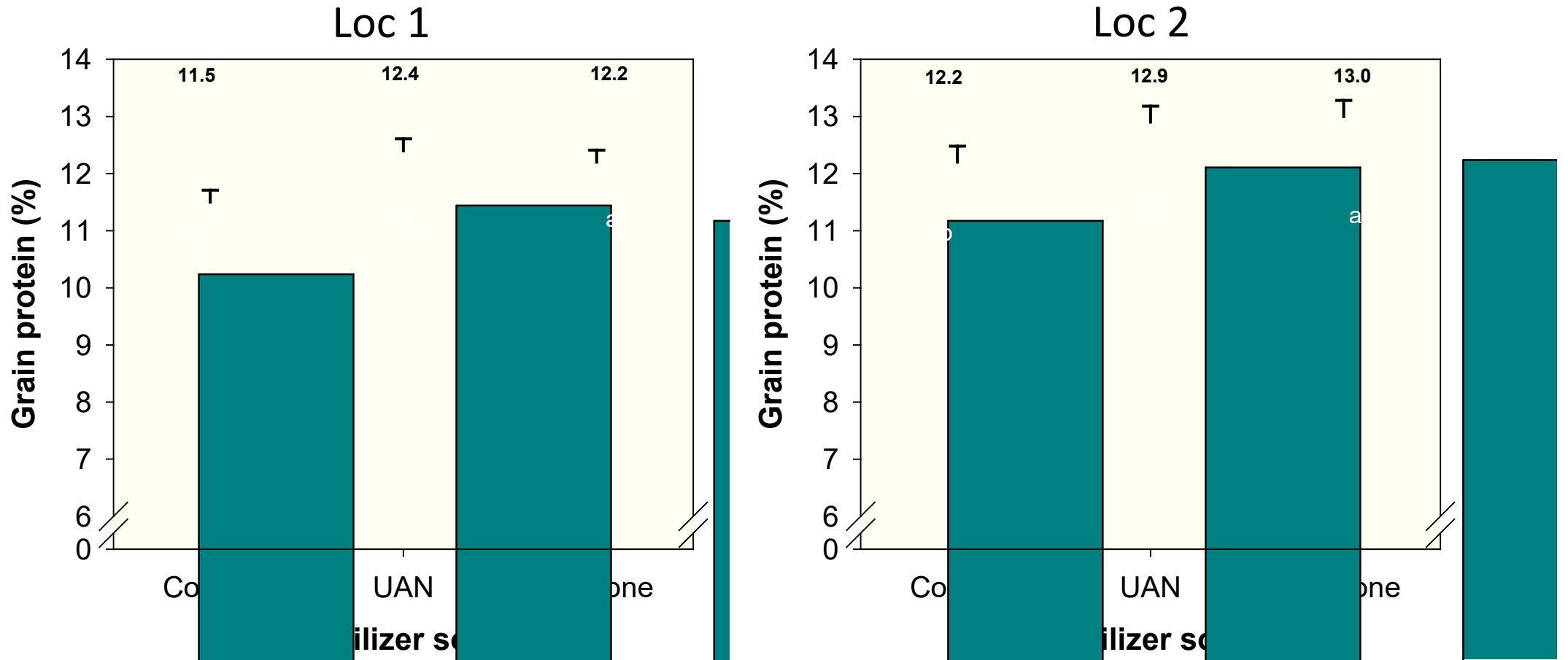
21 trials (2020-2023)

