Potassium Nutrition and Soil Testing

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August 8, 2018

http://gmoanswers.com/sites/default/files/corntatt.jpg/

My Background

5th Generation farm family in eastern Nebraska – 500 acres corn and soybeans

Affiliate Professor Colorado State University.
- Ph.D. Montana State University
- Extension Soil Specialist UC Davis

Coordinate the Agricultural Laboratory Proficiency (ALP) Program, 118 labs. Conduct Regional Research in Soil Sampling, Soil Fertility, Lab Analysis and

Miller, 2010

University of Illinois Publication

http://corn.agronomy.wisc.edu/Management/L011.aspx

The potassium paradox: Implications for soil fertility, crop production and human health

S.A. Khan*, R.L. Mulvaney and T.R. Ellsworth

Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign, 1102 S. Goodwin Avenue, Urbana, IL 61801, USA.
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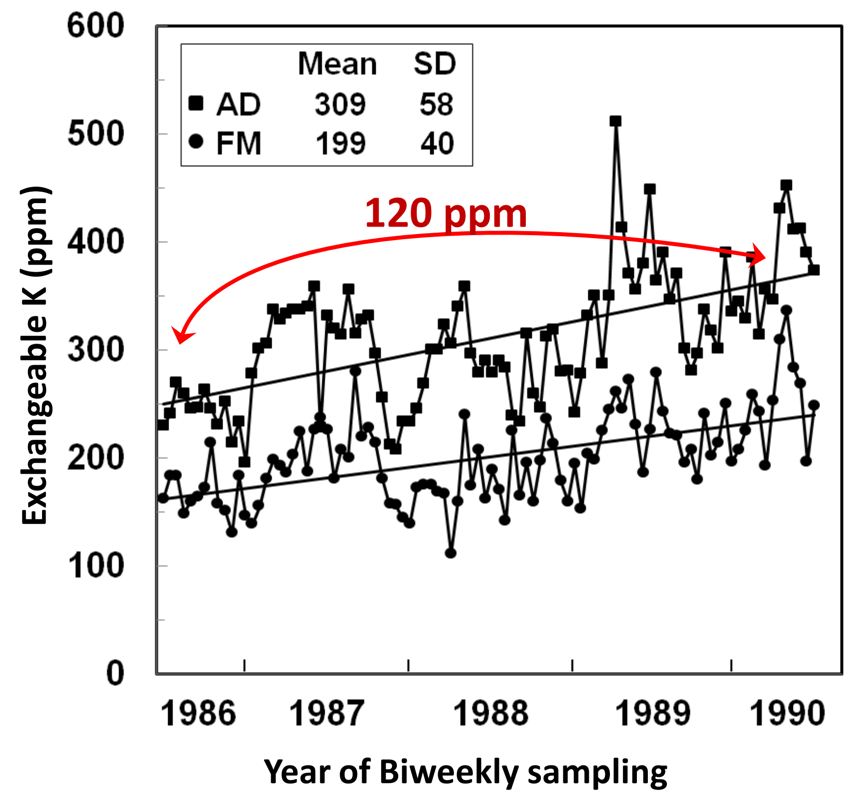
"Khan and Mulvaney see no value in soil testing for exchangeable K and instead recommend that producers periodically carry out their own strip trials."

University of Illinois, October 28, 2013
AgProfessional.com/News



Miller et al, 2018

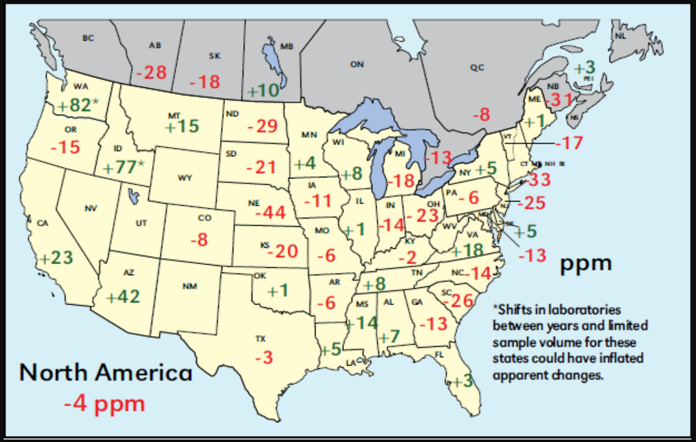
Overview

- Potassium Trends: Soil and Tissue
- Corn K Nutrition
- Field K Studies
- STK, Ear Leaf K and Yield
- Fertility Management

Miller et al, 2018

Soil Test K Trends

IPNI Report shows STK declining, In Nebraska, Iowa and Kansas, over the past 10 years.

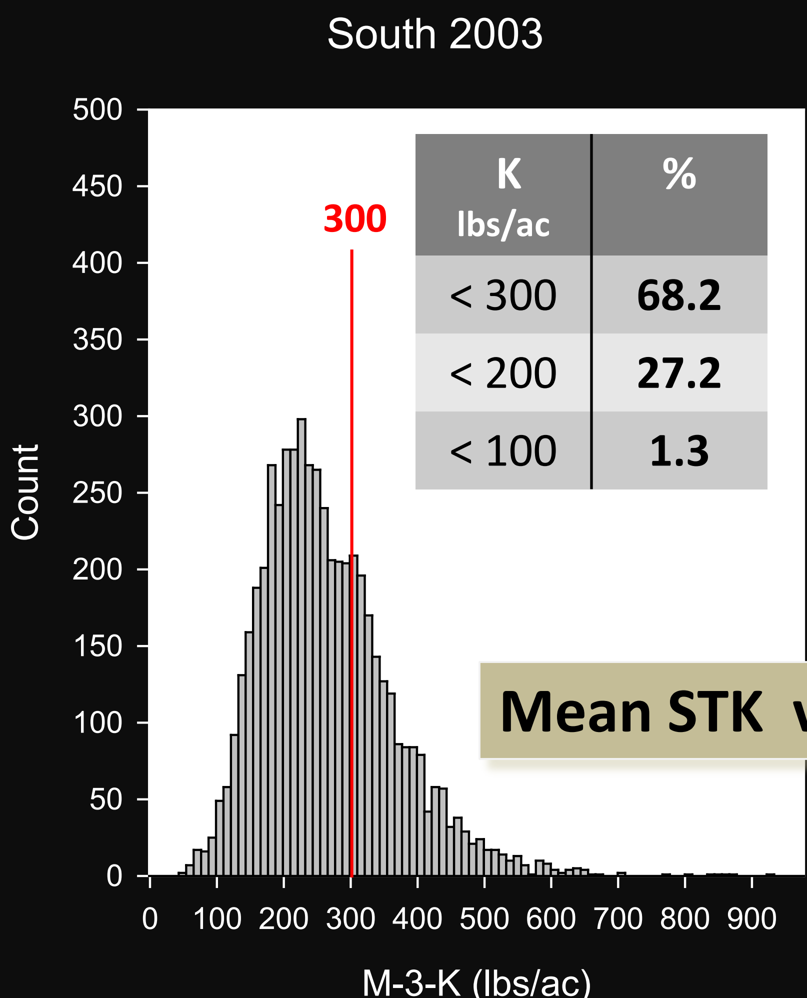


State	STK Decline (ppm)	
	2005 - 2010	2010 - 2015
Nebraska	- 44	+ 12
Kansas	- 20	- 15
Iowa	- 11	- 6

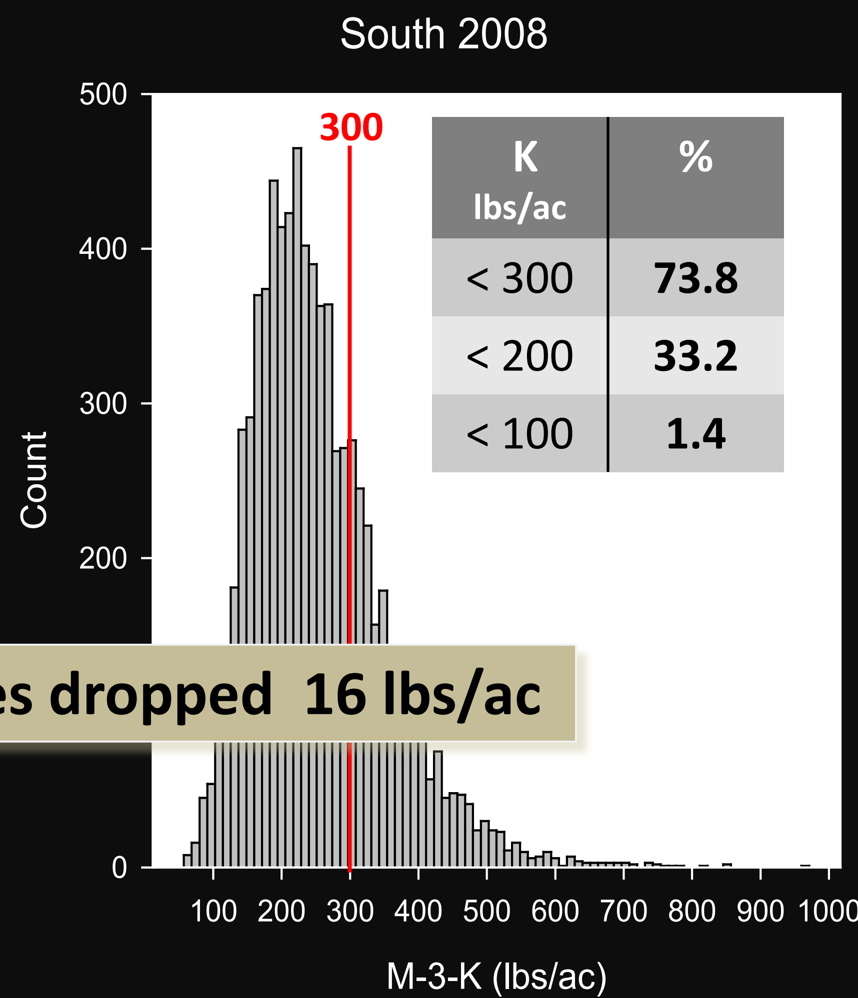
IPNI, /soiltest.ipni.net .

Miller et al, 2018

Lab Soil Test K - Indiana



K lbs/ac	%
< 300	**68.2**
< 200	**27.2**
< 100	**1.3**



K lbs/ac	%
< 300	**73.8**
< 200	**33.2**
< 100	**1.4**

Mean STK values dropped 16 lbs/ac

Source: **Sure-Tech Laboratories**

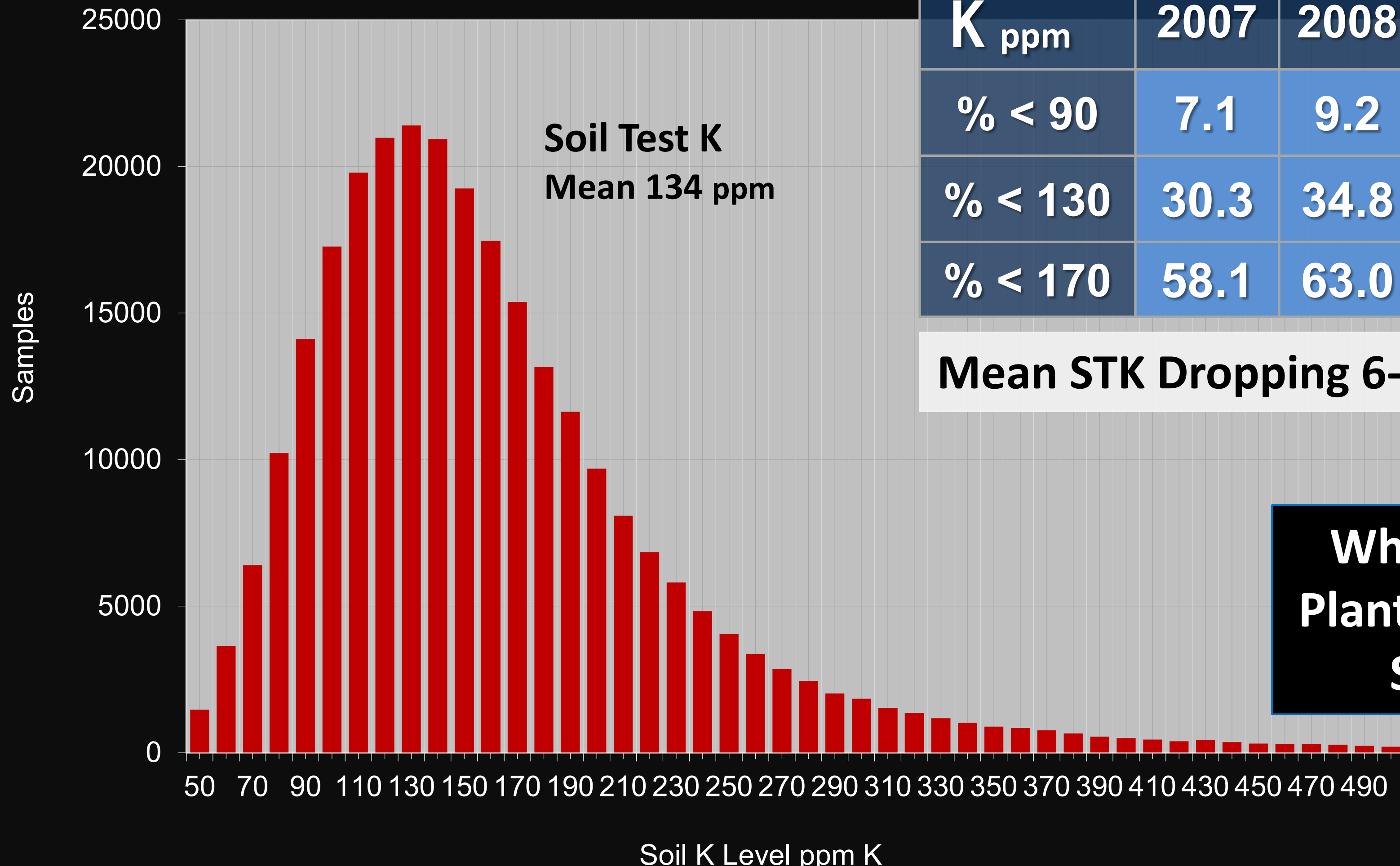
Miller, 2018

Lab Soil Test K - Iowa

Potassium
19
K
39.0983

Observations

2007-2009 Soil Test K ppm Distribution [1]



