Potassium for Corn: Soil Testing and Yield Response in the Northern Plains

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Our Potassium Journey

- Potassium nutrition for corn
- Revising the recommendations
- Potassium rate study: 2015-2016
  - Soil test comparison
  - Yield response to fertilization
  - Sampling time for soil potassium

Potassium nutrition for corn

Deficiency symptoms

- Chlorosis, necrosis of outer leaf margin
- Mobile nutrient in plant
  - Expressed in lower leaves

Potassium nutrition for corn

Near Lisbon, ND (Aug. 2016)
Soil K: 47 ppm

<u>Plot 106</u>	<u>Plot 107</u>
0 K_2O/ac	150 K_2O/ac
174 bu/ac	226 bu/ac

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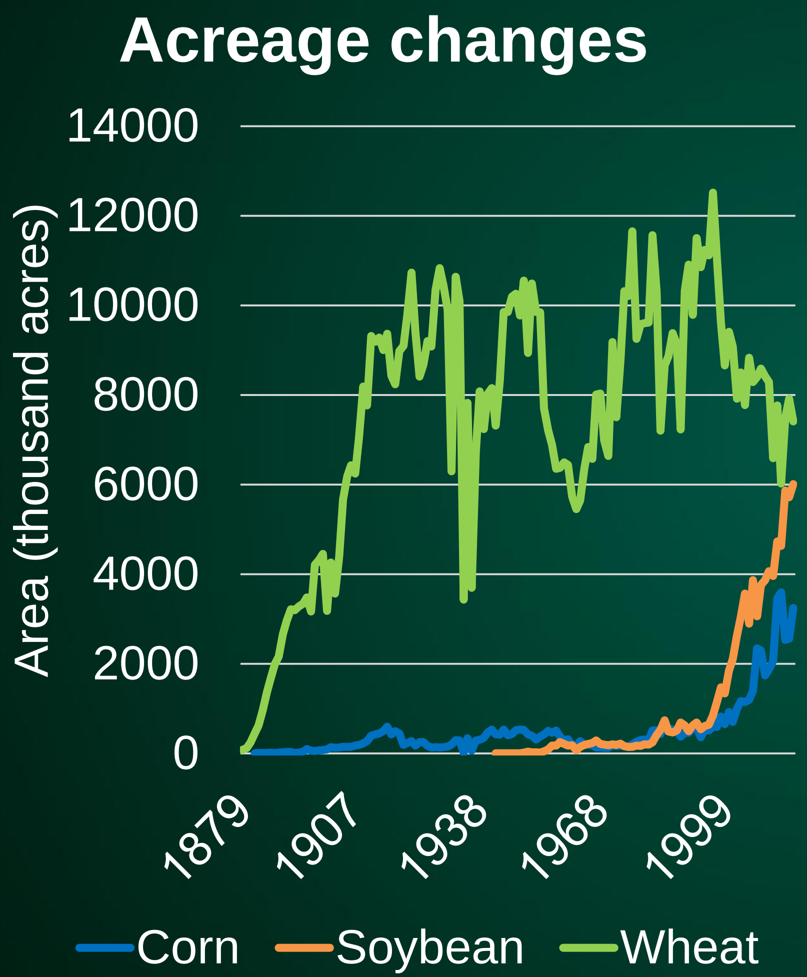
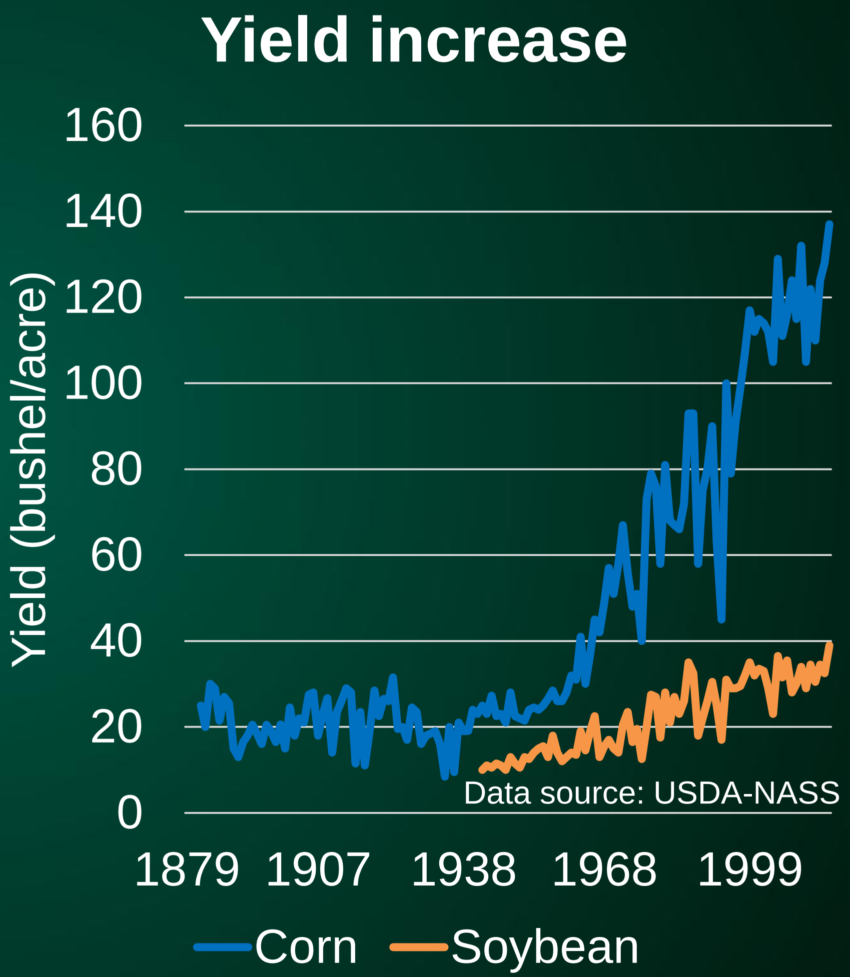
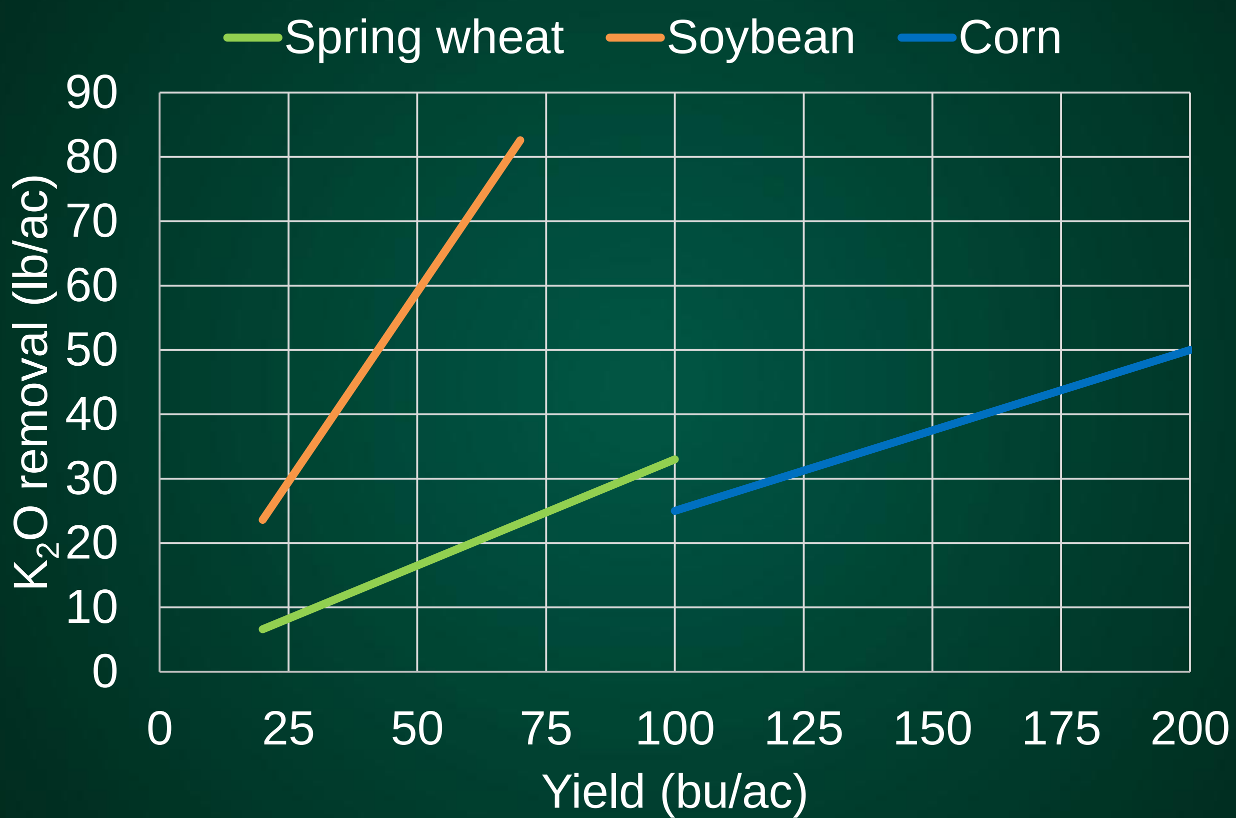
- Potassium mineralogy

Increase in ND corn/soybean acres





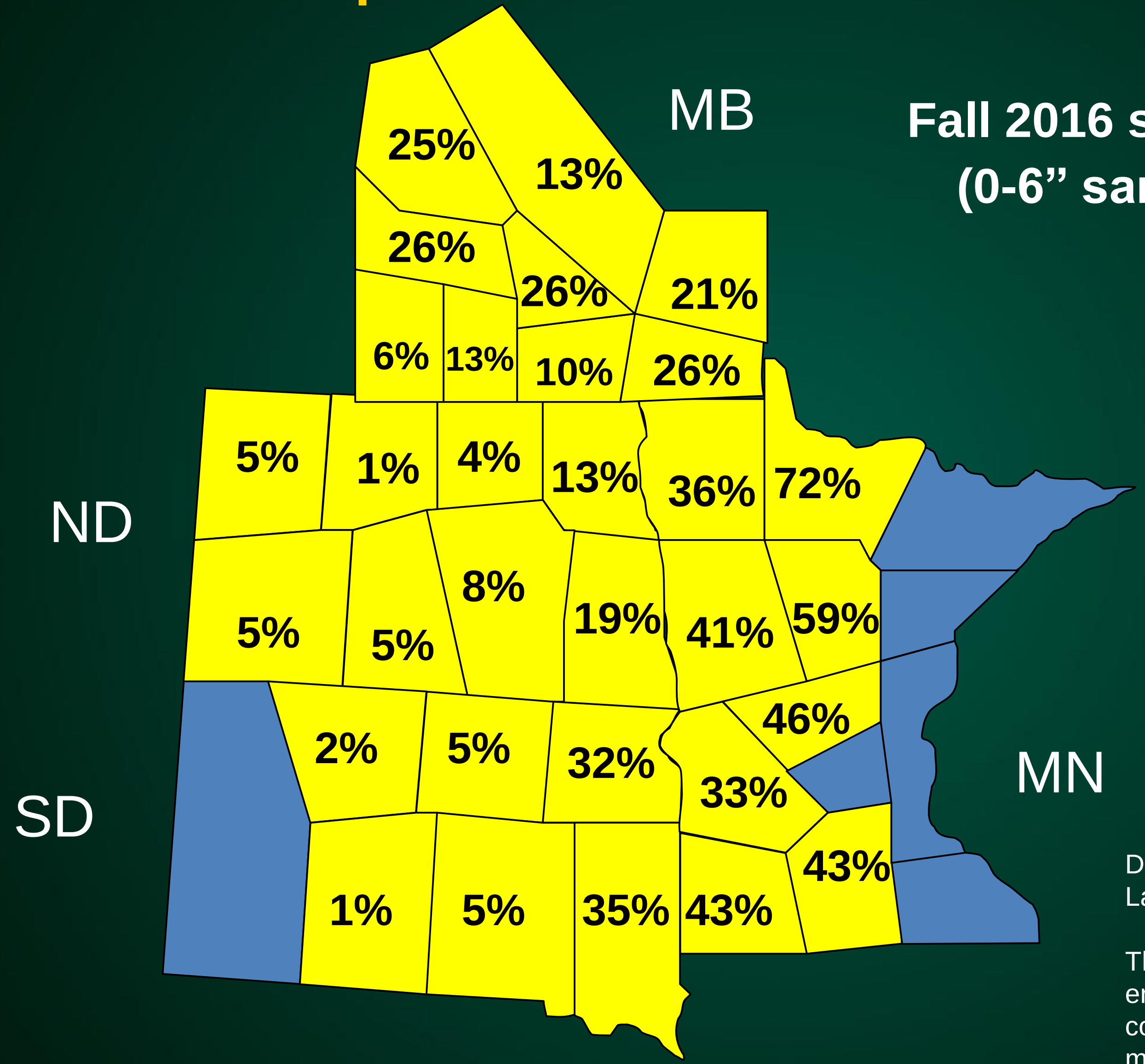
Typical K removal in grain for principal crops at various yields



Change to corn/soybean production removing K at twice the rate

Soil samples with less than 150 ppm K

Fall 2016 samples
(0-6” samples)



Data provided courtesy of AGVISE Laboratories, Northwood, ND.