KS fertilizer research funds

Relationship between soil profile N and wheat yield with no N fertilizer

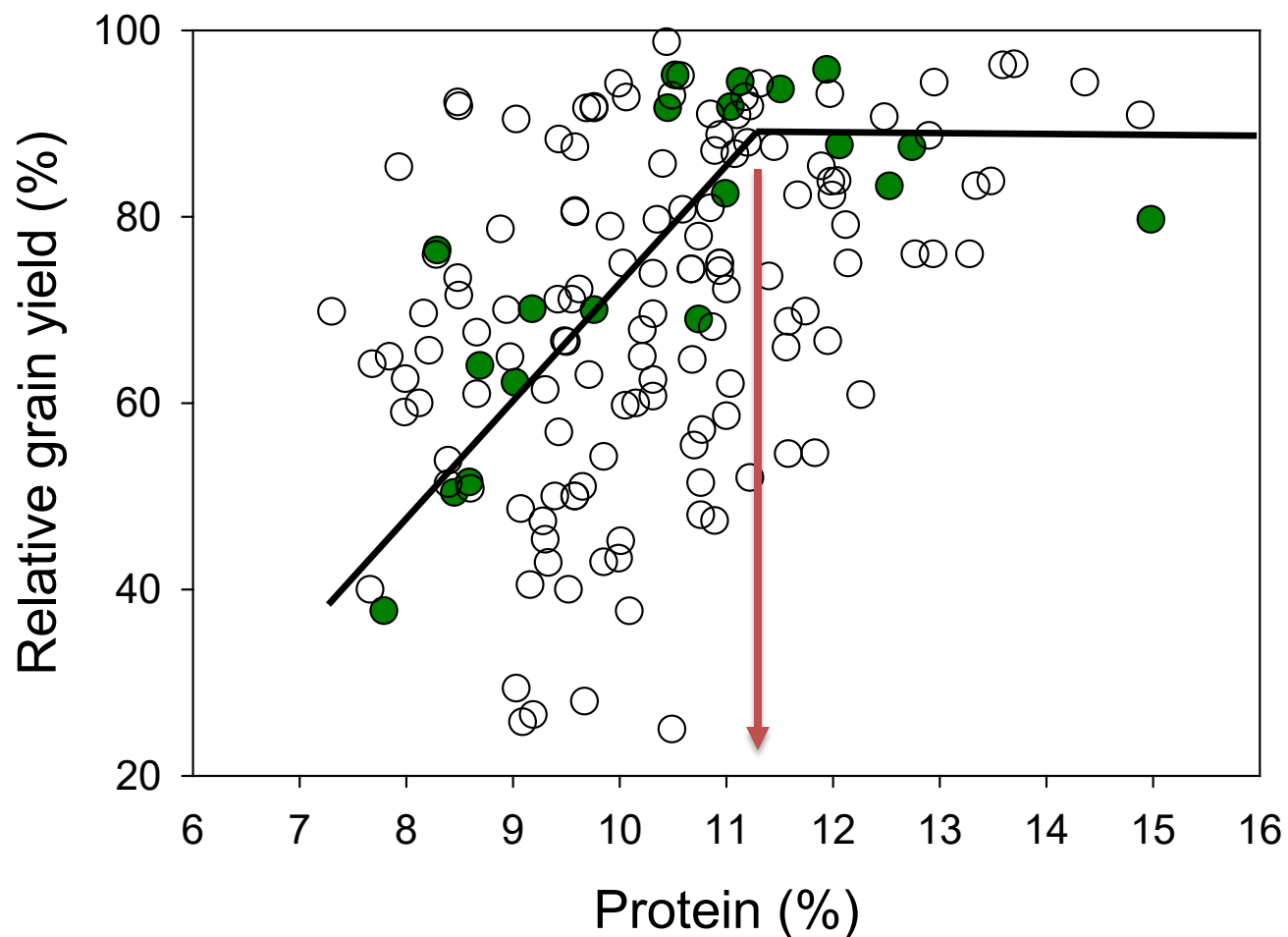


Foliar nitrogen with fungicides and grain protein, what about yield?