% Less Than

K ppm	2007	2008	2009
% < 90	7.1	9.2	12.9
% < 130	30.3	34.8	41.6
% < 170	58.1	63.0	67.8

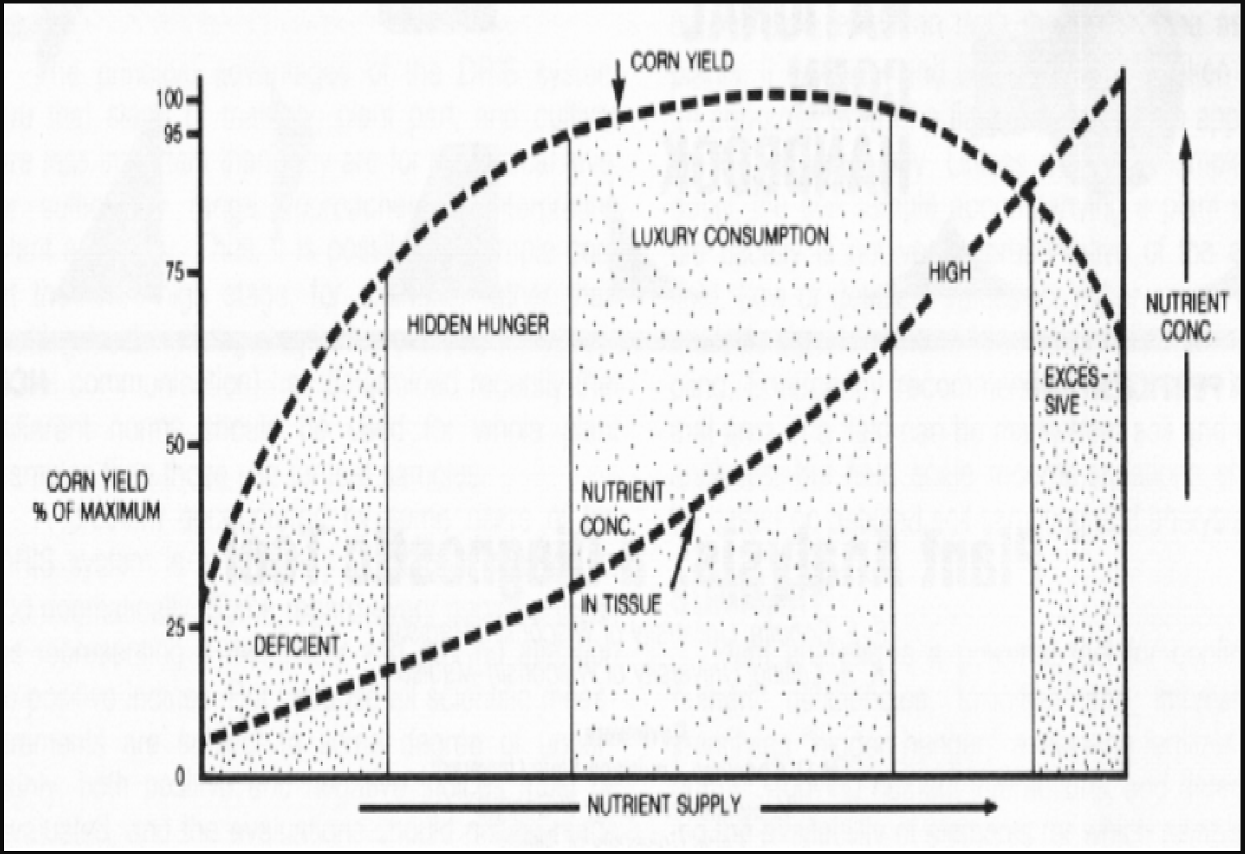
Mean STK Dropping 6-7 ppm/yr

What Does Plant Analysis Show

[1] Source: **LGI Laboratories**, 2010.

Miller, 2017

Plant Nutrition



http://www.extension.purdue.edu/extmedia/nch/nch-46.html Adapted from Brown, J. R. 1970. Plant analysis. Missouri Agr. Exp. Sta. Bull. SB881

Miller et al, 2018

Corn Nutrient Deficiencies - Indiana

Ear Leaf R1-R2, 3670 samples, six years

Nutrient	Deficiency threshold [1]	Percent of samples deficient [2]						Six year Average
	< Less Than	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	
N (%)	< 2.90	9.7	8.9	41.3	18.0	23.6	51.4	25.5 %
P (%)	< 0.30	8.3	12.1	49.2	15.3	8.1	36.5	
K (%)	< 1.90	41.5	30.8	67.0	32.0	36.2	16.7	37.4 %
S (%)	< 0.16	0.5	0.2	8.1	2.4	3.7	30.1	
Zn (ppm)	< 20	6.9	10.3	3.1	9.6	5.5	19.8	

[1] *Critical Nutrient level based on: https://www.extension.purdue.edu/extmedia/AY/AY-9-32.pdf Extension Bulletin E-2567 (New), July 1995*

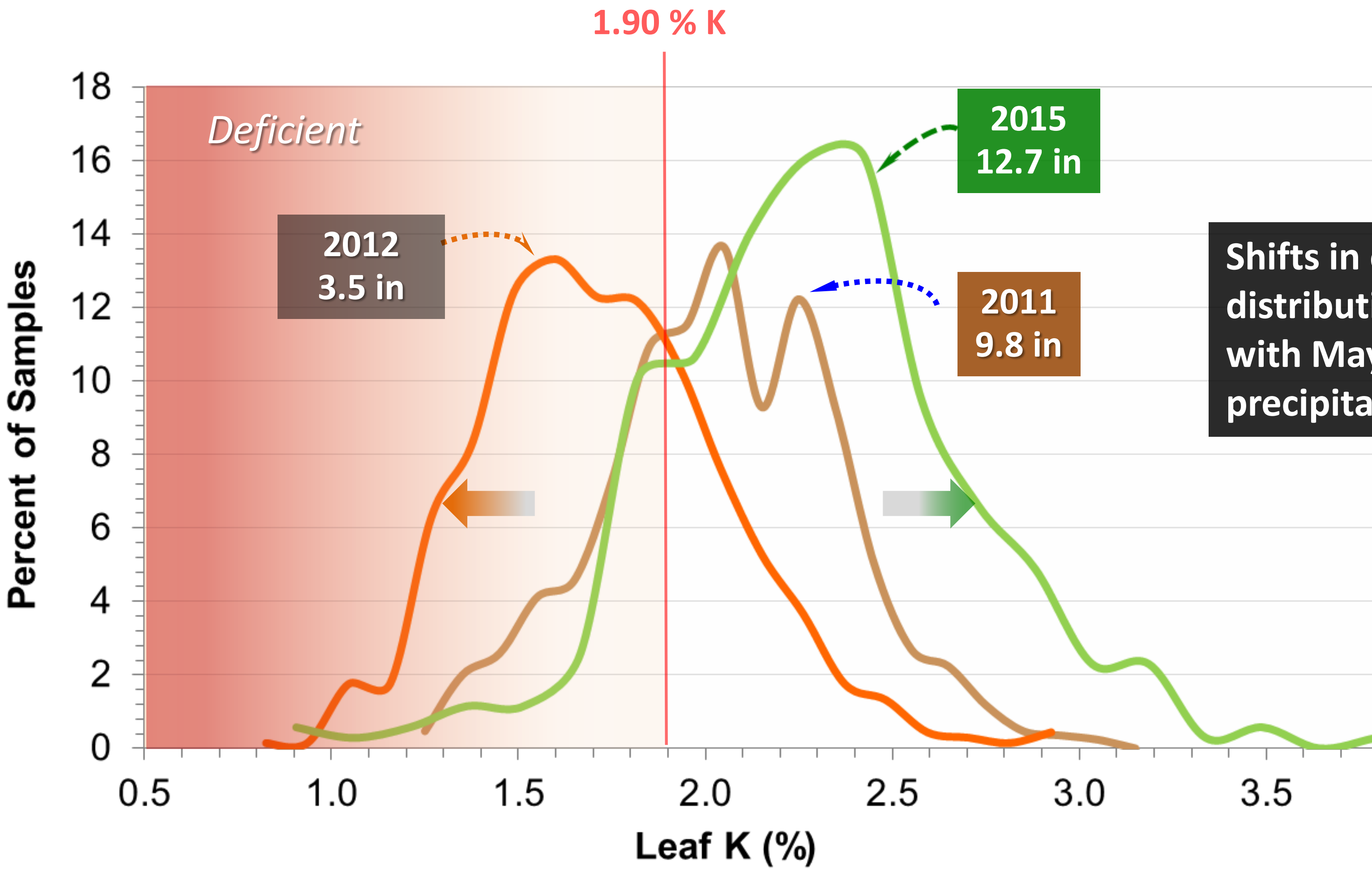
[2] *Corn ear leaf GS R1-R2.*

Source: Betsy Bower, Ceres Solutions, Lafayette, IN

Miller et al, 2018

Corn Ear Leaf K Frequency Plot

Observations three years, GS VT-R1 Western Indiana: 1883 samples



Shifts in ear leaf K distributions vary with May-June[1] precipitation

CERES SOLUTIONS
Cultivating results.

Source: Betsy Bower, Ceres Solutions

Corn Nutrient Deficiencies

Ear Leaf R1-R2, 24,710 samples, three states

Nutrient	Deficiency threshold [1]	Percent of samples deficient 2013 – 2015 [2]			Three year Average
	< *Less Than*	*Indiana*	*Wisconsin*	*Minnesota*	
N (%)	< 2.90	31.0	31.1	40.4	34.6 %
P (%)	< 0.30	20.1	24.4	31.5	
K (%)	< 1.90	28.3	53.8	54.5	45.5 %
S (%)	< 0.16	12.1	3.6	11.7	
Zn (ppm)	< 24	11.6	7.0	51.1	

[1] *Critical Nutrient level based on: https://www.extension.purdue.edu/extmedia/AY/AY-9-32.pdf Extension Bulletin E-2567 (New), July 1995*

[2] *Corn leaf GS R1-R2.*

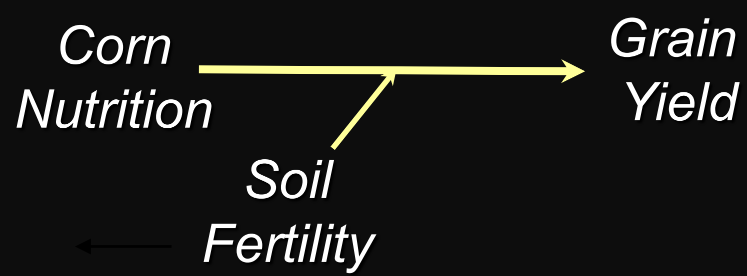
Miller et al, 2018

K Fertility

You can't resolve a problem unless you know its cause.