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Revisiting potassium in North Dakota

- Increase in corn/soybean acreage
  - Higher yields, higher K export
- More soil tests below critical level
  - 1980: 3% of samples (Nelson, 1980)
  - 2010: 17% of samples (Fixen et al., 2010)
  - 2015: 16% of samples (IPNI, 2015)
- Potash price spike

  ~$150/ton (1980-early 2000s)

  $853/ton (2009)

Developing a recommendation: Find the soil test critical level

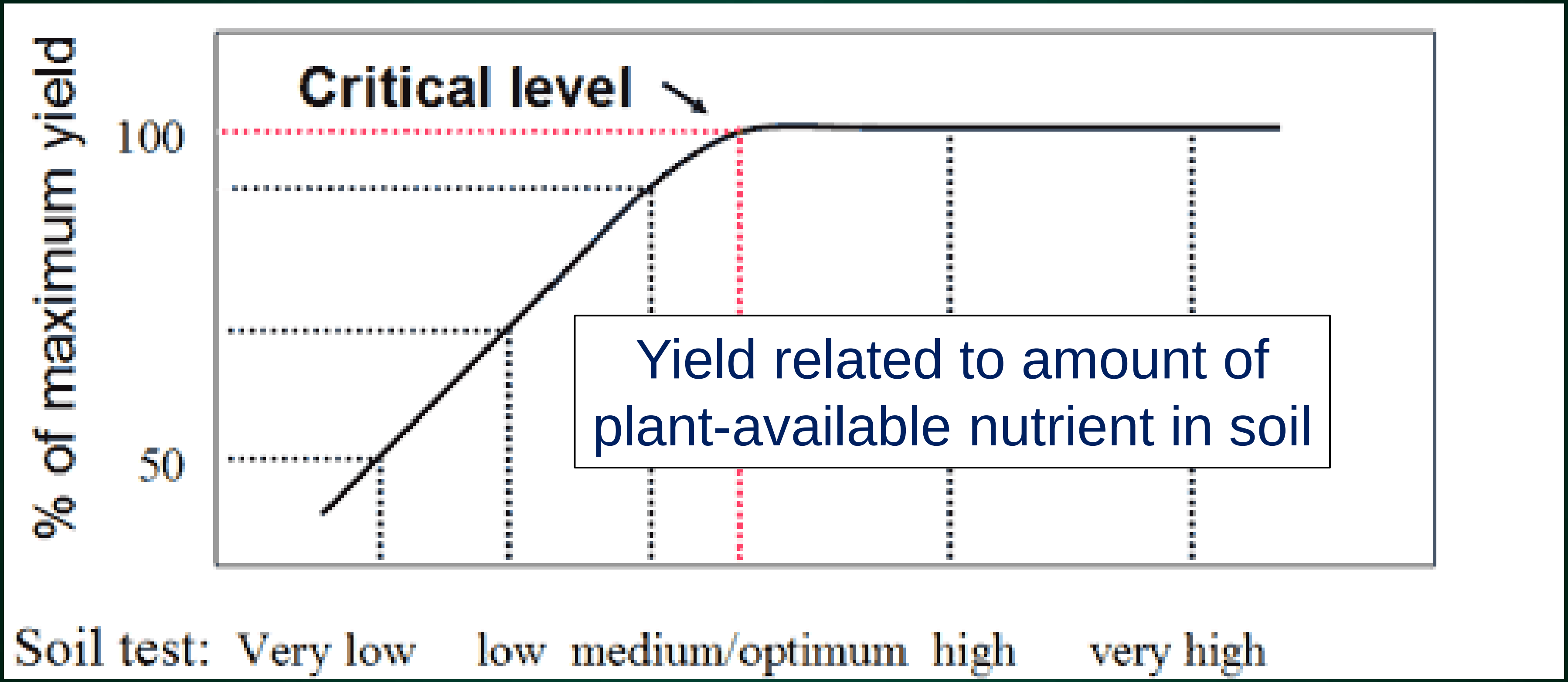
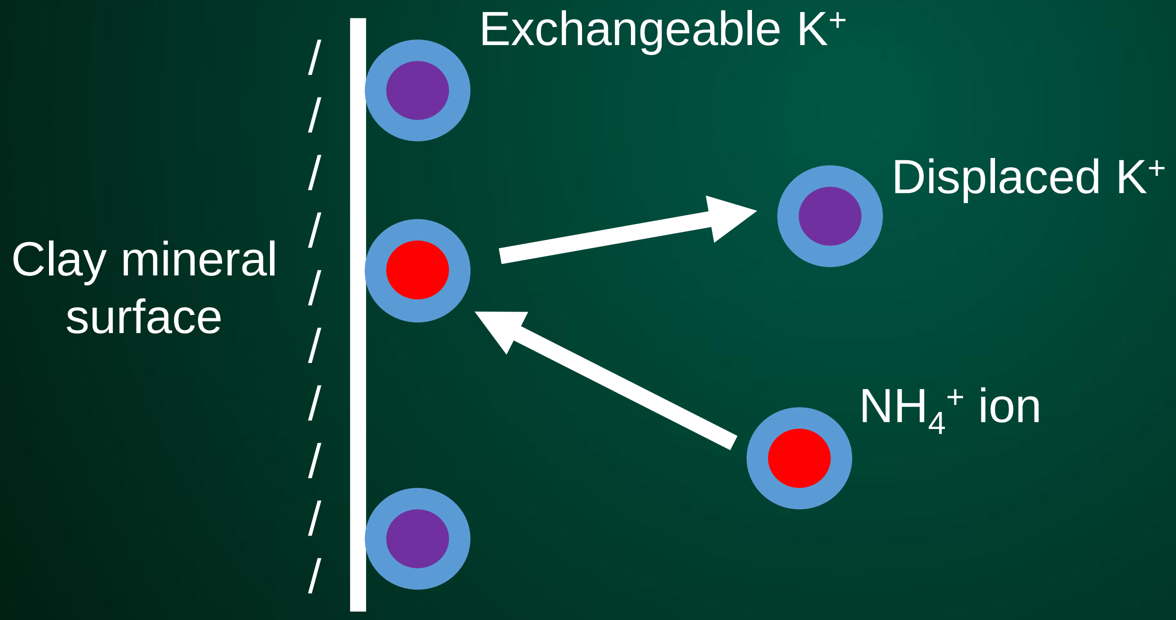


Image from https://courses.cit.cornell.edu/css412/mod3/ext_m3_pg3.htm

Soil testing for potassium

Standard method in North Central region:

1.0 M NH_4OAC (pH 7) extraction on dry soil



Scrutiny of soil K test method

Standard method in North Central region:

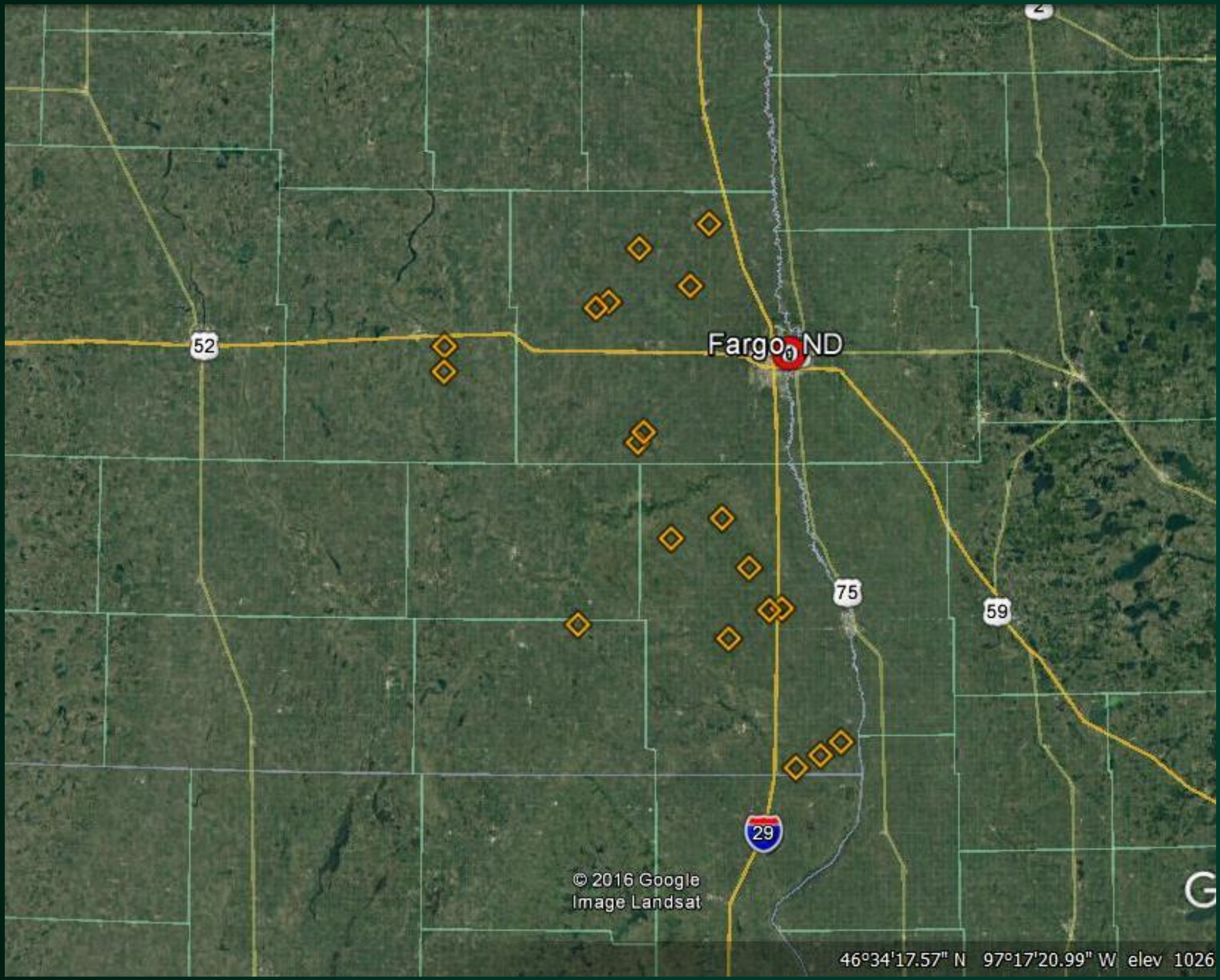
1.0 M NH_4OAC (pH 7) extraction on dry soil