~ 6.3 lbs N/acre

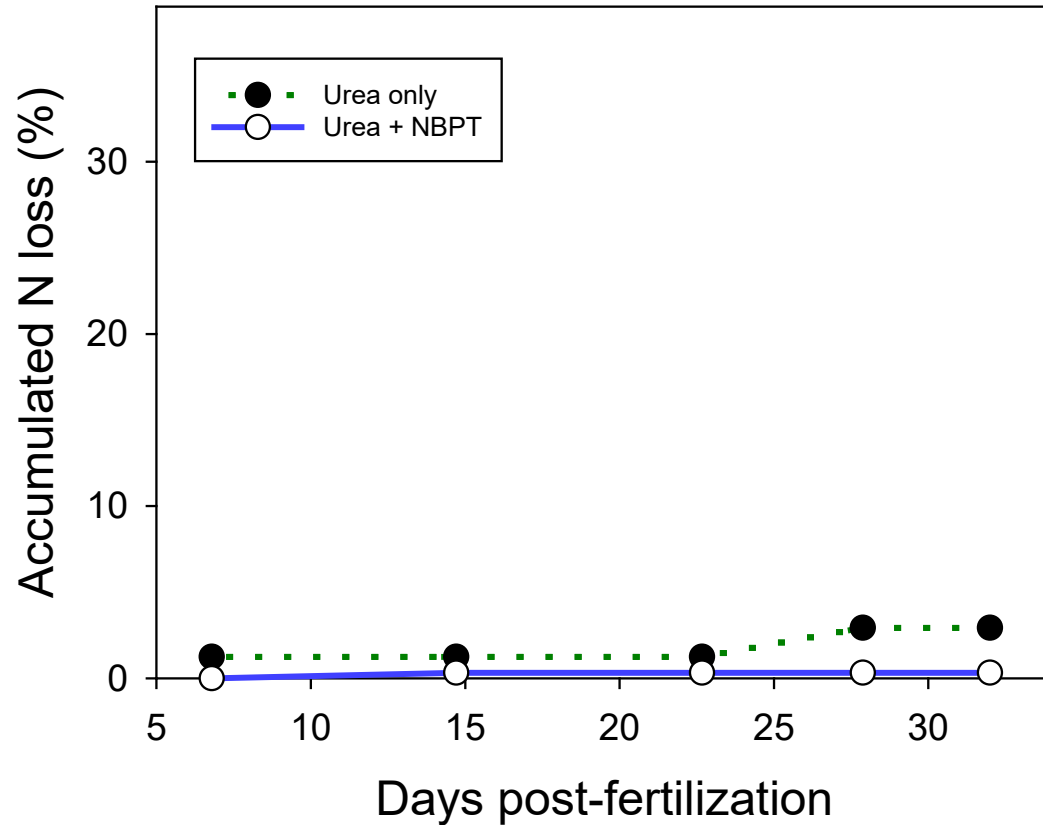
Grain protein content as an indicator of N sufficiency



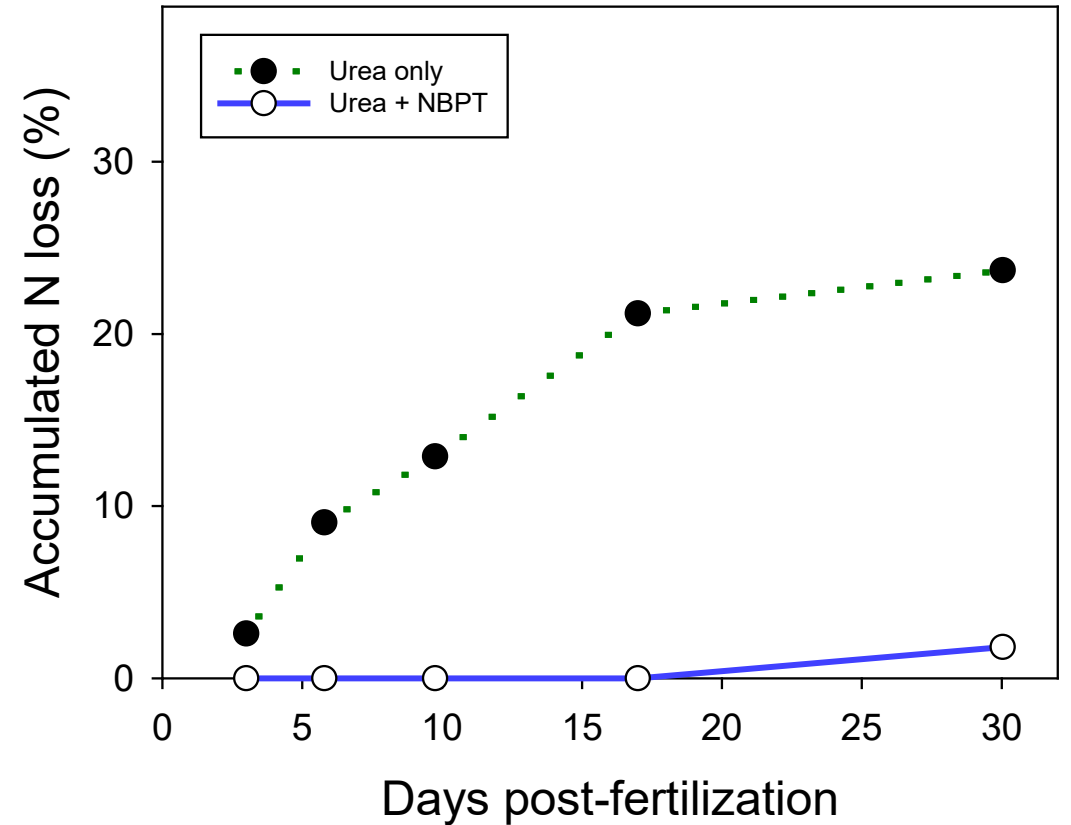
- 21 trials (2012-2023)
- 134 trials (last ~15 years)