Robert Lustig UCSF, CA

Root Cause Analysis



Miller et al, 2018

Plant Potassium Nutrition

Crop Demand

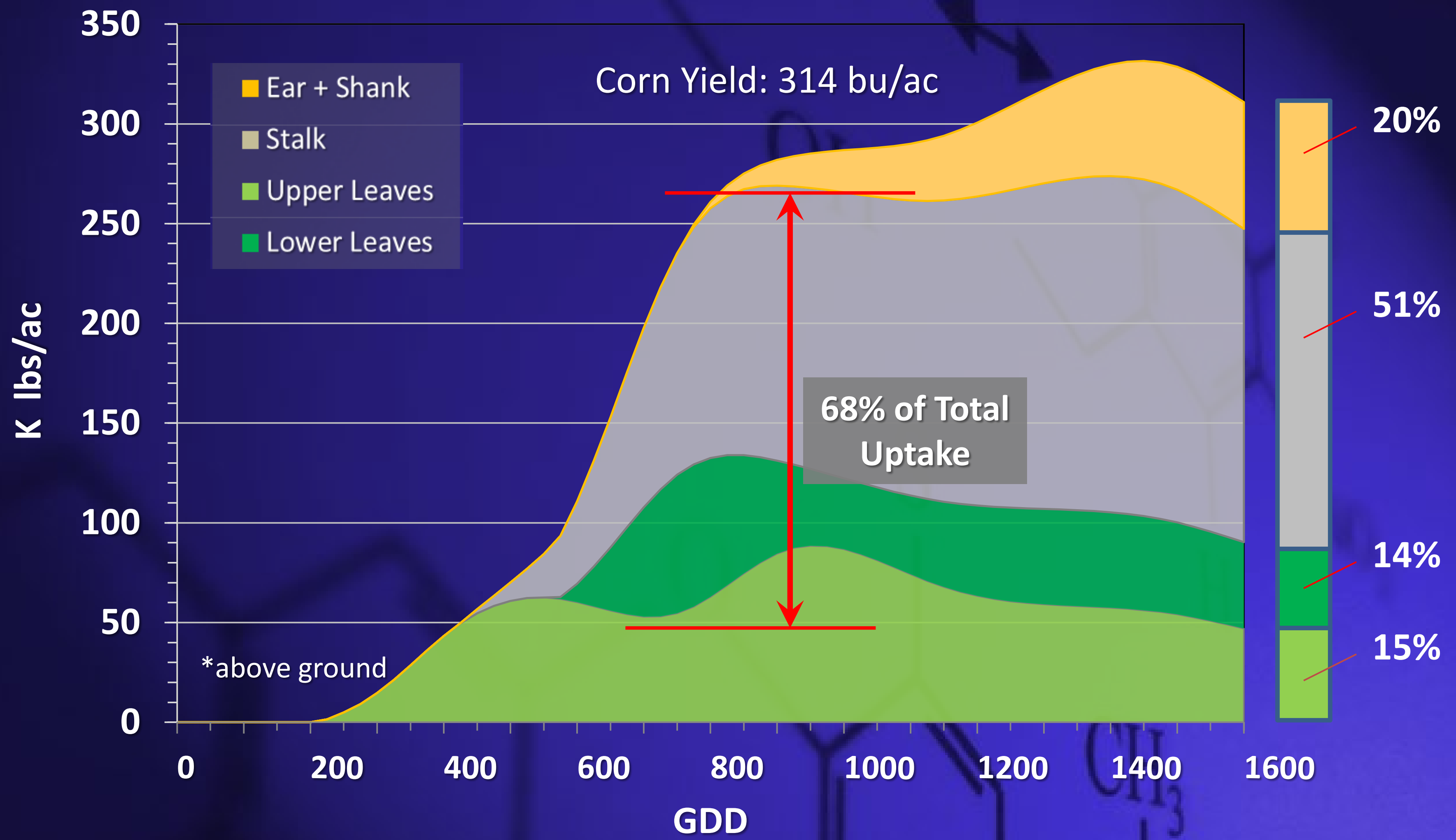
- Plant Nutrition
- Phenology of Uptake
- Plant Population

Soil Supply

- Soil Chemistry
- Nutrient Transport
- Stratification

Miller et al, 2018

Potassium Accumulation: Karlen et. al. 1988 [1]

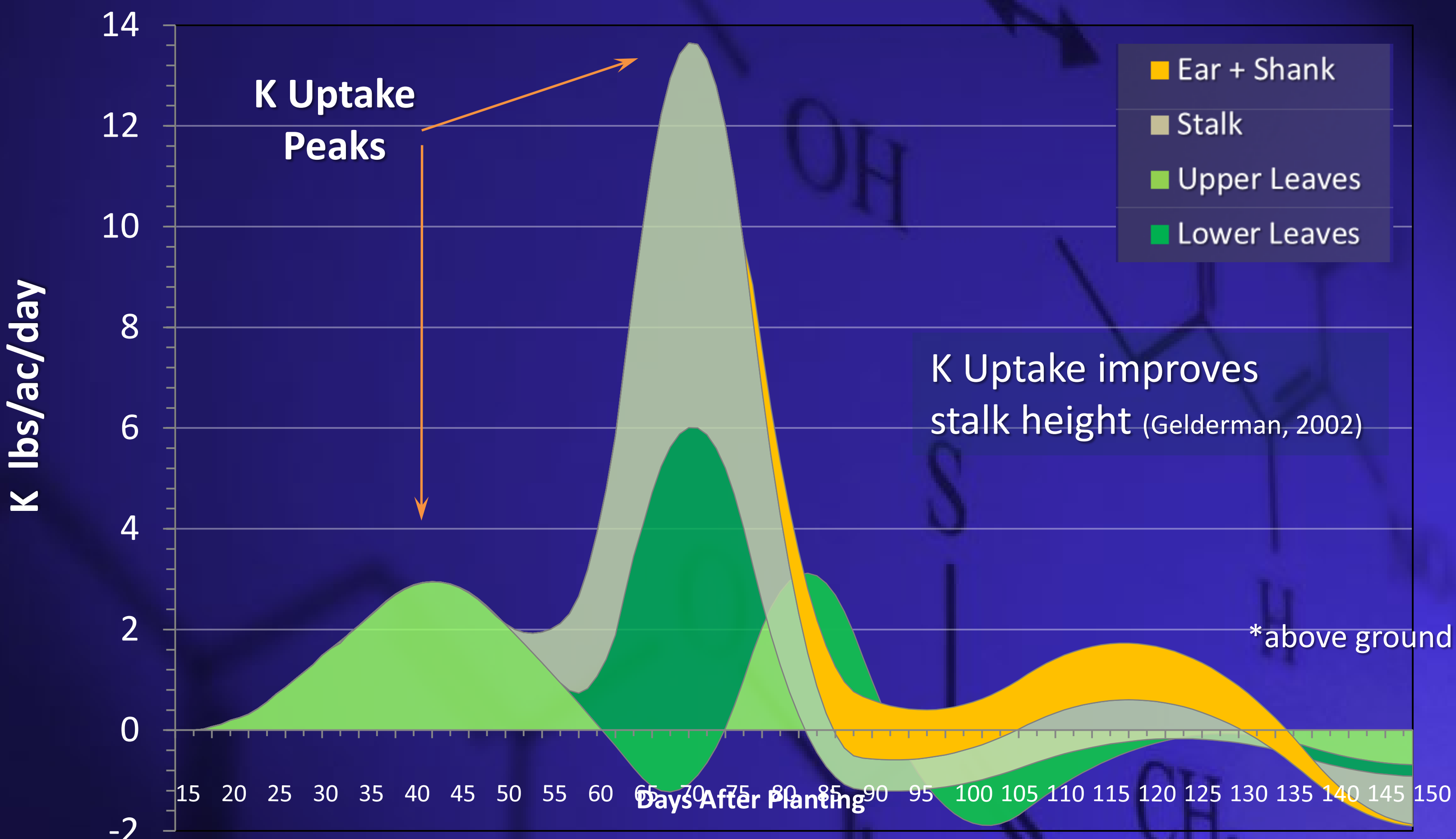


[1] *Calculated from: Karlen and Flannery. 1988. Agron J. 80:232-242.*

Miller et al, 2018

Corn Potassium Accumulation Rate [1]

www.udel.edu



[1] *Calculated from: Karlen and Flannery. 1988. Agron J. 80:232-242.*

Miller et al, 2018

Nutrient Uptake and Corn Population

Nutrient	Aerial Uptake grams per plant (g)	Estimated Uptake per 1000 plts/ac (lbs)
N	3.5 – 4.5	7 – 9
P	0.6 – 1.0	1 – 2
K	2.5 – 3.5	6 – 8

Increasing corn population from 24,000 to 34,000, requires 60 - 80 lbs/ac increased K.

[1] *Source: Data review of published literature for corn populations ranging from 10,000 to 44,0000 plant per acre. : Sayre, 1948; Jordan et al 1950; Hanway, 1962; Rhoades and Stanley 1981; Karlen et al 1987; Karlen et al 1988; and Doberman, 2003.*

Miller et al, 2018

Population and Soil Rooting Volume

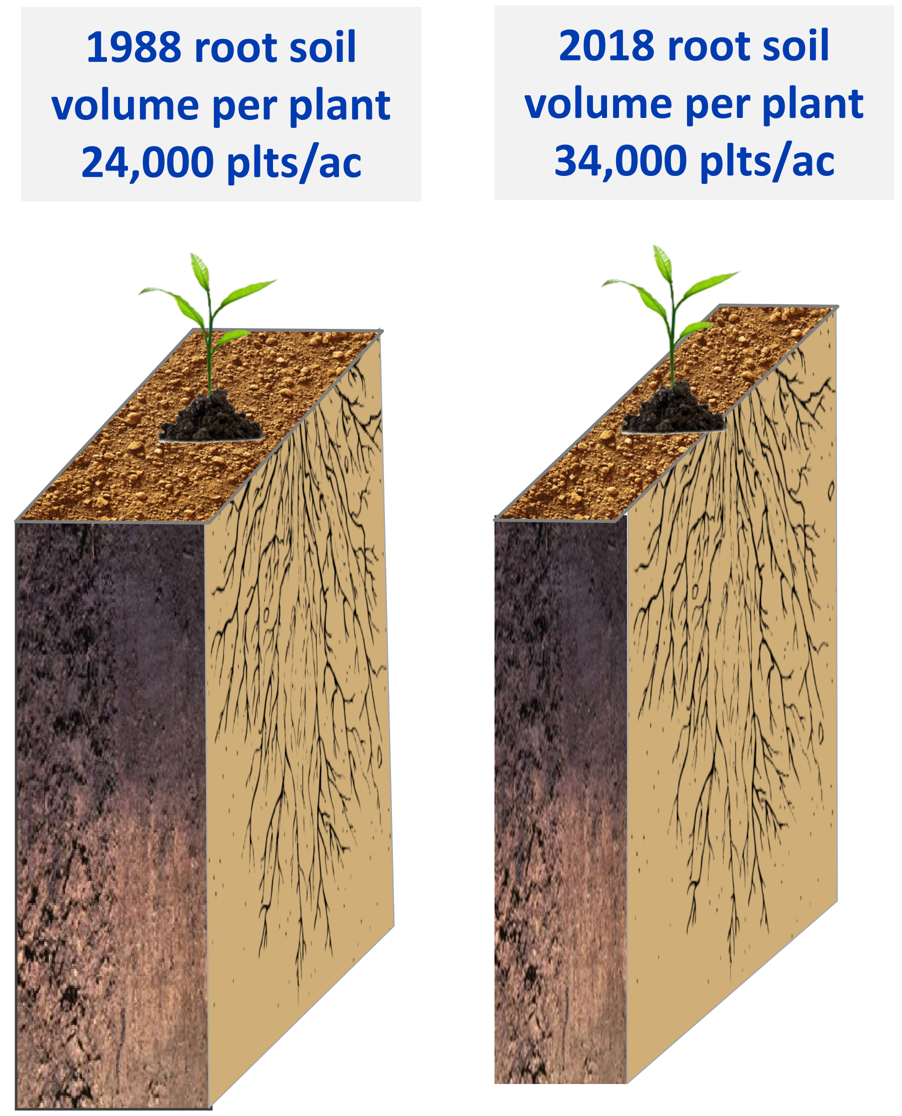
Impact of Population over 30 years

Increasing plant population from 24,000 plts/ac to 34,000 plts/ac results in:

- a **<u>30%</u>** decrease in soil rooting volume per plant[1].

- an increase in total corn K uptake of **60-80** lbs/ac.

Thus higher population requires **42%** more K from a **30%** smaller soil rooting volume.



[1] Based on data Doberman et al, 2003.