- Effect of sample drying on extractable K
- Inconsistent yield responses to K fertilization
- Plant availability of nonexchangeable K
  - The K sandwich (a packed lunch)
- Seasonal soil test K variation

Study objectives

1. Evaluate corn yield response to K fertilization
2. Identify adequate soil K test method
    - Determine critical level
3. Assess seasonal soil K variation

Potassium rate trials



2015: 13 sites

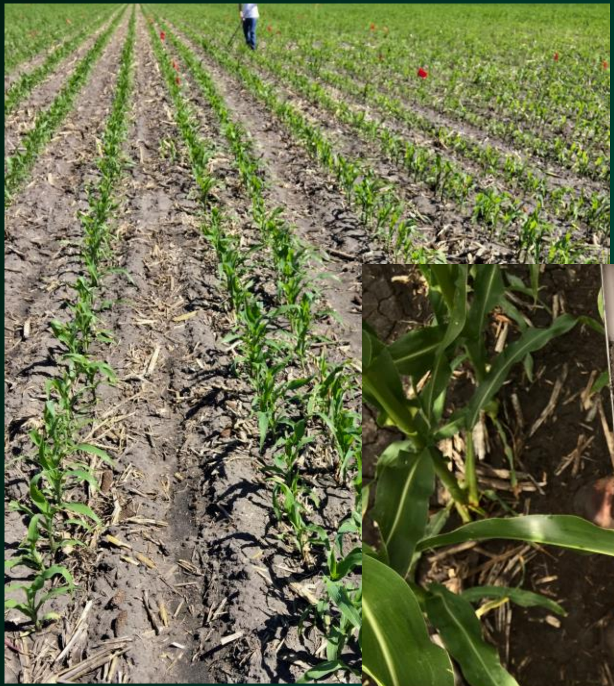
2016: 6 sites

Study Timeline

Spring

- RCBD with four reps
  - Expt. Unit: 10 ft x 30 ft
- Urea, MAP, gypsum broadcast
- Six KCl (0-0-60) rates
  - 0, 30, 60, 90, 120, 150 lb K_2O/acre
  - Shallow incorporation (2-3 inches)

Study Timeline



Summer
- Soil samples
  - Biweekly: 0-6 inch
- Plant samples (2016)
  - V5: Whole plant
  - VT: Ear leaf

Fall
- Harvest one 30-foot corn row
- Yield, grain moisture, test weight

Soil test methods evaluated

- 1.0 M NH_4OAC (pH 7) extraction, 5 minute
  - Air-dried soil, ground
  - Field-moist soil, sieved
- Ion-exchange resin capsule, 168 hour incubation (UNIBEST, Inc.)
- Sodium tetraphenylboron extraction (Cox et al., 1999)
  - 5 minute, most reactive nonexchangeable K
  - 168 hour, total nonexchangeable K
- Soil mineralogy (ACT Labs, Ontario)

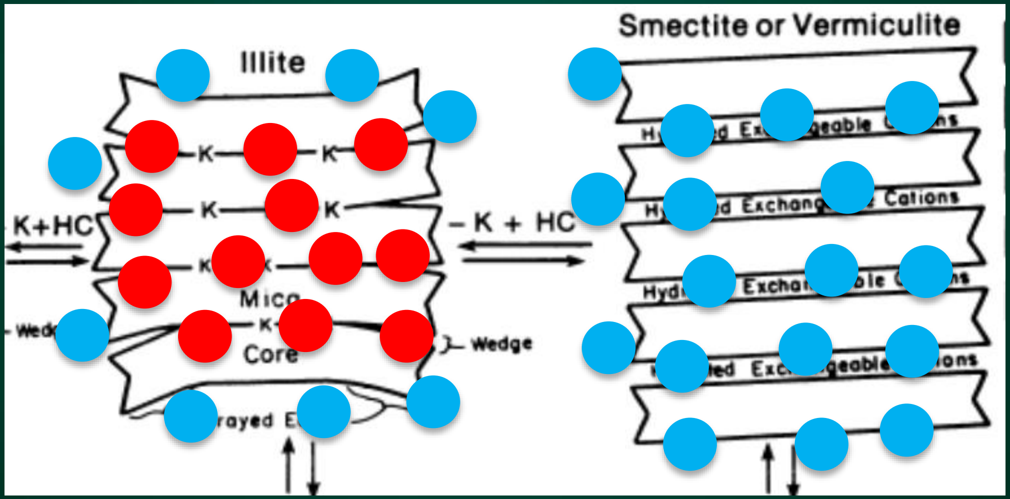
What K pools does a soil test target?

Tetraphenylboron: Releases interlayer-K
Resin: Equilibrate with exchangeable/interlayer-K

NH_4OAc
Dry soil: layers warp/collapse
Moist soil: field condition

<u>Nonexchangeable K</u>
K ions trapped in wedge sites or interlayer spaces

The K sandwich



From McLean and Watson, 1985

<u>Exchangeable K</u>
K ions adsorbed onto clay surfaces

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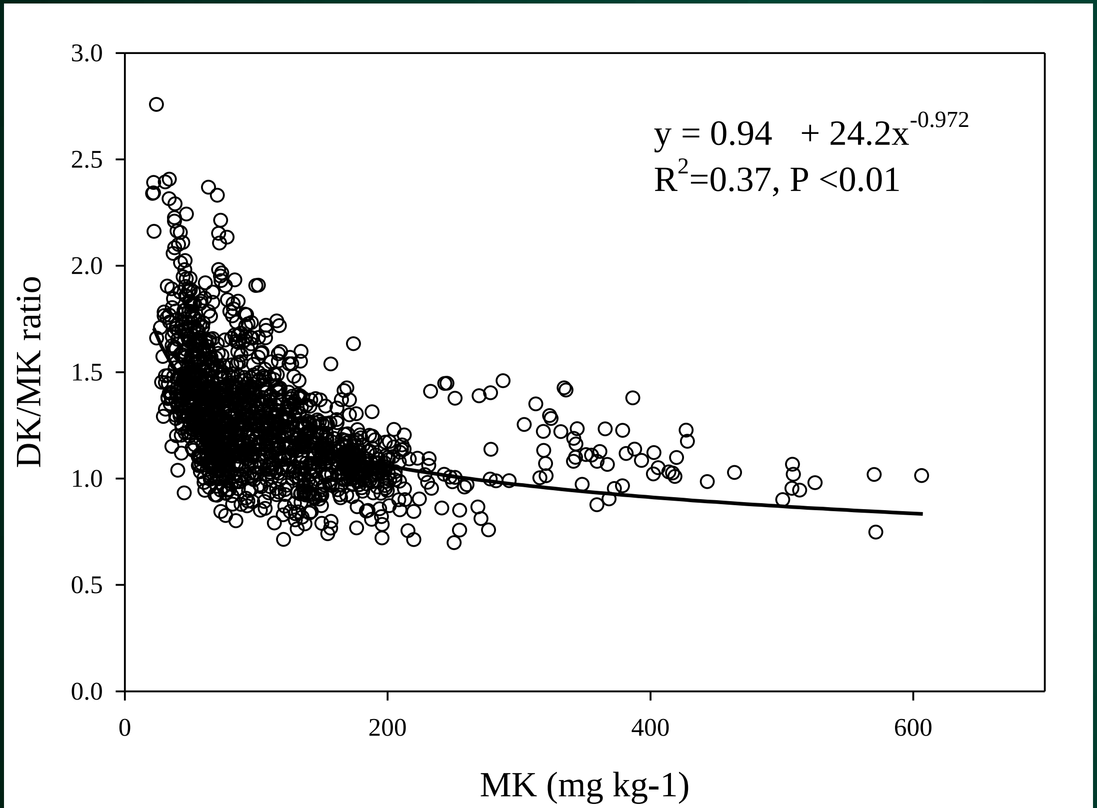
Correlations among K extraction methods

r	Dry K	Moist K	TBK 5min	TBK 168hr	Resin K
Dry K	1.00	0.96	0.94	0.75	0.67
Moist K		1.00	0.89	0.70	0.70
TBK 5min			1.00	0.88	0.46
TBK 168hr				1.00	0.14
Resin K					1.00

Good correlation between NH_4OAC and 5-min TBK

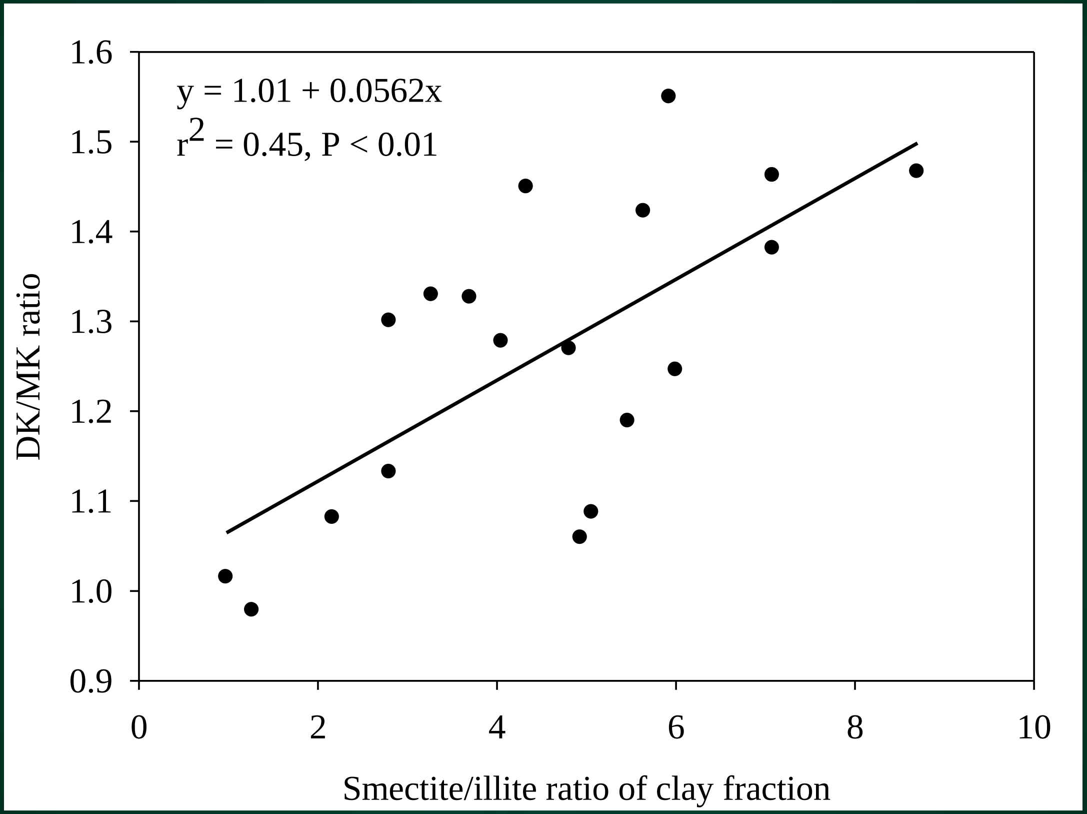
TBK and resin methods not related, different mechanisms