Volatilization potential with top-dress urea

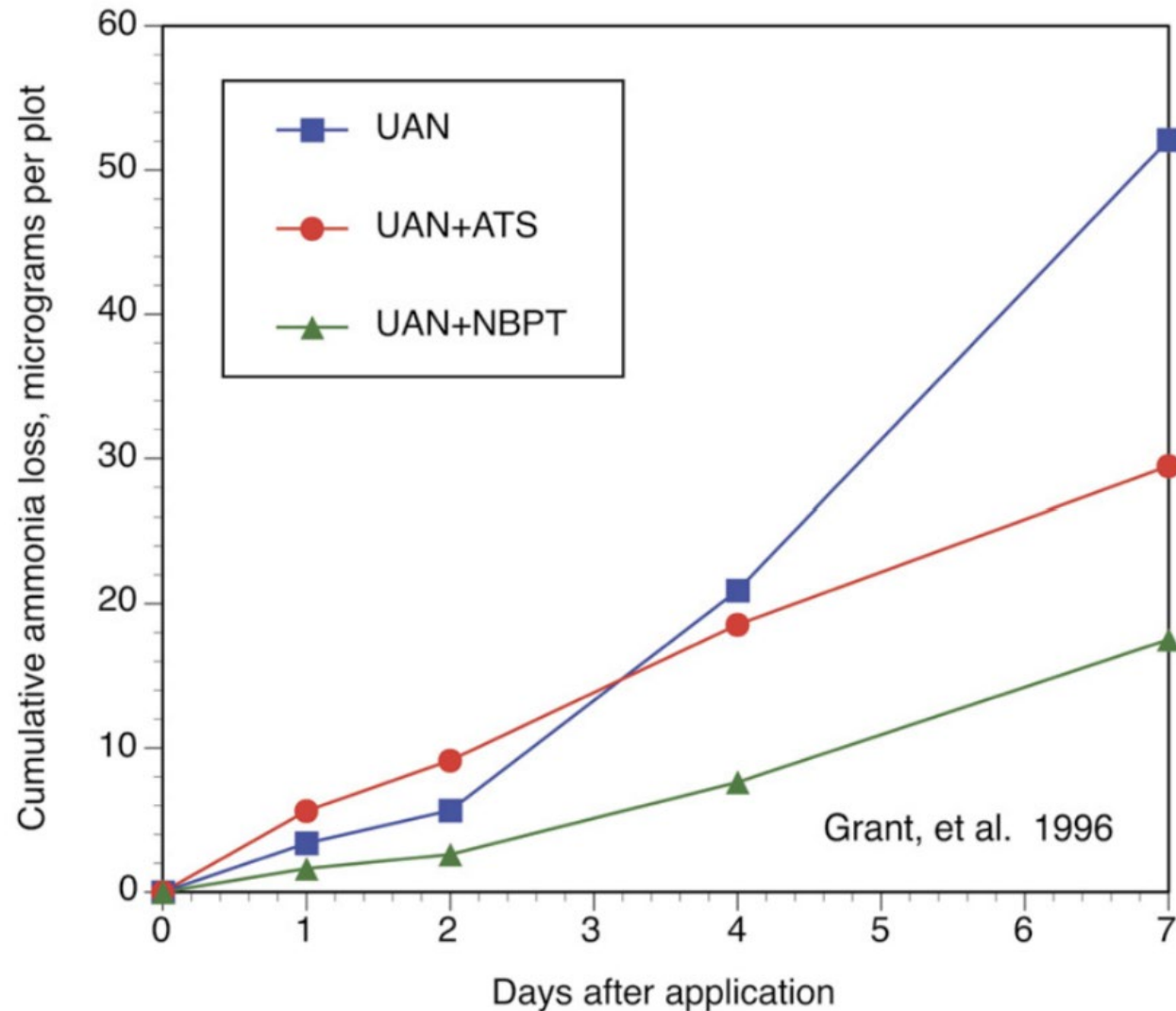
Low surface residue