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Plant Potassium Nutrition

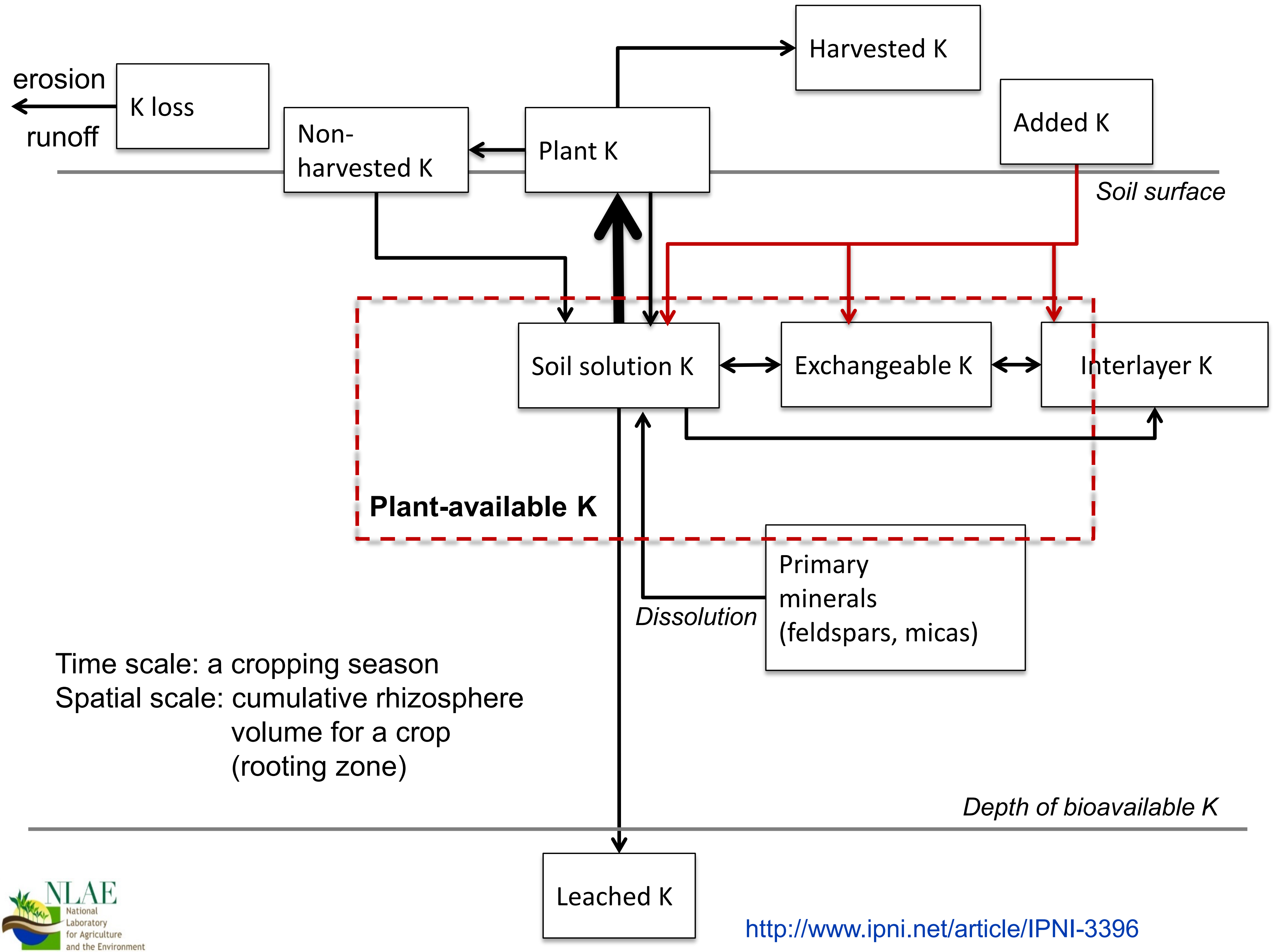
Crop Demand

- Plant Nutrition
- Plant Population
- Phenology of Uptake

Soil Supply

- Soil Chemistry
- Nutrient Transport
- Stratification

Miller et al, 2018


Harvested K
erosion
K loss
runoff
Non-harvested K
Plant K
Added K
Soil surface
Soil solution K
Exchangeable K
Interlayer K
Plant-available K
Primary minerals (feldspars, micas)
Dissolution
Time scale: a cropping season
Spatial scale: cumulative rhizosphere volume for a crop (rooting zone)
Depth of bioavailable K
Leached K
NLAE
National Laboratory for Agriculture and the Environment
http://www.ipni.net/article/IPNI-3396

Soil Potassium Transport

Root Interception

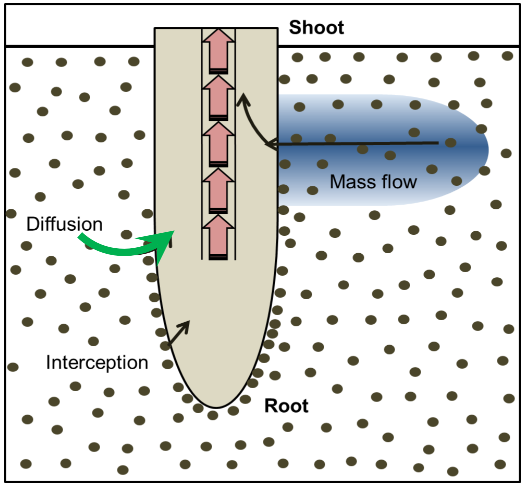
Direct root contact with soil K, 1-2% of total uptake.

Mass Flow

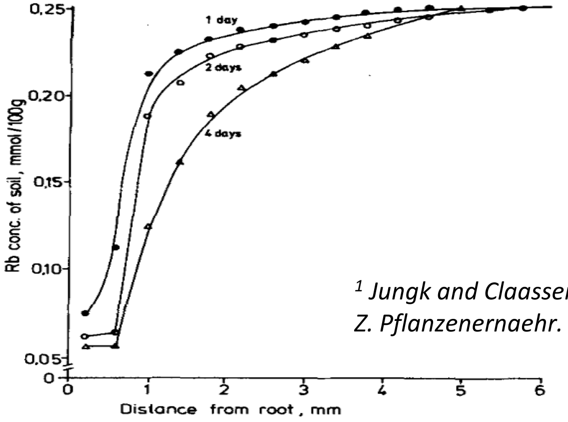
Soil solution K acquired through mass flow of soil water to plant root, 10-20% of total.

Diffusion

K movement down ion concentration gradient from bulk soil to root surface, 70-80% of uptake. Decreases with lower soil moisture content.



http://plantsinaction.science.uq.edu.au/sites/
plantsinaction.science.uq.edu.au/files/4.1-Ch-Fig-4.3.png



[1] Jungk and Claassen, 1986. Z. Pflanzenernaehr. Bodenk

Miller et al, 2018

STK Stratification and Soil Supply

FRI-15

Depth	STK (ppm)
0-2”	242
2-4”	126
4-6”	78
6-8”	48
8-12”	32

[1] *Source: KRx research site Hubbard, IA, 2014.*

Decreased tillage has resulted in consistent STK stratification at surface, 94% of sites.

Standard soil sampling, provides no information on rooting zone K stratification.

KRx Site	STK (ppm) [2]	
	0 - 6”	2 - 6”
O’Neil, NE	107	85
Paulina, IA	238	141
Monroe, SD	266	176

[2] KRx research sites 2016, limited tillage.

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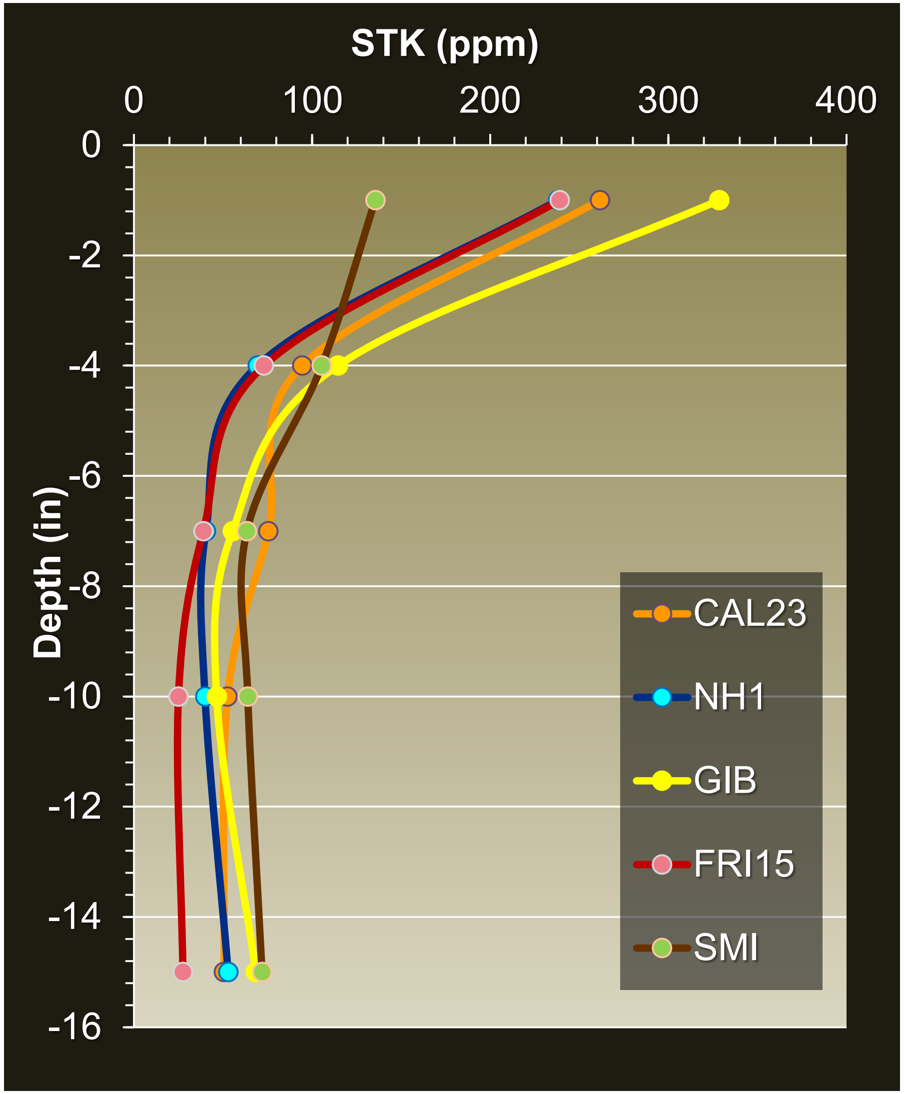
STK Stratification – Five Sites 2014



STK consistently elevated at surface levels (> 3x subsoil) across 94% of KRx locations across four states.

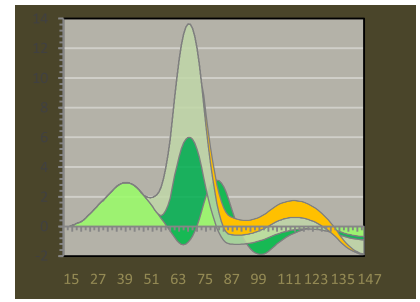
Specific sites the 0-2" depth was 5X the content of the 6-8" depth. All sub soils had STK < 90 ppm.

[1] 2014 KRx Project, SD, MN, IA, IL.

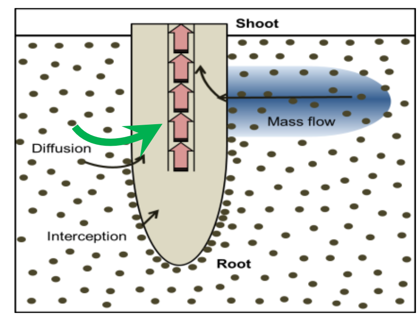
Miller et al, 2017

Impact on Corn K Nutrition

A corn plant population of 34,000 with a yield goal of 250 bu/ac will have a K uptake[1] of 280 lbs/ac, of which 190 lbs is accumulated during GS V4-V12.



Thus soil K diffusion (estimated 80%) must provide a max 7 - 9 lbs/ac/day from a stratified root zone. Soil moisture limitations <u>reduces</u> K diffusion, and uptake.



[2] Calculation based on data of Karlen et al (1987) and estimates of soil diffusive supply.

Miller et al, 2018

Soil Testing

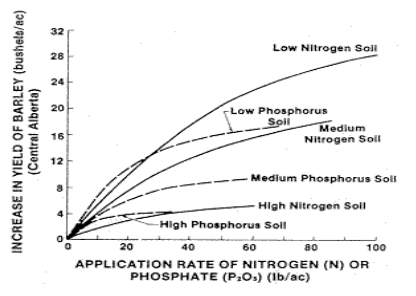
Root Cause Analysis

Corn Nutrition → Grain Yield

Soil Fertility

Lab Analysis

Calibration Data



Application

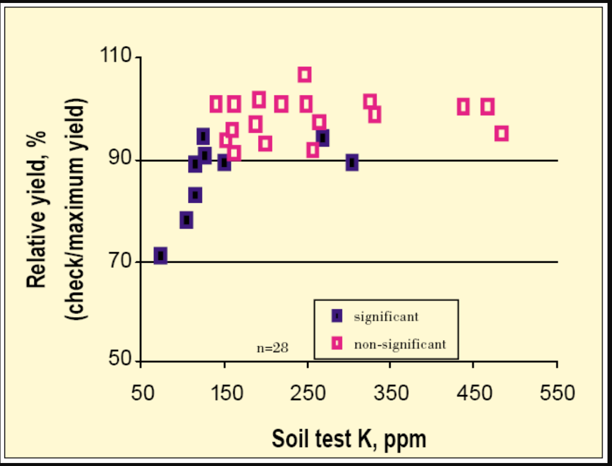
Miller et al, 2018

Nutrient Management

Soil

Soil Testing

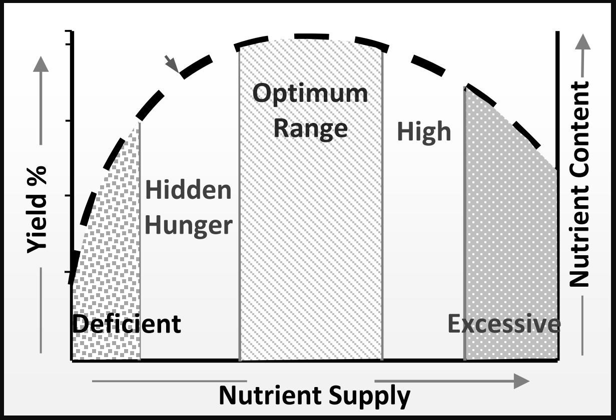
An evaluation of nutrient availability based on the probability of crop yield response utilizing a laboratory chemical extraction. It has little to do with total nutrient uptake or crop requirement.