Sample drying increased NH_4OAc-extractable K



- Average: 1.26 times higher
- Range: 0.8-2.4
- Increase higher for low K soils

Smectitic soils released more K



And *then* drying got complicated…

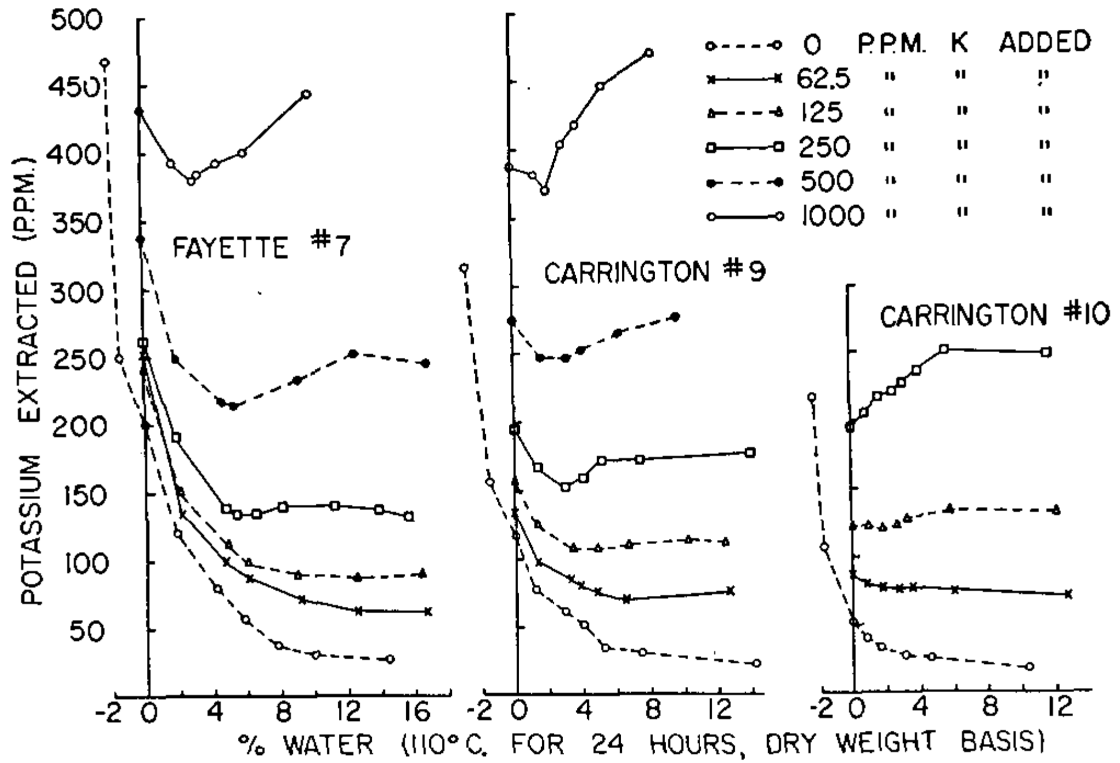


Figure 1.—K extracted with neutral 1*N* NH_4Ac from soils that had been dried to various moisture levels after increments of KCl had been added.

From Scott et al., 1957

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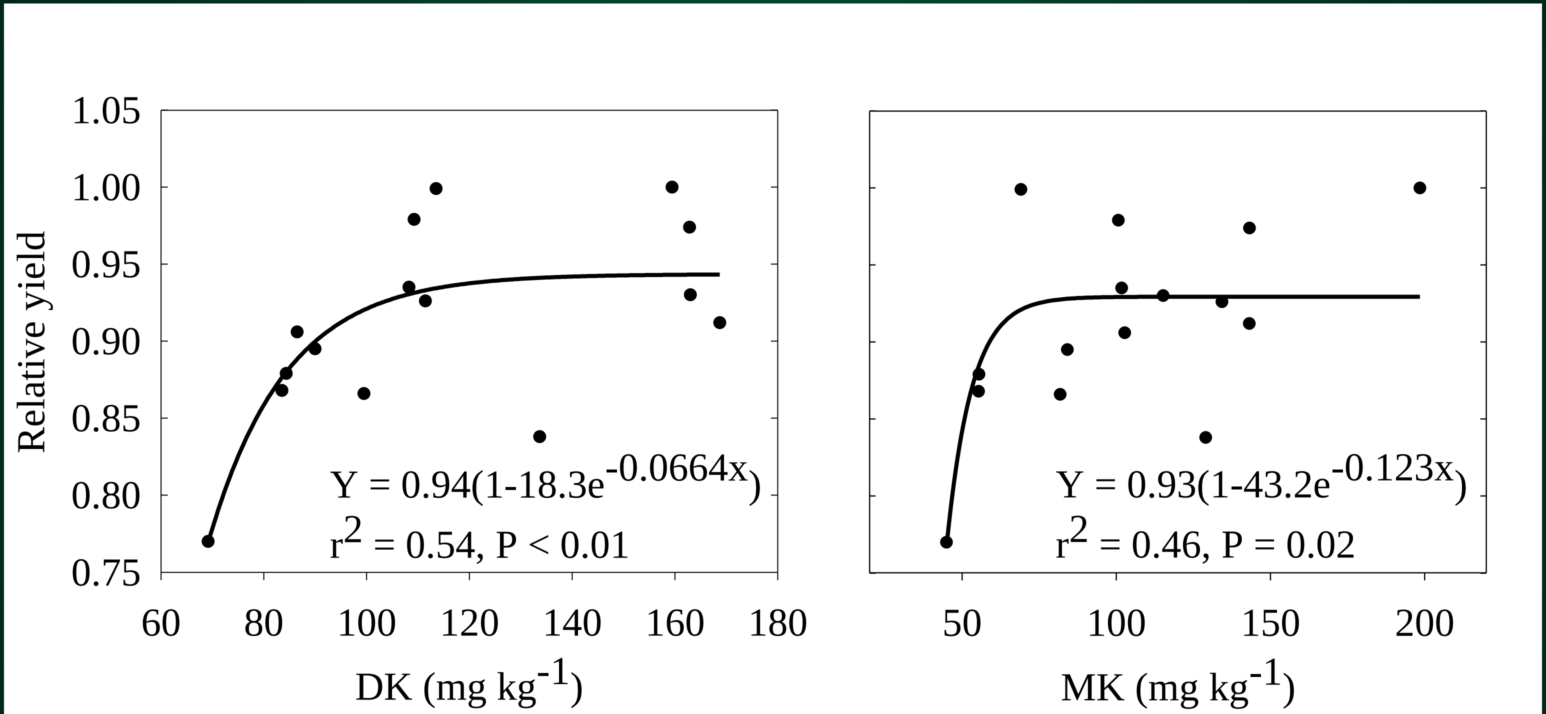
Yield response prediction by soil test class

Frequency of yield response prediction by dry soil K test					
	Soil K test class (mg kg^{-1})				
	VL	**L**	**M**	**H**	**VH**
	0-40	**41-80**	**81-120**	**121-160**	**161+**
Number of sites in soil test class	0	3	6	5	5
Number of sites with significant yield response	---	2	2	2	1
Probability of significant yield response	---	67%	33%	40%	20%

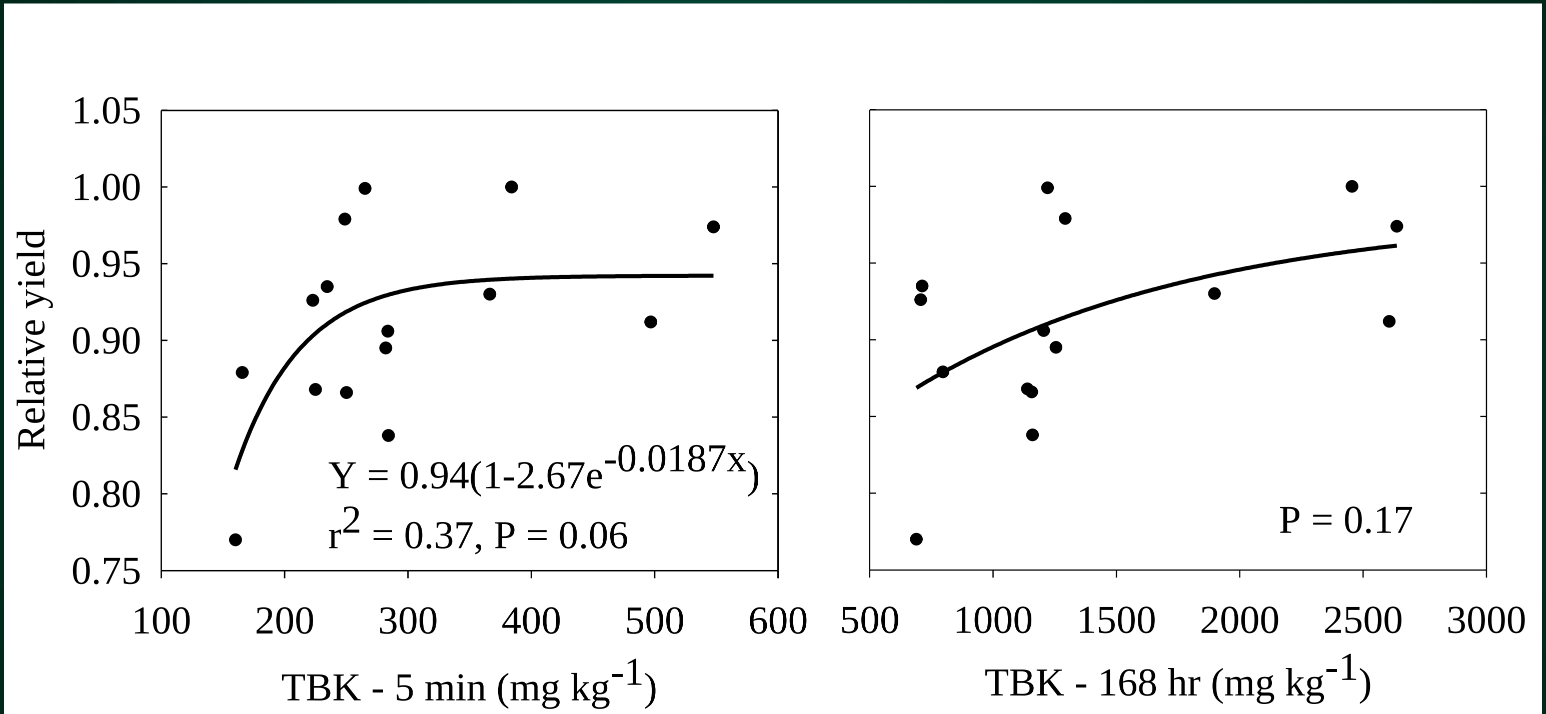
- Six of 14 sites below 150 ppm critical level responded (less than half)