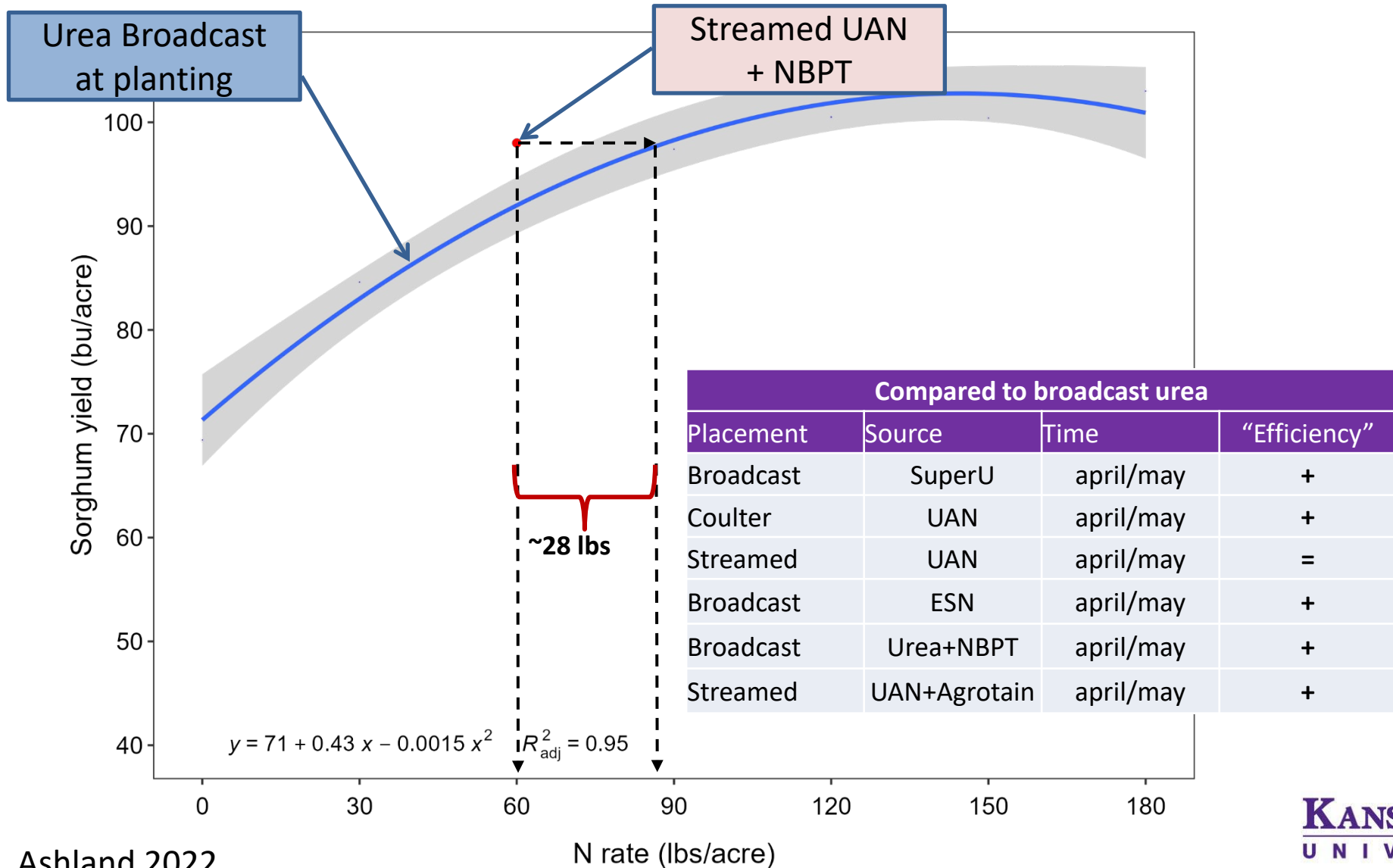
High surface residue



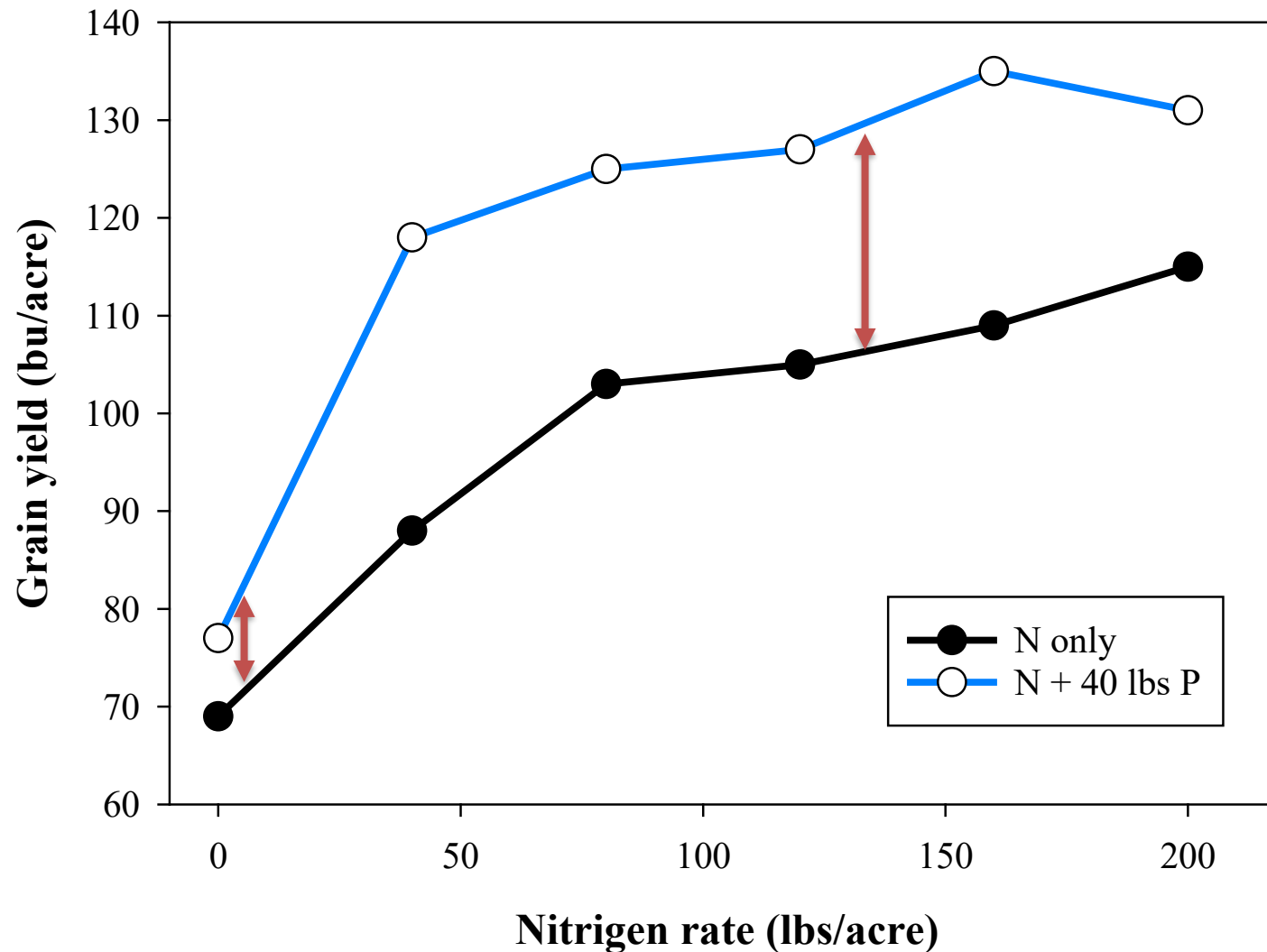
Nitrogen volatilization loss from UAN (urea portion) with NBPT and ammonium thiosulfate (ATS)