Gerwing, Gelderman and Bly, 2003

Tissue Testing

Is an assessment of leaf/plant nutrient concentration based on a standard norm and historical observations.



Modified from Brown, J. R. 1970. Plant analysis. Missouri Agr. Exp. Sta. Bull. SB881

Miller, 2011

Miller et al, 2018

KRx Project

KRx project was launched in 2011 to evaluate grain yield response to applied K across eight states based on the 4Rs approach, using spoke injection.

Assess STK, ear leaf nutrient and K fertilizer on grain yield.

Rates: 0, 50 and 100 lbs/ac

K Deficiency Winchester, Indiana, 2012 - Dave Taylor

Miller, Bower, Smith, 2015

KR$_X$ Corn Yield Response

KR*x* Project Results 2012, NE, IA, IL and IN. K applied V3-V5 rate 50 lbs/ac $^{-1}$

K effect on ear size

Site	STK	Check	+K [1]	Increase
City / State	ppm	bu/ac		
Merrick, NE	151	169	170	+ 1
Cherokee, IA	290	218	227	+9
Piatt, IL	305	141	154	+ 13*
Sullivan, IN	116	94	110	+ 16*
Warsaw, IN	198	73	67	- 6

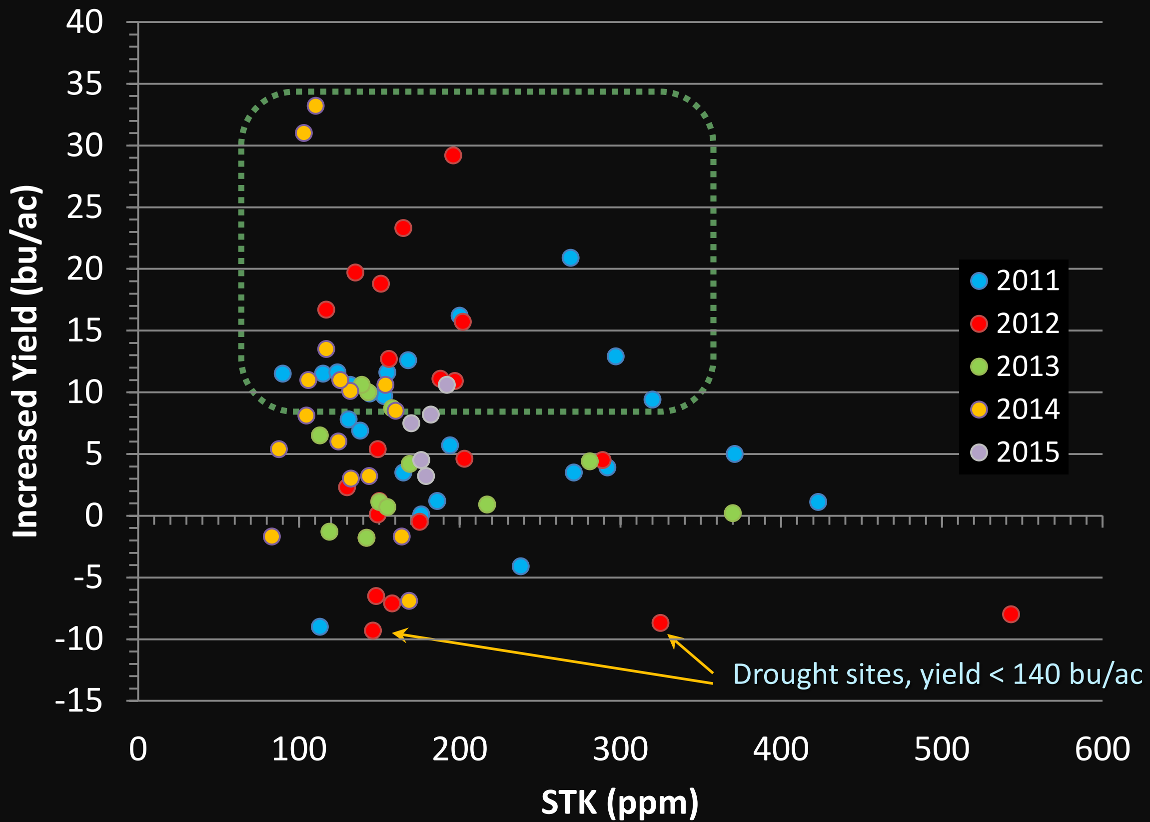
[1] Yield significant at the 0.10 level, corn 15.5% moisture.

K increased yield on a soil STK > 300 ppm

Miller et al, 2018

KR_X STK vs Corn Yield – Five Years

A K application[1] improved grain yield at 33 of 82 locations over 5 years.



Probability of yield response

STK	75 to 150	-	56%
STK	150 to 200	-	50%
STK	200 to 300	-	36%
STK	300 to 600	-	14%

Yield increase
8 - 33 bu/ac

[1] Yield increase to application of 50 lbs/ac K at V3-V5.

Miller et al, 2018

Impact of Applied K on Ear Leaf K

Number of sites where ear leaves shown a significant increase in leaf K with an application[1] of 100 lbs/ac K side dressed at GS V3-V4.

Year	Sites	Number of sites with an increase of ear K from fertilizer
2011	24	1
2012	22	3
2013	18	2
2014	16	2
2015	8	0

[1] K applied as KCl + KSO_4 blend using spoke wheel applicator, 3 inches off row at depth of 3 inches.

90% of sites show no increase of ear leaf K with applied K fertilizer.

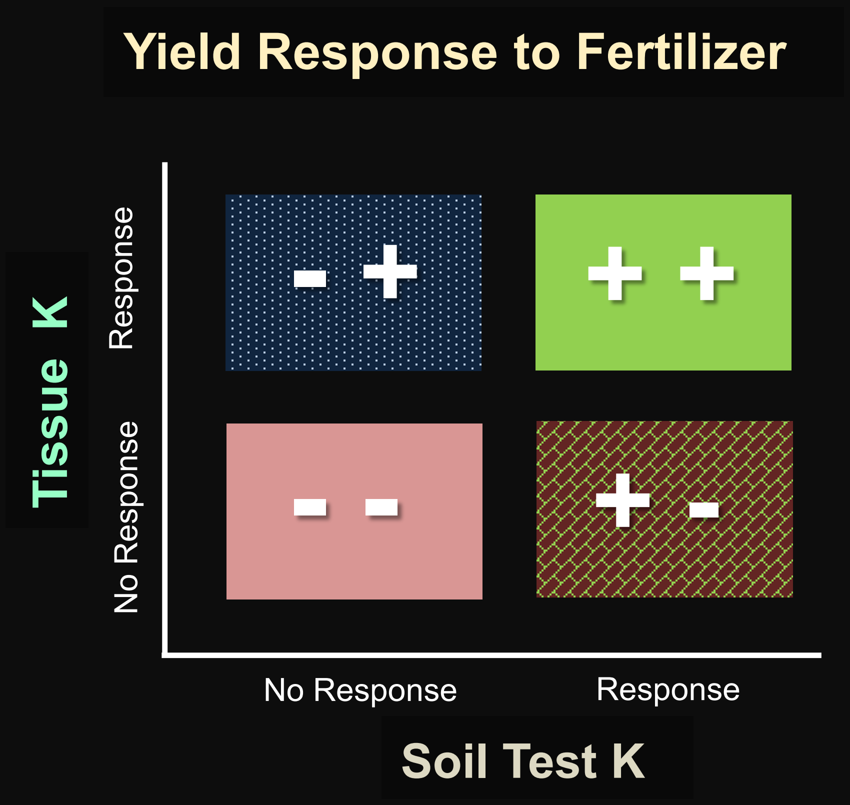
Question did fertilizer correct a corn K deficiency?

Miller et al, 2018

STK vs Corn Yield

Premise of soil testing, that a lack of crop yield response to K fertilizer indicates no nutrient deficiency.

<u>However</u>, just because there is little or no yield response does not mean that a K fertilizer application corrected a crop K deficiency.



Miller et al, 2018

STK vs Corn Yield

www.hear.org/starr/images/image/?q=080914-9918&o=plants

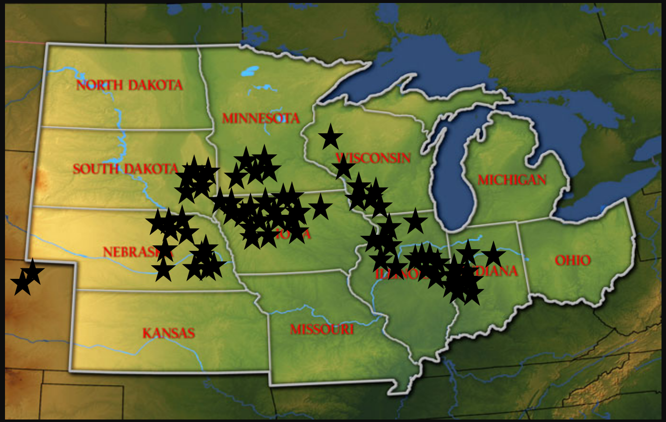
Questions

- ✓ Does soil test K influence yield?   Ear leaf K?
- ✓ Does ear leaf K impact yield?
- ✓ Due Soil factors (pH, SOM. CEC etc.) effect leaf K nutrition?

Miller et al, 2018

K_{RX} Research Database

2011-2015, 81 site studies were conducted in grower corn fields across 8 states. **Check plot data:** soil (pH, P, K, Ca, Mg, SOM, CEC - 0-8”); ear leaf R1-R2 nutrients[1]; population, grain yield; replicated. 2016, 50 observation sites were added. Cluster analysis and regression modeling.

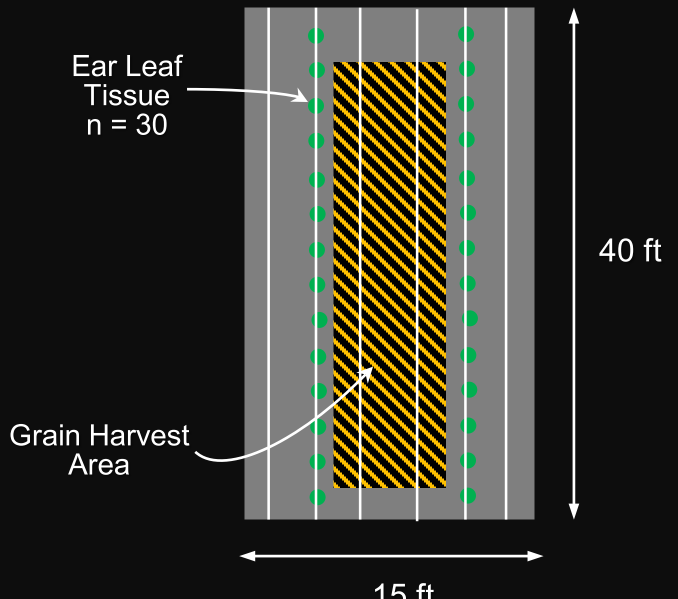


Sites diverse in soil properties, soil types, hybrids, management, crop history, irrigation and weather.

	Minimum	Maximum
pH	**4.9**	**7.6**
STK ppm	**71**	**605**
SOM %	**1.2**	**5.4**
CEC cmo/kg	**3.8**	**28.0**

[1] Data 2016 sites, seven states.

Check plot diagram
Four per site

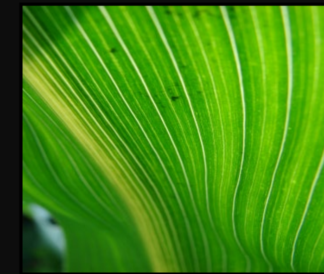


KRx Prescription Potassium

[1] Lab Analysis: Ward Labs, LGI, Solum Laboratory and Sure Tech Labs.

Miller et al, 2018

Cluster Analysis: STK vs Grain Yield

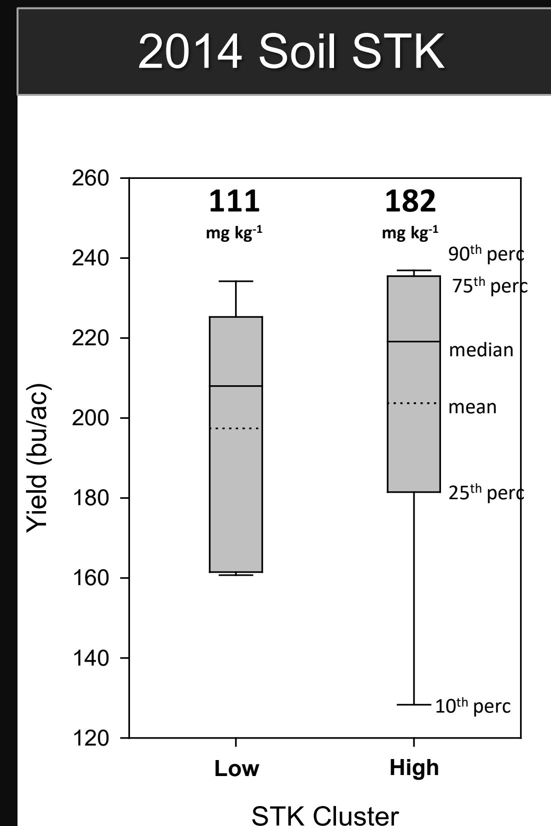


2014, 16 observation sites, 5 states. Data collected on soil M3-K, ear leaf nutrients and yield, M3-K sorted low to high.