Soil test K and yield response: NH_4OAc K on dry and moist soil



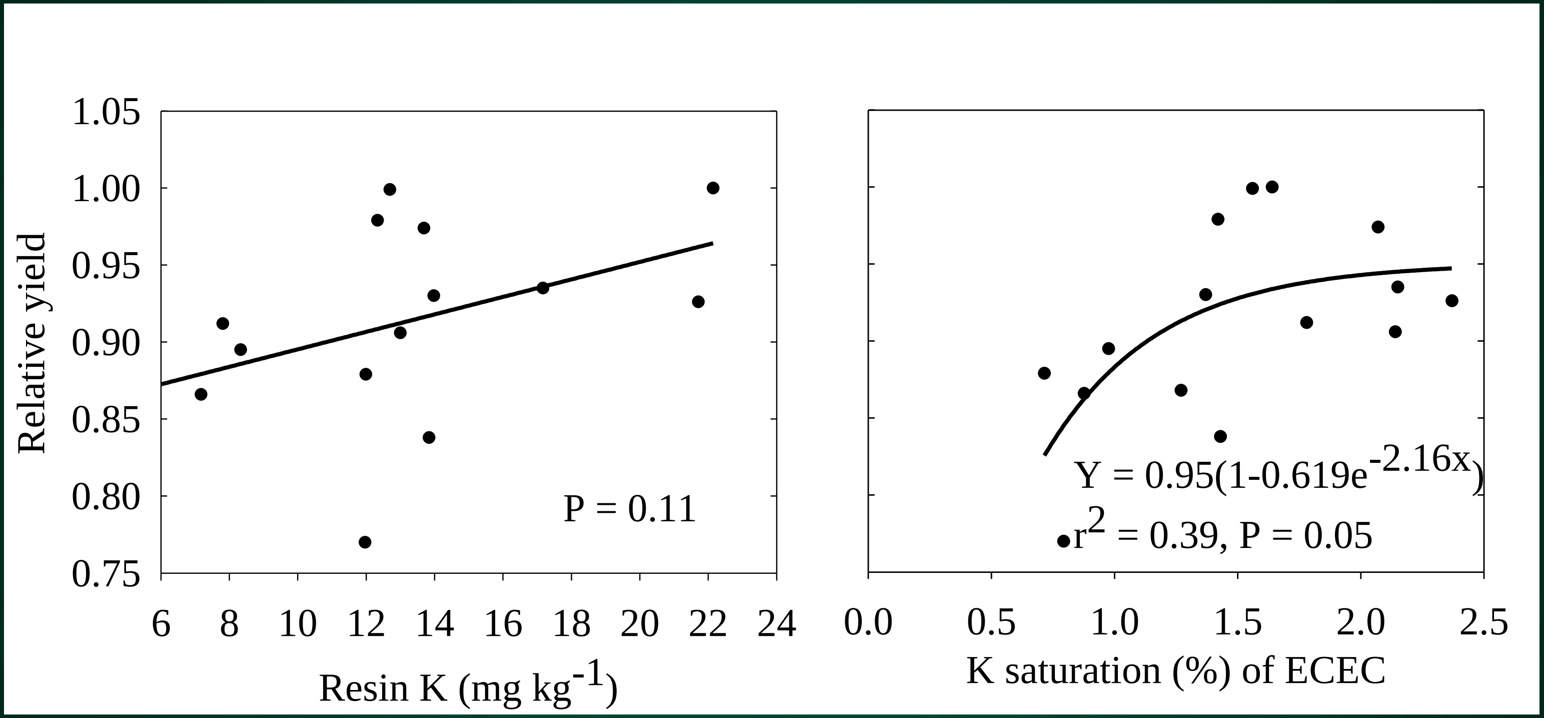
- Dry method still superior to moist method

Soil test K and yield response: Tetraphenylboron K, 5-min and 168-hr



- Not better than NH_4OAc methods

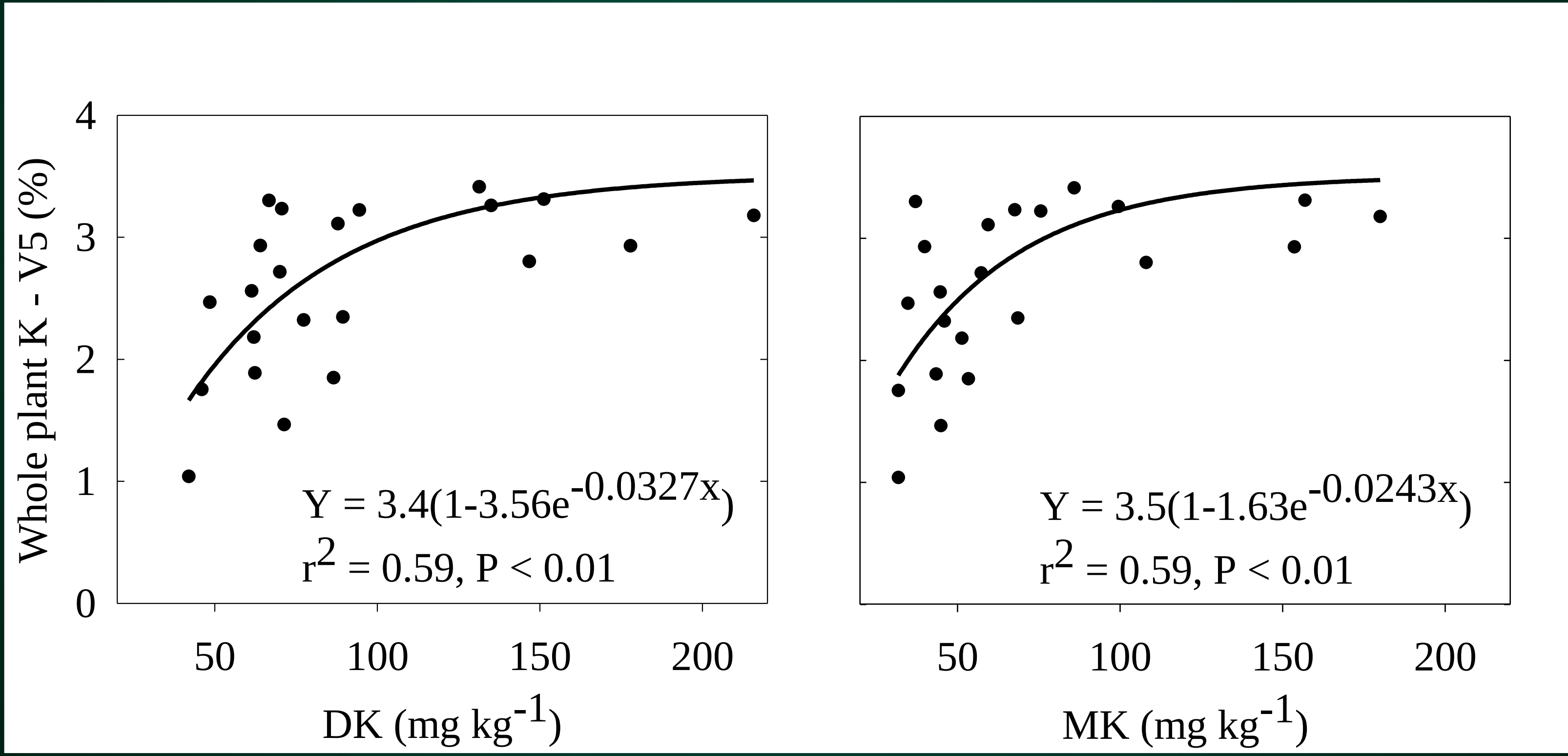
Soil test K and yield response: Resin K & %K saturation



- Resin method not significant, linear relationship
- K saturation not better than sufficiency level

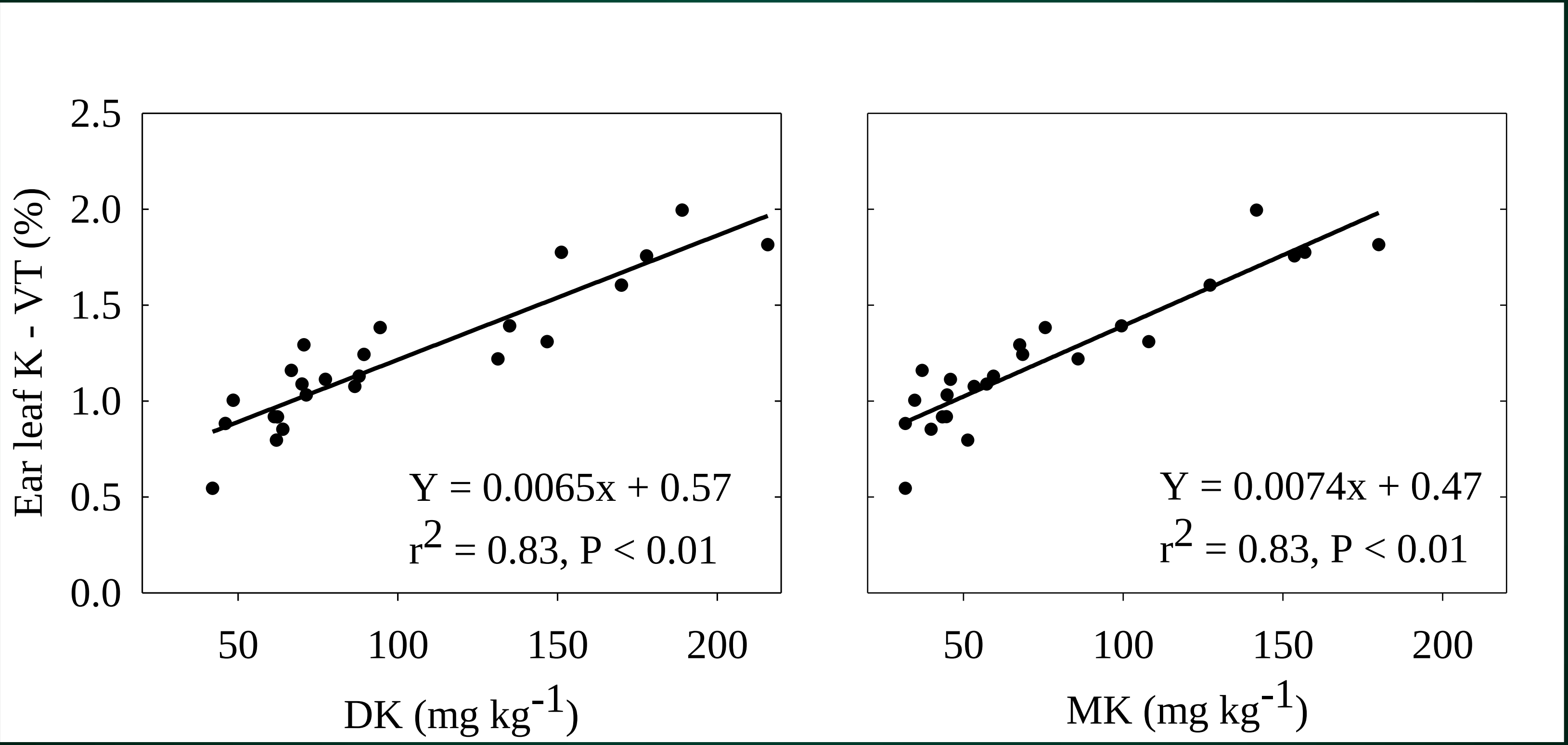
Correlation between Soil Test K and Tissue K

Leaf stage V5 (whole plant)