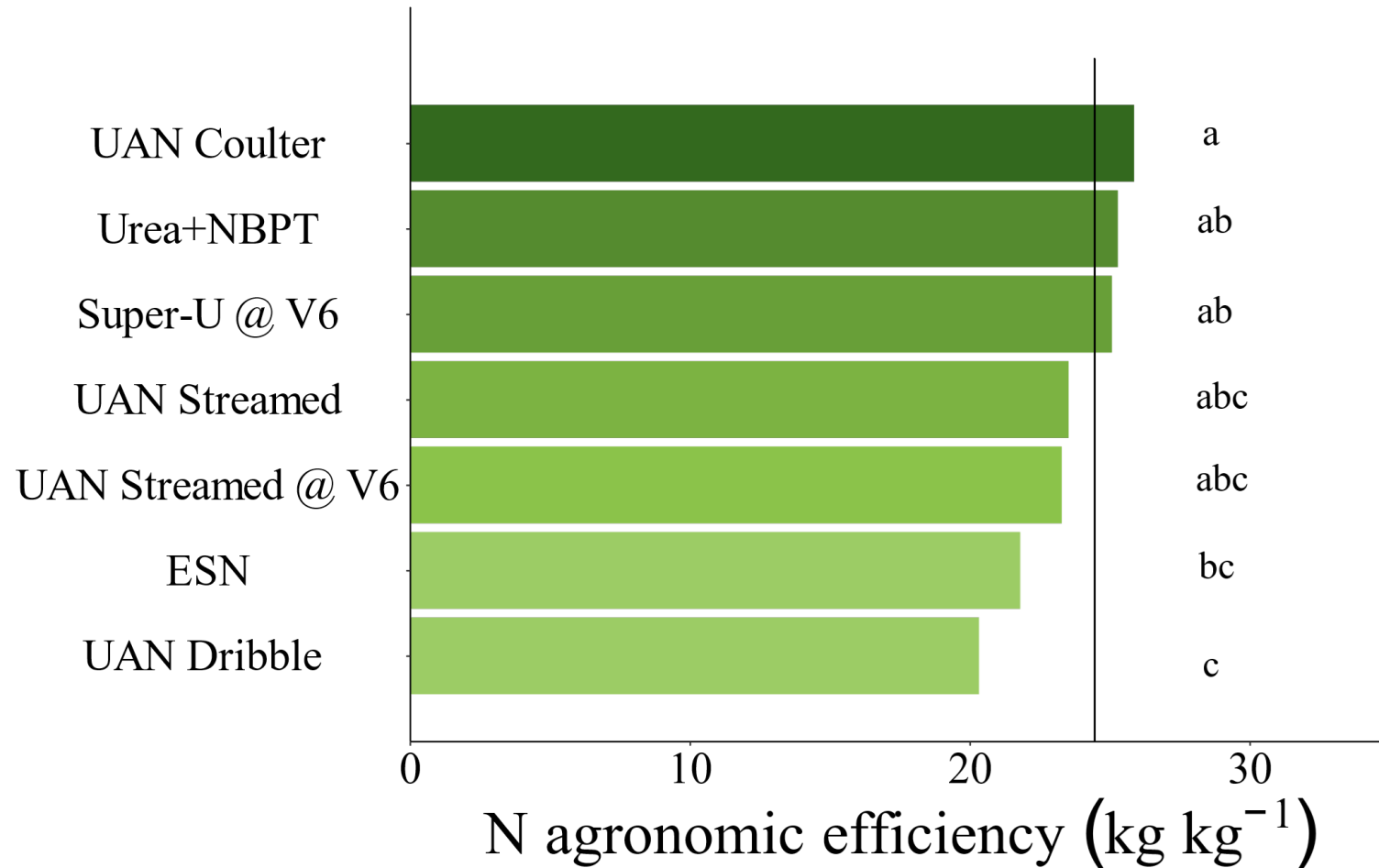
Sorghum and N fertilizer management



Sorghum: nitrogen response and phosphorus interaction



Corn: Nitrogen fertilizer source, time placement combinations to increase efficiency