	STK (ppm)	Yield (bu/ac)
Lowest	90	161
	100	234
	116	222
	122	162
	126	208
	128	131
	139	174
	141	183
	146	182
	151	188
	158	187
	163	128
	186	199
	187	237
	187	219
Highest	189	235

	STK	Yield
Mean	111	197
Stdev	16	34

	STK	Yield
Mean	182	204
Stdev	11	45



Box Whisker Plot

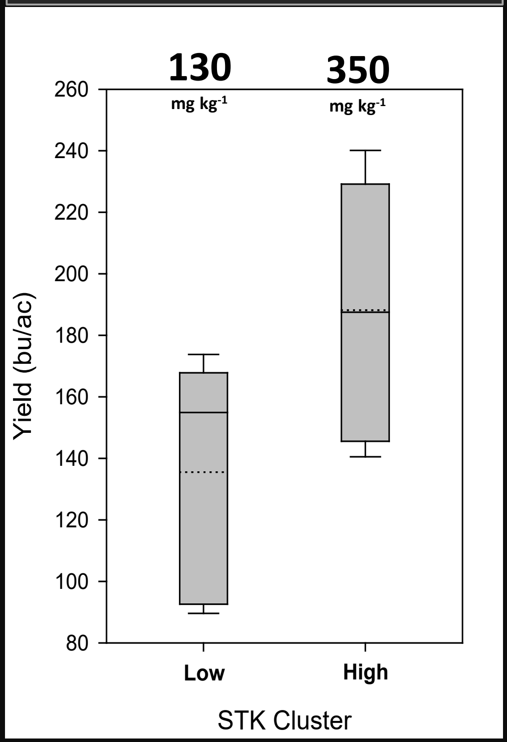
[1] Cluster analysis contrasting five lowest sites and five highest sites for Mehlich 3 K 0-8” response variable grain yield, 8 reps per site.

Miller et al, 2018

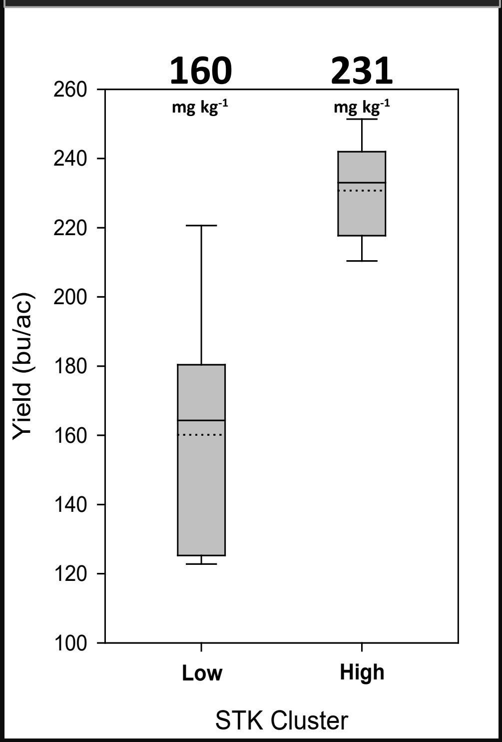
Cluster Analysis: STK and Yield

Box Whisker plot STK cluster[1] comparisons variable grain yield, 3 years.

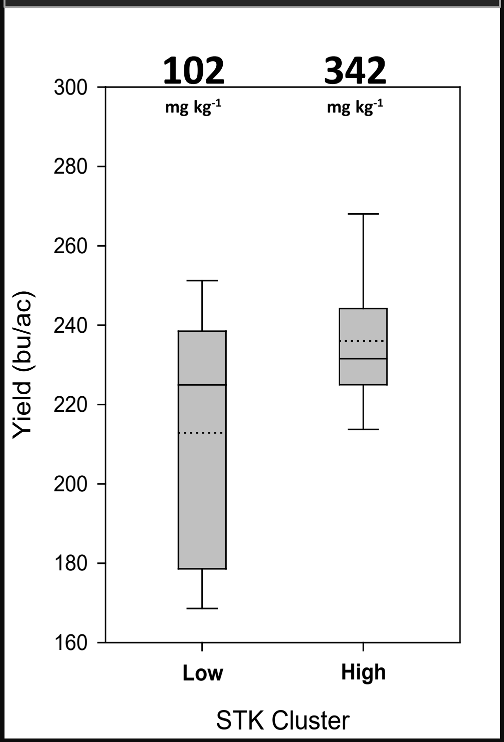
2012 Soil M3-K



2013 Soil M3-K



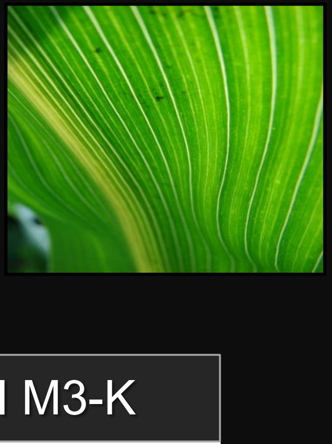
2016 Soil M3-K



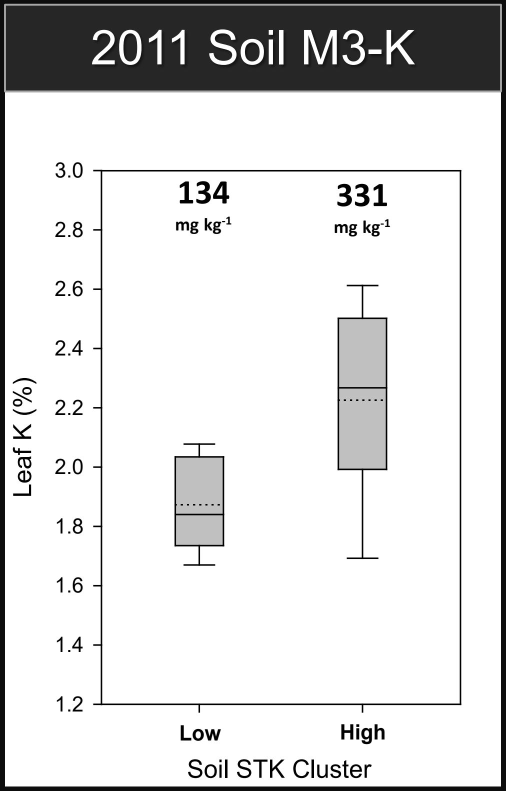
[1] Cluster analysis contrasting five lowest sites and highest sites for Mehlich 3 STK 0-8” in response variable grain yield.

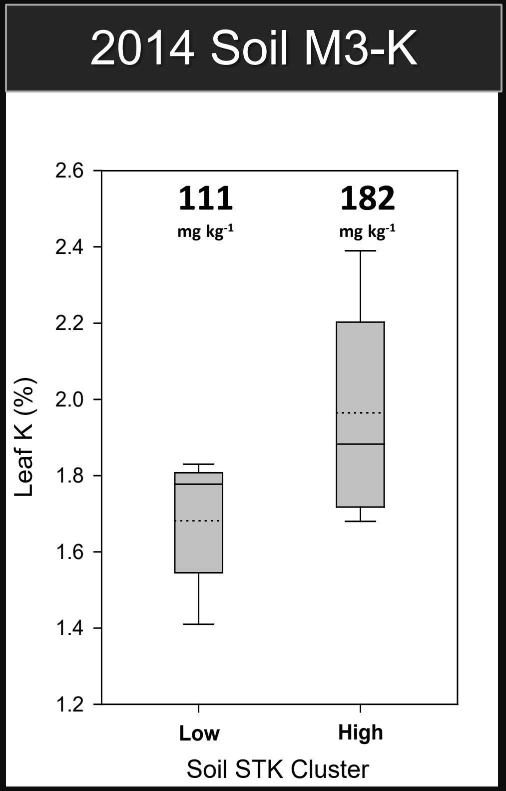
Miller et al, 2018

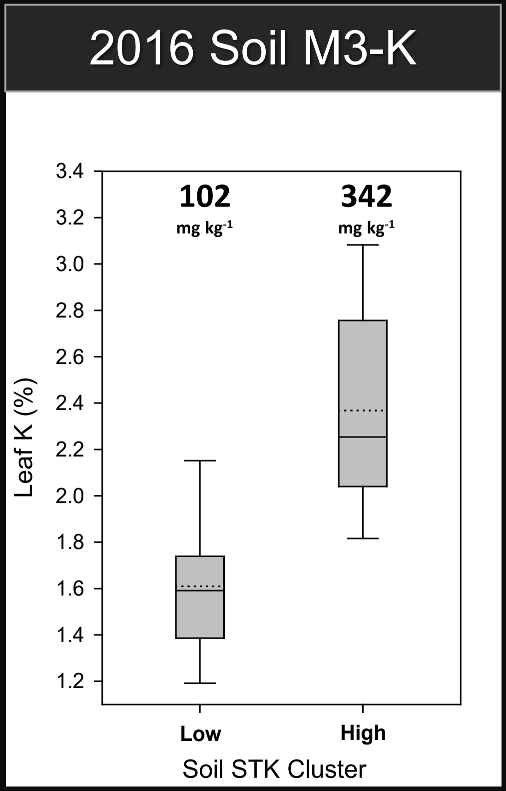
Cluster Analysis: STK vs Leaf K



Box Whisker plot soil M3-K cluster[1] comparisons for variable ear leaf K for three years.



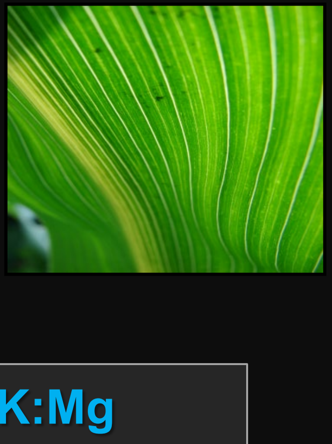




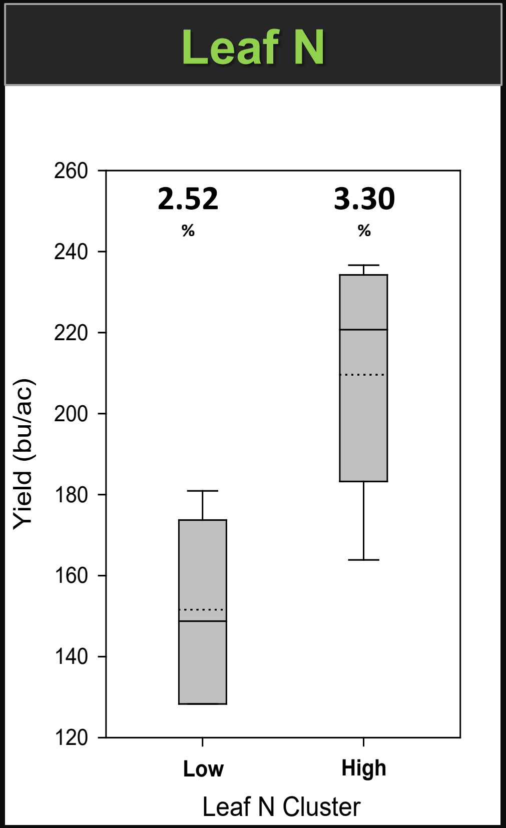
[1] Cluster analysis contrasting five lowest sites and highest sites for Mehlich 3 K 0-8" response variable corn ear leaf K R1-R2.