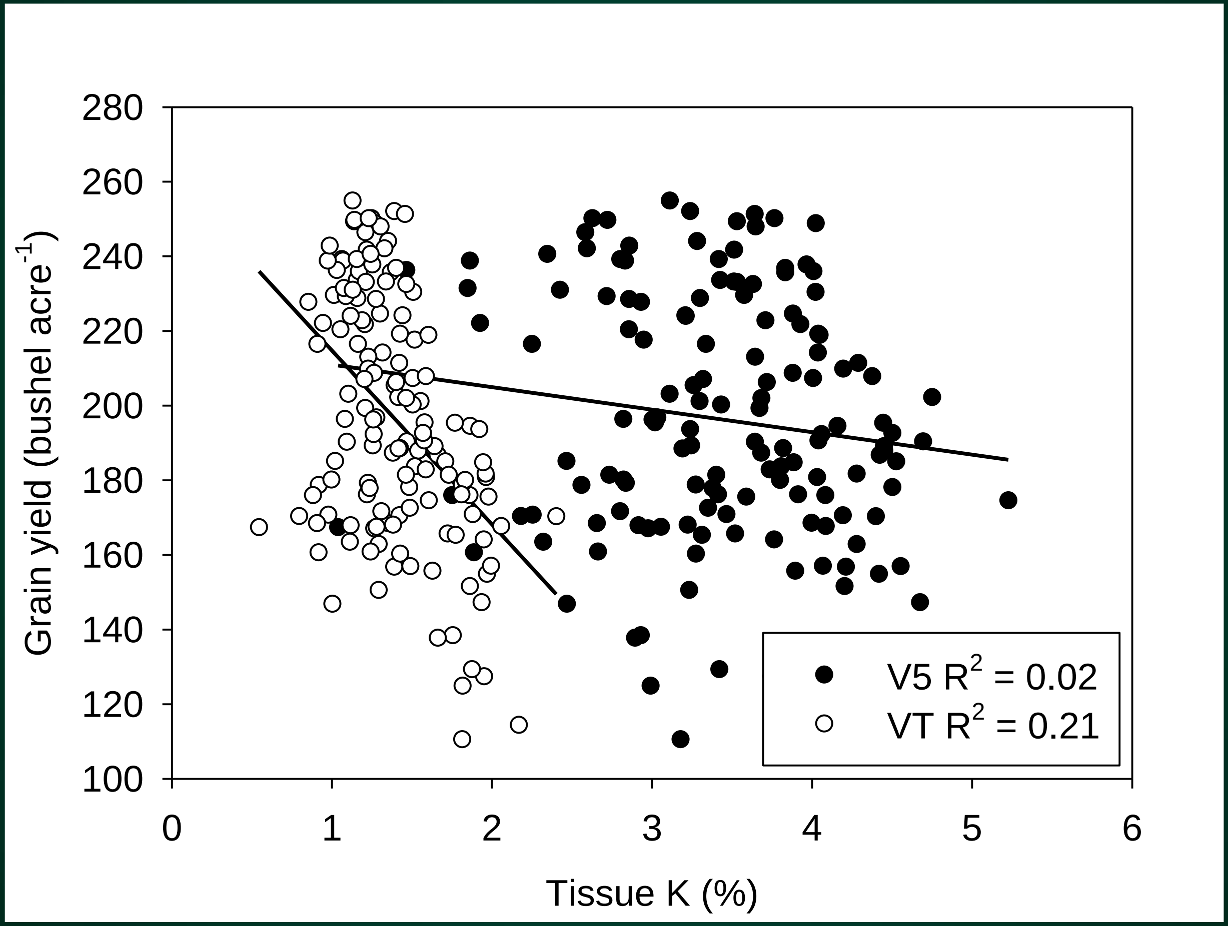


Correlation between Soil Test K and Tissue K

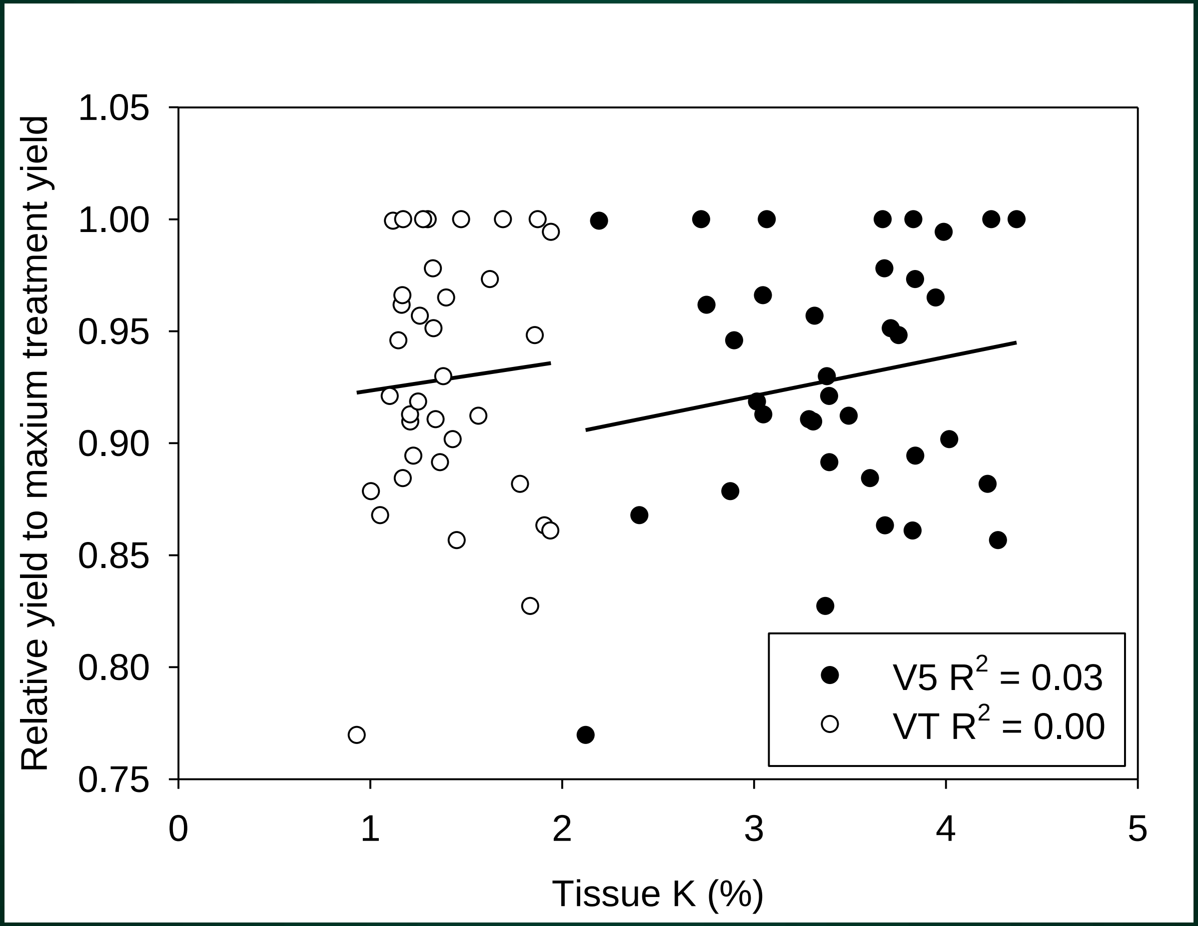
Leaf stage VT (ear leaf)



Does tissue K help predict yield?

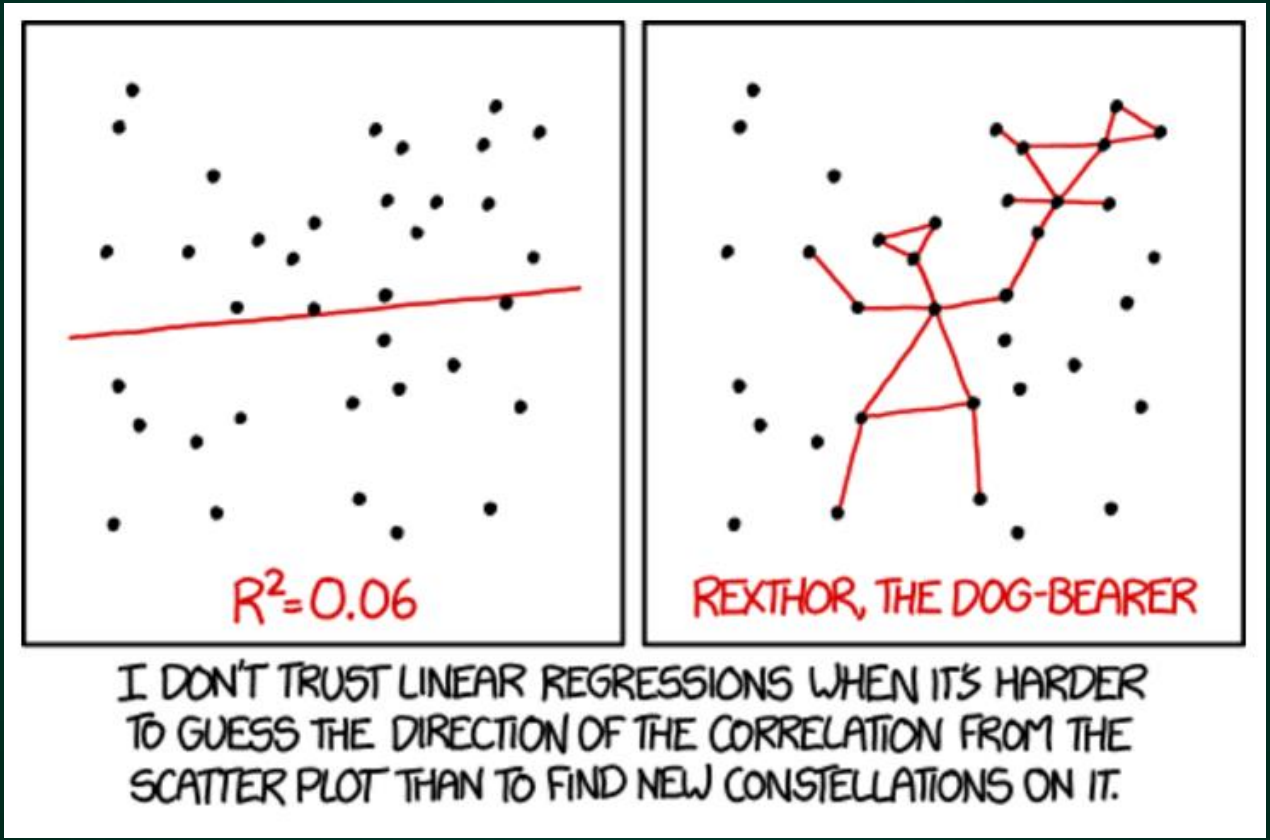


Does tissue K help predict relative yield response?



What good is tissue K analysis?

In-field comparison for deficiency diagnosis



From http://xkcd.com/1725/

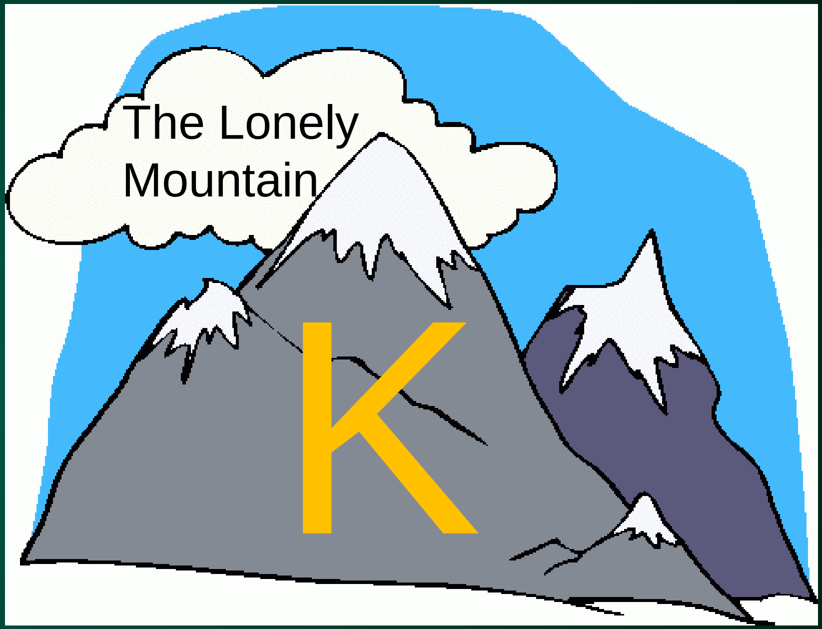
Potassium Mineralogy: An Unexpected Journey