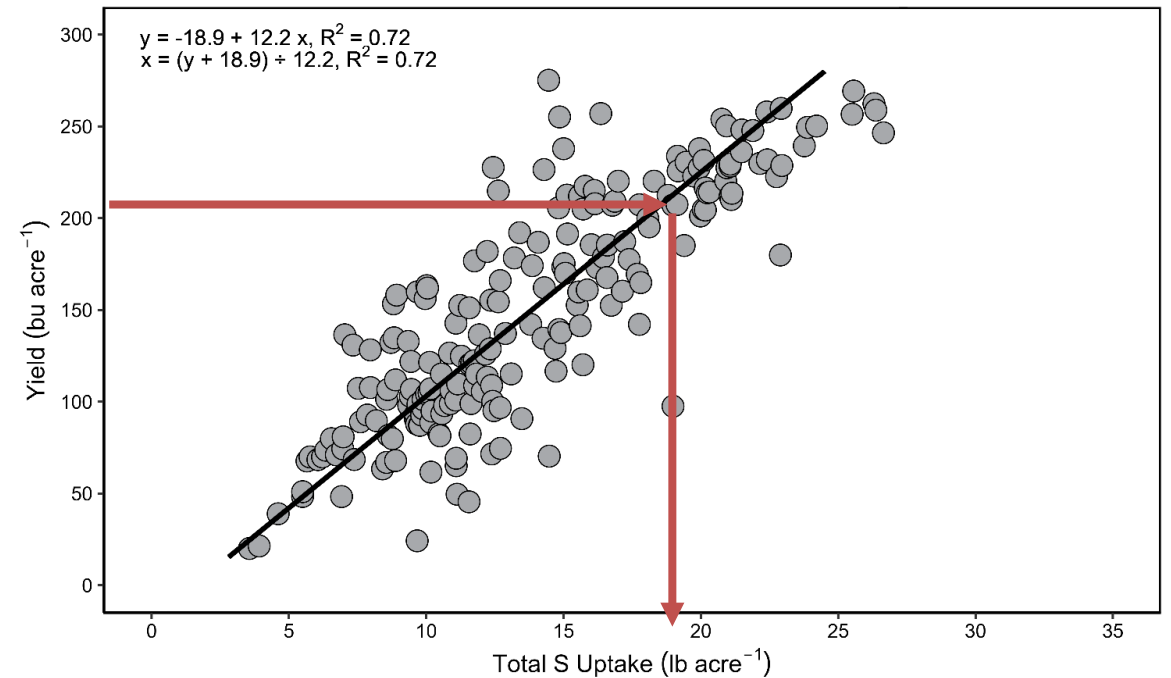
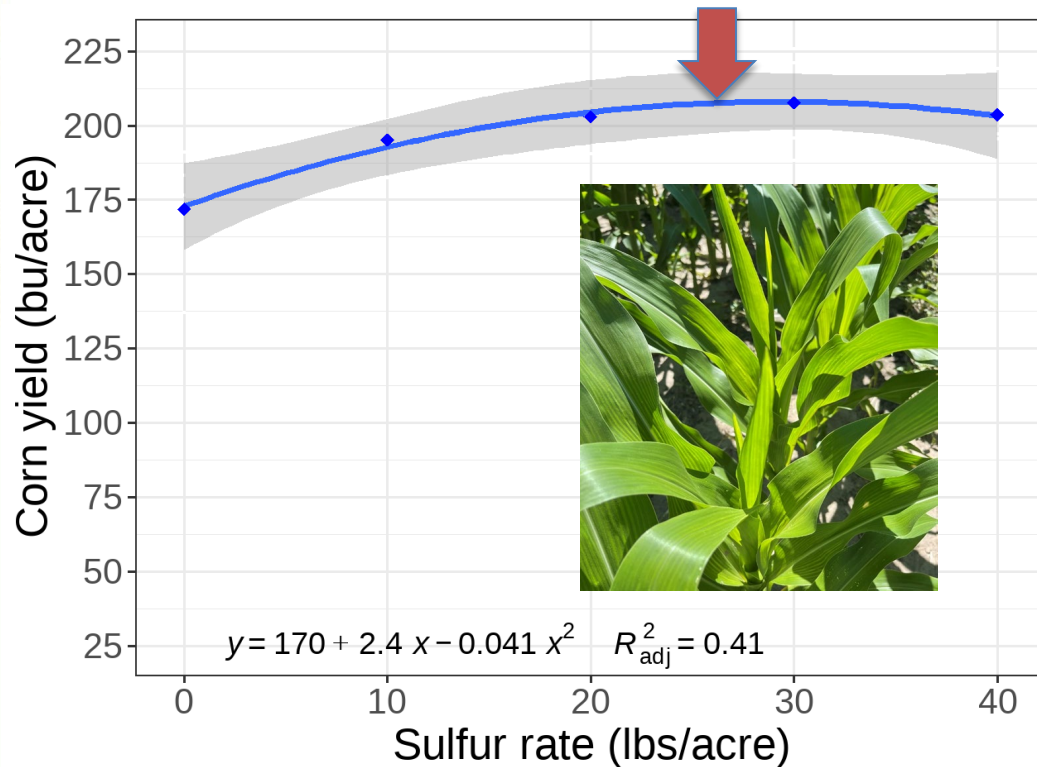
Managing nitrogen in season: key processes affecting N use efficiency

<u>Loss process</u>	<u>N form</u>	<u>Management options</u>

Nitrogen fertilizer sources and efficiency?

- Two main drivers for nitrogen use efficiency (after establishing the optimum rate) are:
 - Placement
 - Time of application
- Additives and specialty fertilizers can help under specific situations

Responsive locations to sulfur



220 bu/a corn take up
~ 19 lb S/a

Other nutrient priorities?

- Sulfur
- Chloride in some soils: wheat, sorghum, and corn
- Potassium is generally optimum; however, soil K will continue to decrease with removal
- Micros in very specific cases (Zn, Fe, B)

Summary

- Corn is highly responsive to N, return to fertilizer is highly likely
 - Maybe more flexibility with wheat and sorghum
- Opportunities with increased efficiency
 - Placement, and additives when necessary



Thank you!

@SoilFertilityKS

ruizdiaz@ksu.edu