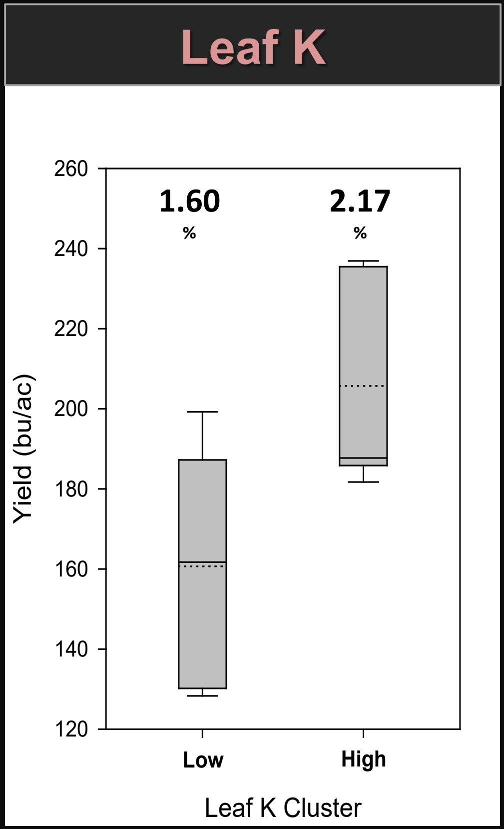
Miller et al, 2018

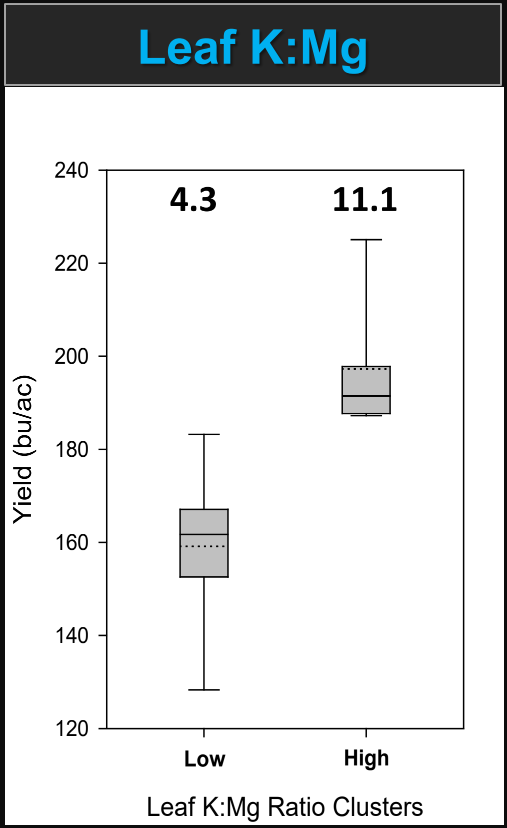
2014 Ear Leaf Nutrients Cluster Analysis



Box Whisker plot nutrient cluster[1] comparisons
Variable grain yield – 2014, 16 sites, cluster size 5 sites each



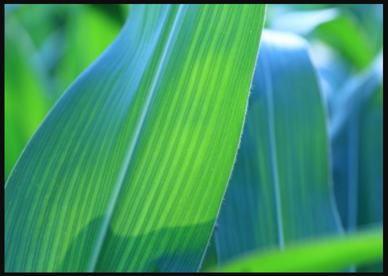




[1] Cluster analysis based on five lowest sites and highest sites for each test parameter (Leaf N, K and K:Mg), response variable grain yield, 8 reps per site.

Miller et al, 2018

Leaf K Cluster Analysis 2014



Cluster [1] comparisons: 2014 - 16 sites

Parameter	**Low K Cluster**		**High K Cluster**	
	Mean	*Stdev*	Mean	*Stdev*
N %	**2.80**	*0.51*	**2.95**	*0.27*
K %	**1.60**	*0.16*	**2.17 ***	*0.14*
Mg %	**0.34**	*0.04*	**0.23 ***	*0.03*
K:Mg	**4.8**	*2.2*	**10.2 ***	*1.8*
N:Mg	**8.4**	*1.5*	**13.3 ***	*1.7*
Yield bu ac^{-1}	**160**	*21*	**210 ***	*23*

[1] Sixteen sites, each cluster five sites, differences *significant at 0.05 level.

Low leaf K clusters show a significant Mg increase Mg, and declines in K:Mg and N:Mg ratios associated with lower grain yield.

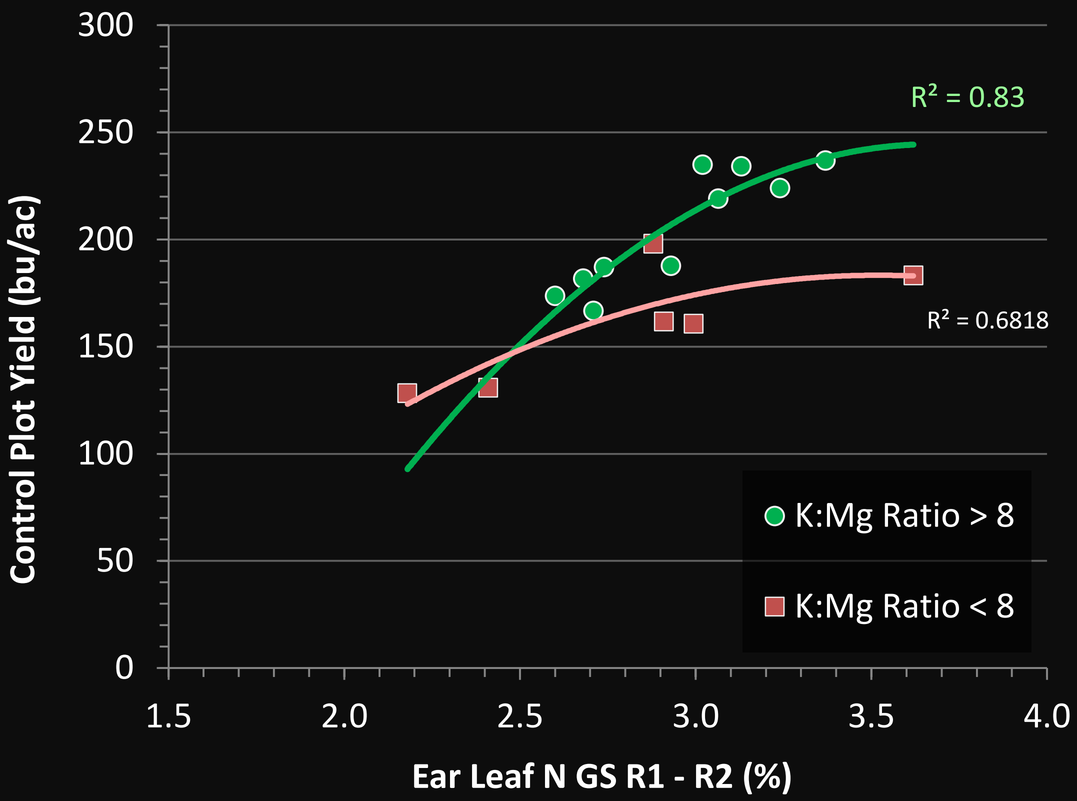
Leaf diagnostic norms reported by Elwali et al. (1985) show the normal range K:Mg of 10.0 ± 4.2 and N:Mg value 14.1 ± 3.7 .

Low leaf K clusters K:Mg and N:Mg are outside normal range.

Miller et al, 2018

Leaf N vs Yield 2014

2014 – Ear Leaf N vs Yield[1] comparisons:



Grain yield increases with ear leaf N content.

However, sites with leaf K:Mg < 8 had lower grain yields than sites with a ration > 8.

Decrease leaf K and elevated Mg associated with lower yields.

[1] Sixteen sites, across five states

Miller et al, 2018

Summary: Ear Leaf K Cluster Analysis

131 sites, 2011 – 2016 cluster mean comparisons

Year	Mean Ear Leaf Low K cluster [1]		Mean Ear Leaf High K cluster		Yield Difference
	K %	K:Mg	K %	K:Mg	Bu/ac
2011	1.77	5.9	2.64 *	11.1 *	40.5
2012	1.52	3.2	1.91	6.7 *	58.2 *
2013	1.67	3.0	1.95	8.3 *	34.6
2014	1.60	4.8	2.17 *	10.2 *	49.5 *
2015	-	-	-	-	-
2016 [2]	1.47	3.6	2.93 *	14.2 *	44.1 *

*[1] Clusters comparisons five sites in 2011, 2012 and 2014; four in 2013; and eight 2016. Insufficient data 2015, five sites. * values are significant at the 0.05 level.*
[2] 2016 Data based on 46 sites, seven states.

45.2 ← **Five year mean**

Cluster comparisons show mean leaf K and K:Mg ratios are different.

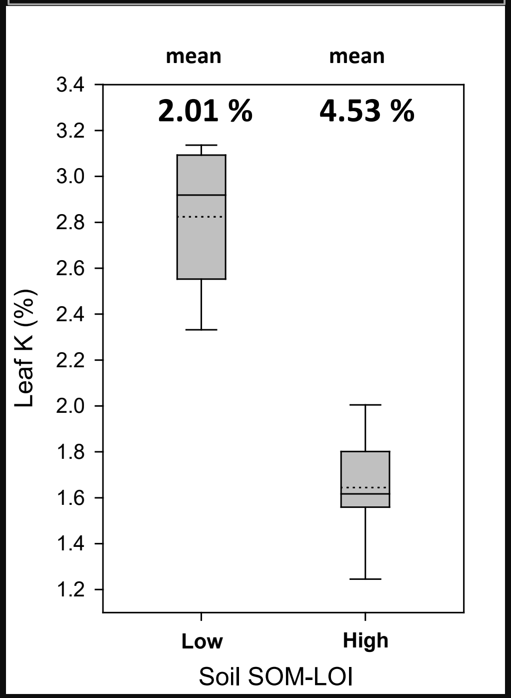
Cluster yield differences were consistent.

Miller et al, 2018

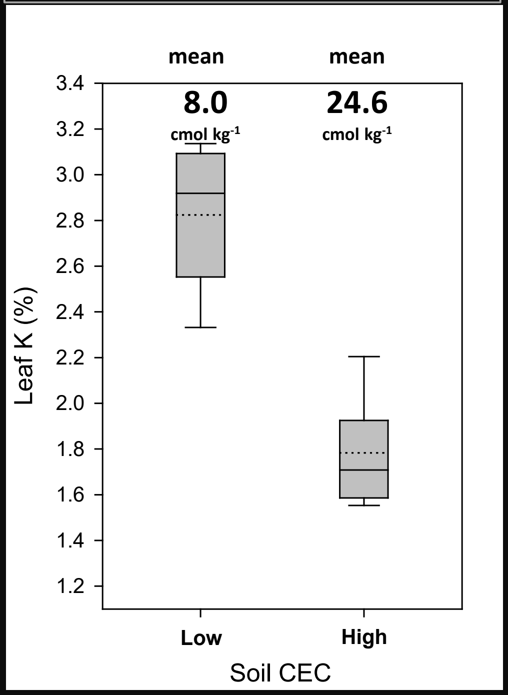
Cluster Analysis Soil Properties 2016

Box Whisker plot soil test parameters[1] comparisons
Variable ear leaf K, cluster size - 8 sites each

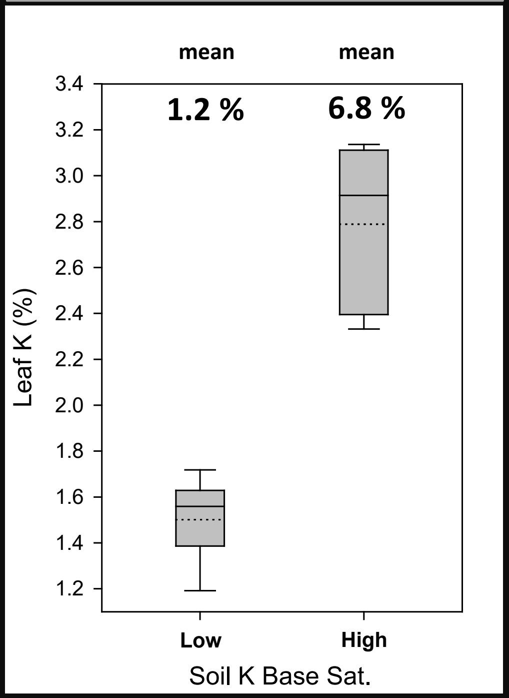
SOM-LOI [2]



CEC



K Base Sat.



[1] Cluster analysis contrasting eight lowest sites and highest sites for soil variables 0-8” depth, response variable ear leaf K R1-R2. (CEC by summation).

[2] Regression of CEC = 5.6(SOM-LOI) - 1.0, R^2 0.864

Miller et al, 2018

Soil K Base Sat Cluster Analysis


http://extension.missouri.edu/explore/images/ipm1007crabgrasslarge01.jpg

K Base Sat. Cluster comparisons - 2016 Sites

Variable[1]	Soil K Base Saturation (%)			
	Low Cluster		High Cluster	
	Mean	*Stdev*	Mean	*Stdev*
K Base Sat (%)	**1.2**	*0.2*	**6.8 ***	*1.7*
CEC (cmol kg^{-1})	**23.4**	*3.5*	**11.7 ***	*4.7*
SOM (%)	**4.28**	*0.58*	**2.40 ***	*0.50*
M3 K:Mg (meq)	**0.05**	*0.01*	**0.43 ***	*0.26*
Leaf K (%)	**1.50**	*0.20*	**2.62 ***	*0.32*
Leaf K:Mg	**4.6**	*1.8*	**13.2 ***	*6.2*
Stalk K (%)	**0.97**	*0.55*	**2.51 ***	*0.67*
Grain (bu/ac)	**202**	*26*	**240**	*11*

[1] Forty-six sites across seven states, K base sat cluster size eight sites each.
[2] * Mean values are significant at the 0.05 level.

Cluster analysis of soil K Base Sat. shows significant differences for soil CEC, SOM, K:Mg ratio.