Primary minerals

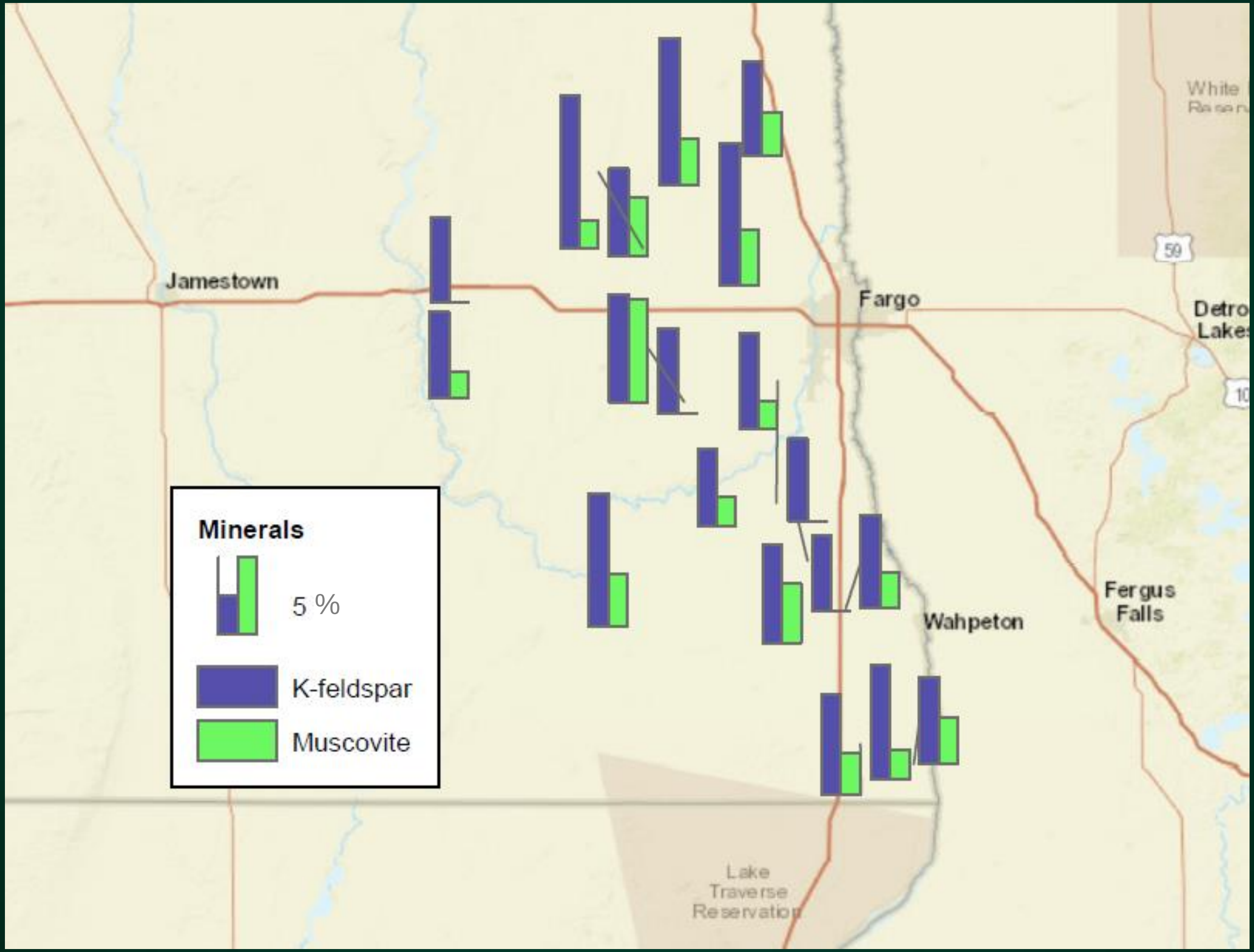
- K-feldspar
- Mica
  - Biotite
  - Muscovite

Clays

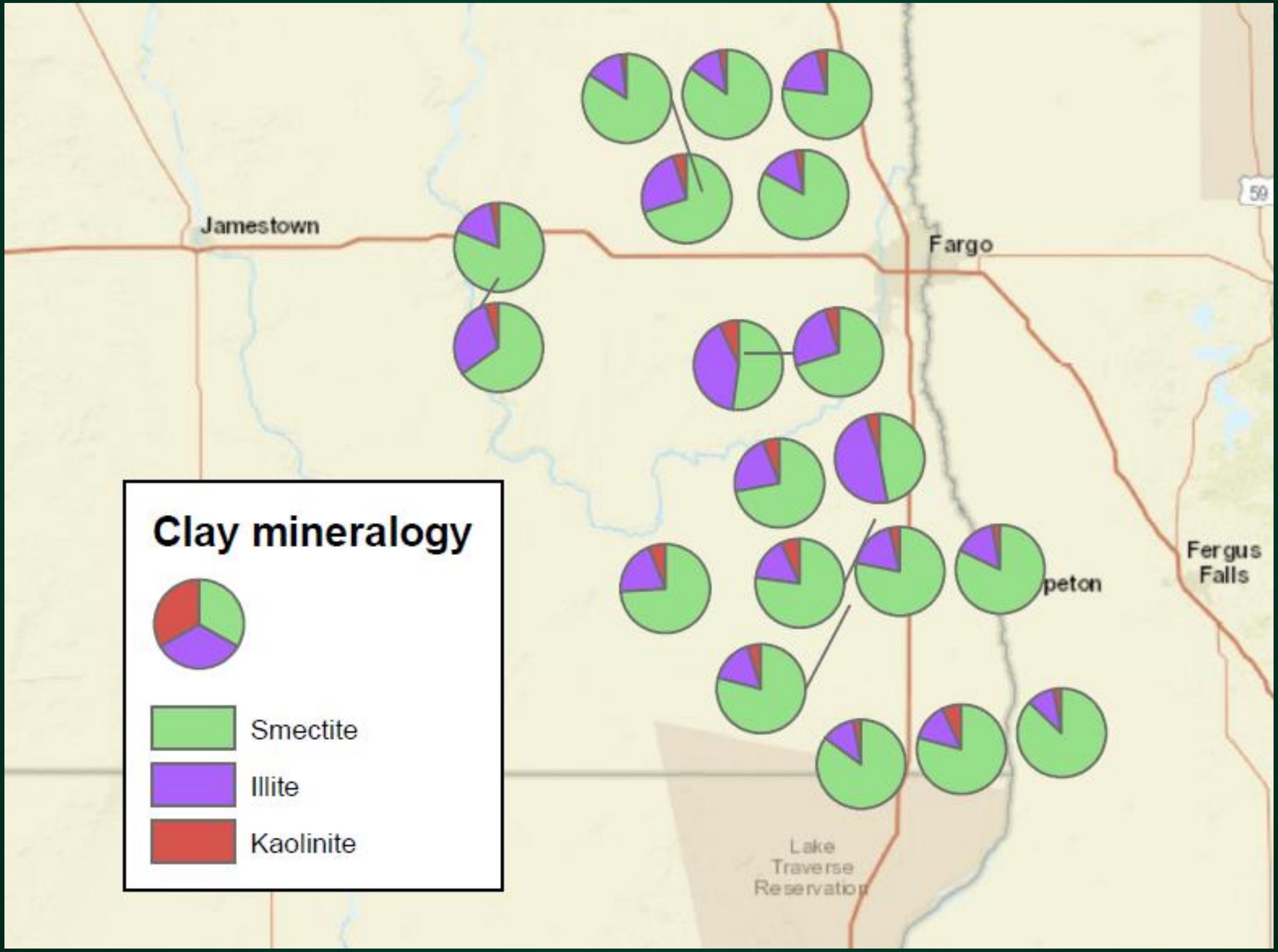
- Illite (K supplier)
- Vermiculite (K fixer)
- Smectite (K fixer when dry)



Site analysis:
K-bearing mineral content



Site analysis: Clay mineralogy

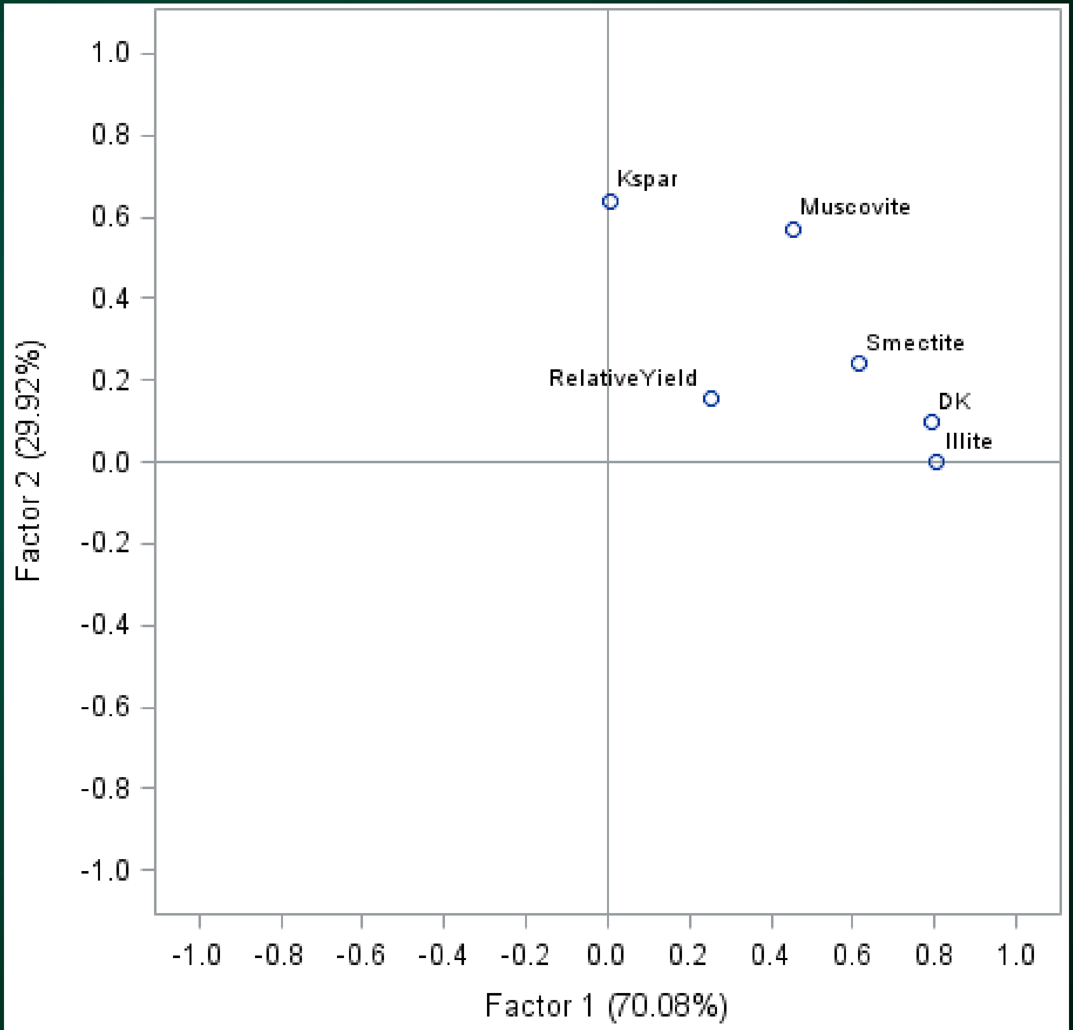


Does mineralogy help explain yield response?

Factor analysis:

Common factors between variables

- Mineralogy
- Relative Yield



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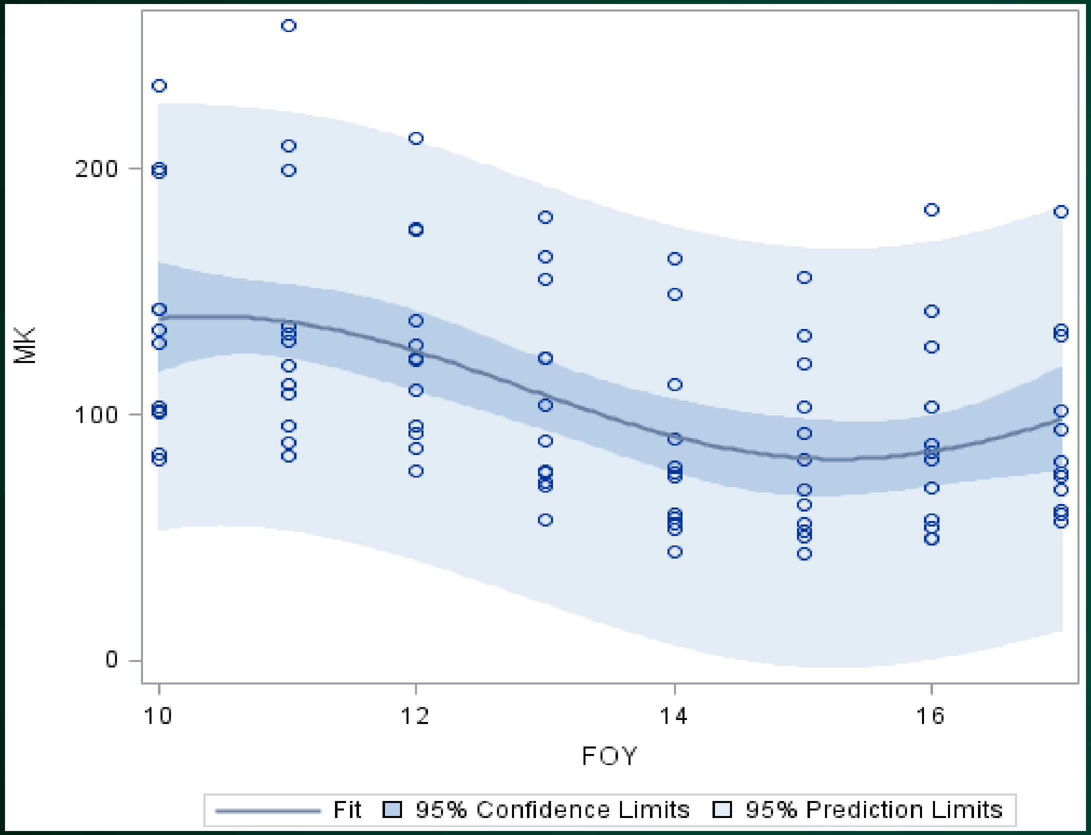
Sampling time: Sinusoidal pattern

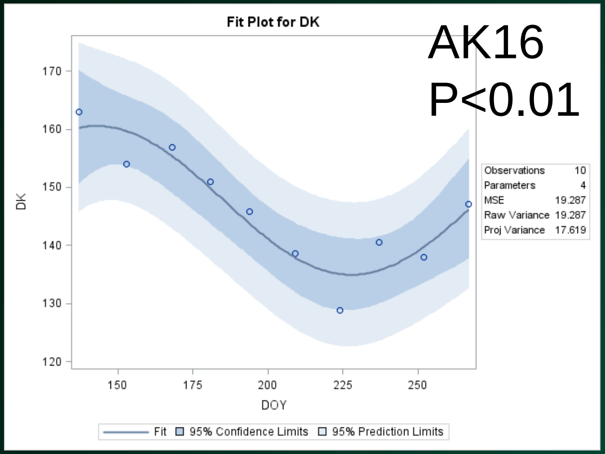


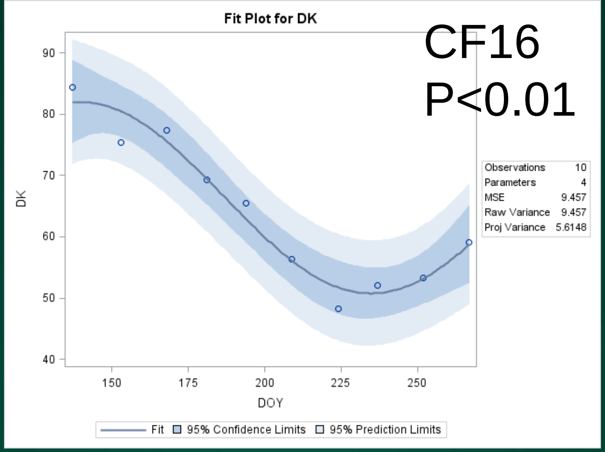
Soil K trend

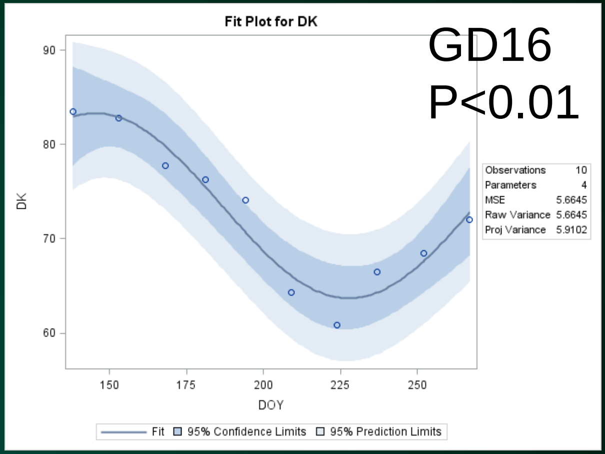
- Highest in spring
- Lowest late summer

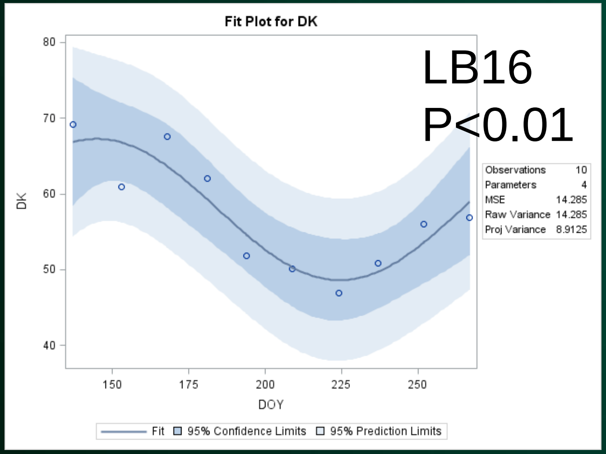
2015: 12 of 13 sites followed sinusoidal pattern over time

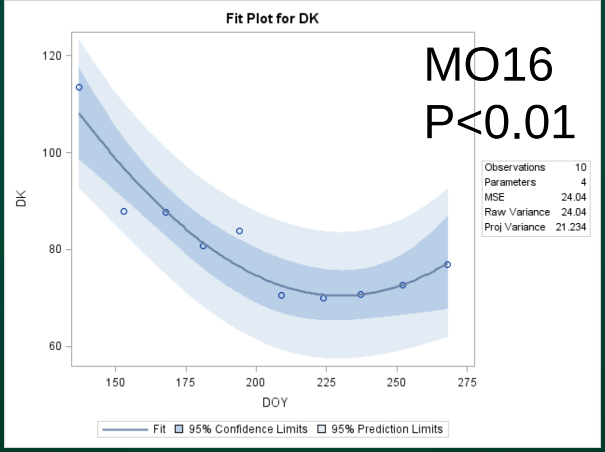
Sampling time: Sinusoidal pattern

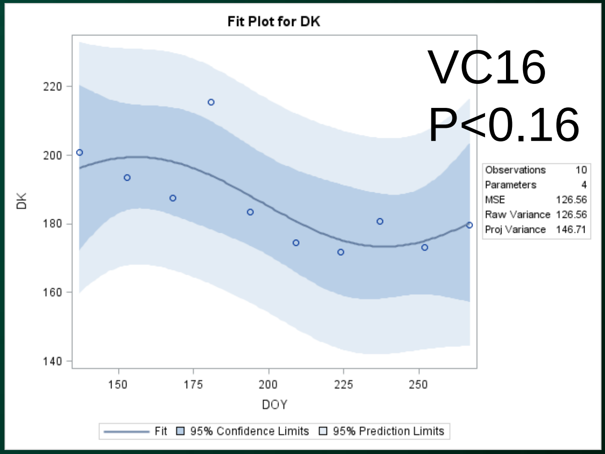












2016: Rainfall variability, not able to combine
(Dry K, 5/6 sites)

Sampling time and soil K levels

- Soil K trends
  - Highest in late May or early June
  - Lowest in late summer
  - Begin to increase after physiological maturity
- Crop K uptake, soil water use, tissue leaching

- Sinusoidal pattern within year
  - Long-term sampling needed to establish year-to-year pattern

Summary

- Sample drying increased NH_4OAc K
  - Variable between soils, mineralogy
- Dry K test failed to predict half of responses
  - Dry K test best predictor of yield response
- Mineralogy and yield response not clear
- Soil K levels follow a sinusoidal pattern over time

Conclusions

- Dry K soil test not sufficient for predicting yield responses to fertilization
  - Moist K, TBK may not be any better
- Take soil samples at same time every year
  - Spring or fall sampling?

- Potassium is far from simple

Thank you!

Acknowledgements:

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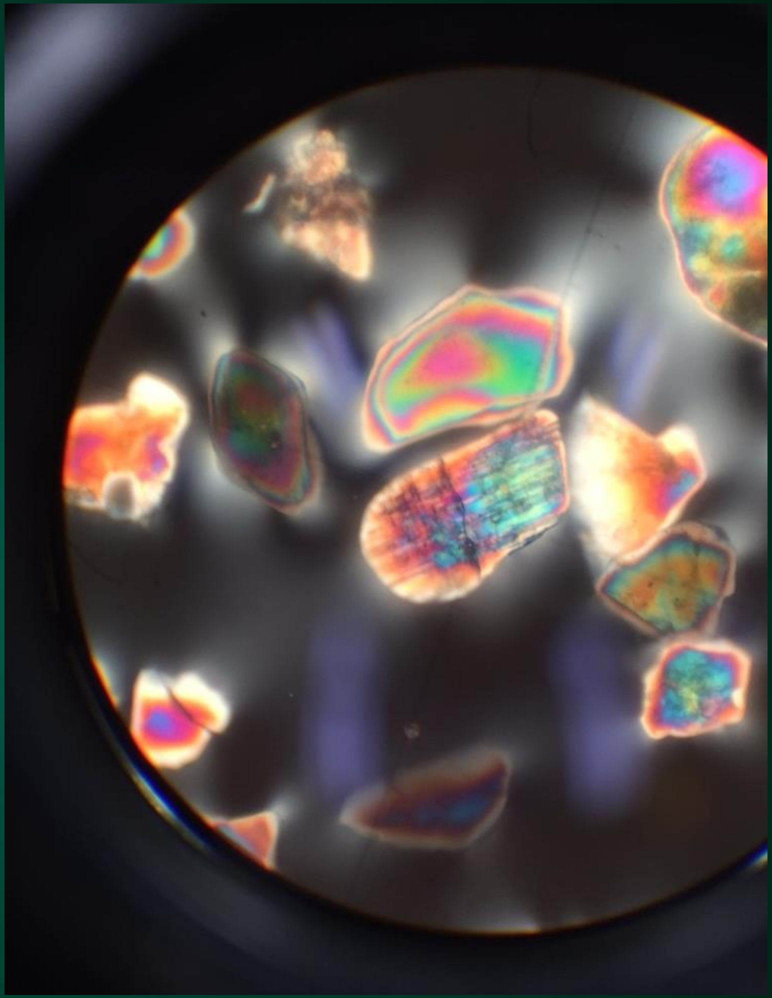
Conner Swanson

Makenzie Ries



"Tartan" twinning of K-feldspar

"There is a lot that we know [about potassium]. I don't know if it is all useful for making a recommendation."

-Dr. Sylvie Brouder (Purdue Univ.), 2014 SSSA Meeting

QUESTIONS?

References

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