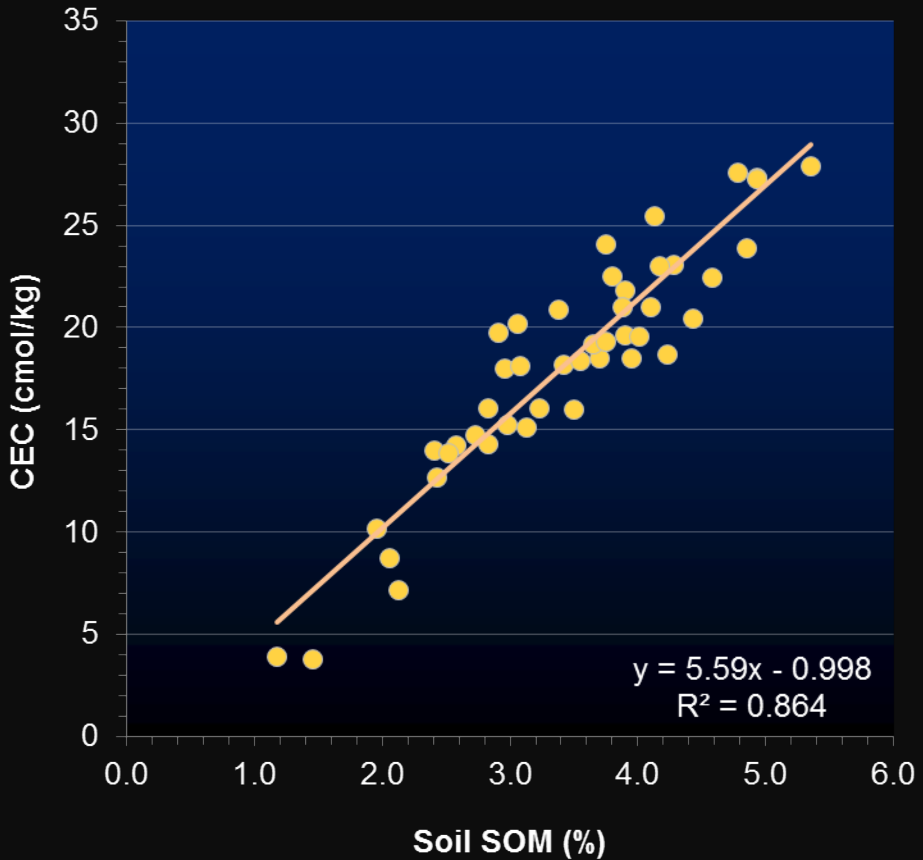
Low soil K Base Sat. was associated with low leaf K, low K:Mg, stalk K and lower grain yields.

Grain yield, although associated with higher leaf K, is a function of factors impacting grain fill (moisture, N, Pest, Temp etc.).

Miller et al, 2018

Soil SOM vs CEC

Relationship of SOM vs CEC 2016, 50 observation sites across 7 states.



Strong relationship between SOM and CEC suggesting cation retention is highly associated with SOM.

SOM is negatively correlated with ear leaf K.

[1] CEC by summation, SOL-LOI – Solum Laboratory.

Miller et al, 2018

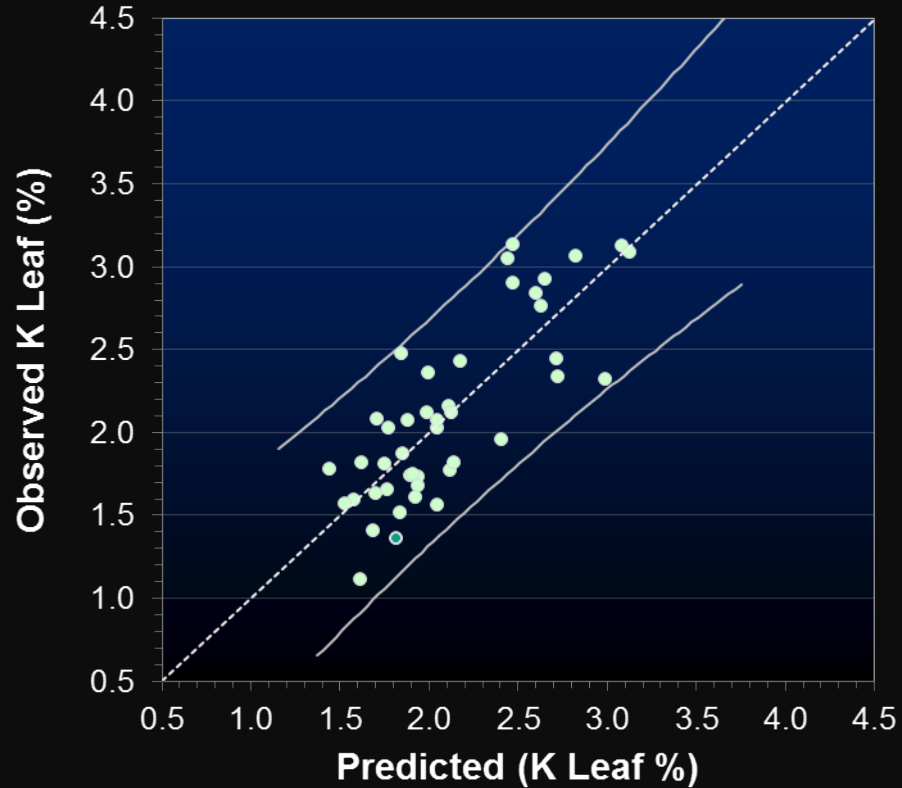
Multi Linear Model of Ear Leaf K

STK linear model had a R^2 of 0.24 with ear leaf K.

Regression analysis[1] shows ear leaf K is associated with K Base Sat, SOM and M3 K/Mg ratio.

K Leaf = 2.6 - 0.24x(SOM) + 0.022x(K Base Sat) + 1.05x(M3 K:Mg)

R^2 - 0.65



[1] Forty-six sites 2016 across seven Midwestern states.

Miller et al, 2018

Soil K Base Sat. Ranges 2016

Soil K Base Sat. Range	Parameter	
(%)	Percent of ear leaves < 2.0% K	*Average Grain Yield (bu/ac)*
< 1.5	100 %	205
1.5 – 2.0	70 %	222
2.0 – 3.0	54 %	236
3.0 – 5.0	33 %	244
> 5.0	12 %	245

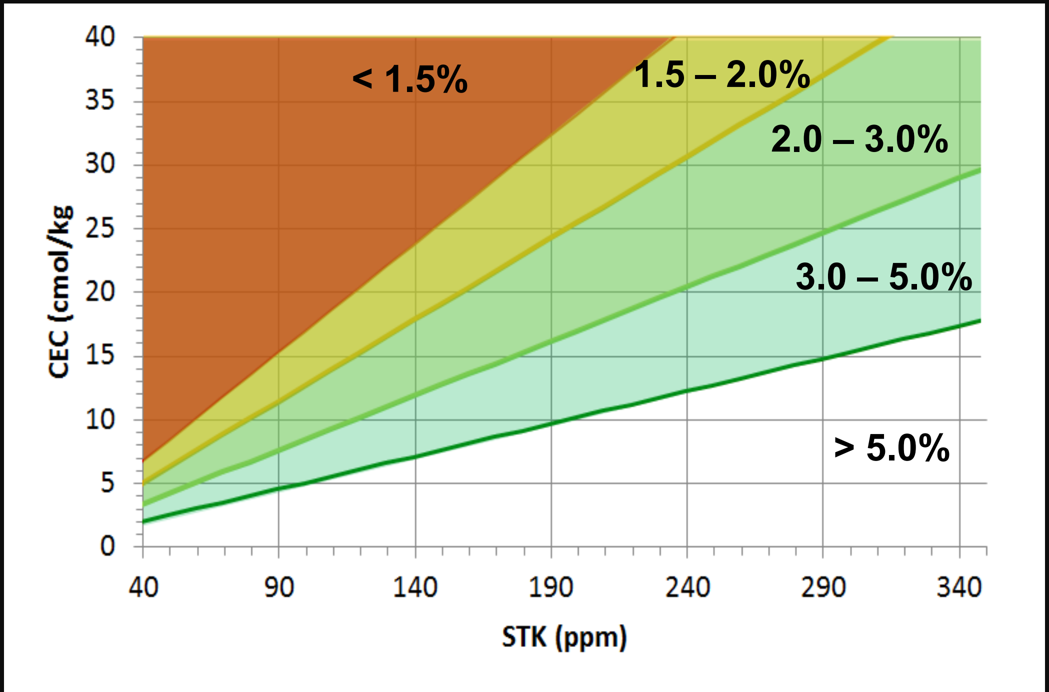
[1] 2016, 46 field sites, each K base sat range represent 7-9 observations sites, soil sample 0-8" depth collected spring 2016, ear leaves collected at GS R1-R2.

Cluster analysis of soil K Base Sat. shows significant impact on leaf K concentration and average grain yield.

Note data is diverse as it represents 46 observations collected across seven states ranging in soil types, weather, management and hybrids.

Miller et al, 2018

Soil K Base Sat. vs STK



Soils with STK of 190 ppm with CEC > 30 cmol/kg are likely to have ear leaf K deficiency.

Whereas, soils with 90 ppm K with CEC of 5-6 cmol/kg are likely not to be K deficient.

[1] 2016, 46 field sites, each K base sat range represent 7-9 observations sites, soil sample 0-8” depth collected spring 2016, ear leaves collected at GS R1-R2.

Miller et al, 2018

2017 Soil K Base Sat Comparisons

Cluster [1] comparisons: 2017 - 20 sites

Parameter	Low K Base Sat	High K Base Sat
	Mean	Mean
K Base Sat %	1.4	6.5 *
Soil K:Mg	0.07	0.48 *
Leaf K %	1.40	2.47 *
Leaf K:Mg	2.9	14.9 *
Stalk K %	0.73	2.02 *
Yield bu ac^{-1}	241	265 ns

[1] Twenty sites across six states, each cluster five sites, differences *significant at 0.05 level.

Low soil K Base sat clusters show significant lower soil K Base sat, and K/Mg ratio.

Leaf data shows low ear leaf K leaf K:Mg and stalk K for sites with low K base sat.

Yield cluster difference in 2017 is 24 bu ac^{-1} lower yield.

Miller et al, 2018

Summary of Field Observations

Additional Research planned for 2018 in IA, SD, IL, MN, and NE.

- ✓ Soil test K minor association with leaf K and grain yield.
- ✓ Ear leaf K > 1.9% and K:Mg > 8 are associated with higher yields, averaging 45 bu ac^{-1} over low leaf K clusters over five yrs.
- ✓ Soil K Base Saturation is correlated with ear leaf and stalk K, and higher yields. CEC, SOM and M3-Mg levels are negatively correlated. K Base Sat, decreases with depth.

Miller et al, 2018

Observations on Grain Yield

2016 Sites comparison of yield clusters

Variable[1]	Grain Yield Clusters	
	Low Cluster (mean)	High Cluster (mean)
Grain (bu/ac)	185	266 *
STK (ppm)	143	219 ns
K Base Sat (%)	1.9	3.6 ns
Leaf N (%)	2.54	2.85 ns
Leaf K (%)	1.76	2.16 ns
Leaf Zn (ppm)	26	35 *

[1] Forty-six sites across seven states, yield cluster size eight sites each.
[2] * Mean values are significant at the 0.05 level.

Yield cluster comparisons show no differences for in pH, Bray P, SOM, CEC or M3-Zn. Trends were noted for higher K base sat, leaf N and Leaf K with yield.

Multiple factors impact grain fill and yield, but only leaf **Zn** was significantly higher for the high yield grain cluster.

Miller et al, 2018

Over View Corn K Nutrition

K Demand GS V3-V5

Low demand 0.5 – 2 lbs/ac/day

Low K Base Sat and decreased soil moisture have limited impact on crop demand and growth

K Diffusion

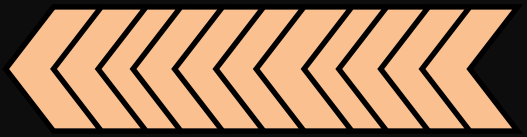
Over View Corn K Nutrition

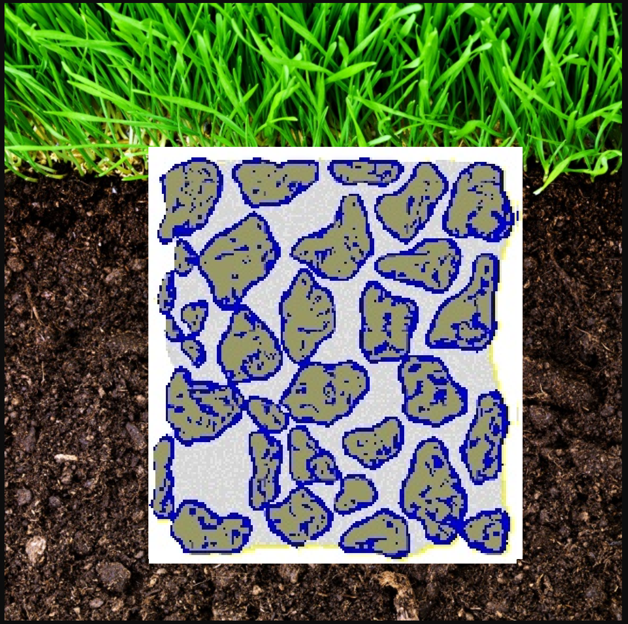
K Demand GS V5-V10

Peak demand 8-12 lbs/ac/day

Low K Base Sat and decreased soil moisture have large impact on crop uptake and growth

K Diffusion





Management Tools

KRx Prescription Potassium

Soil Analysis

- Assess K Base saturation: <3% K:Mg < 0.15

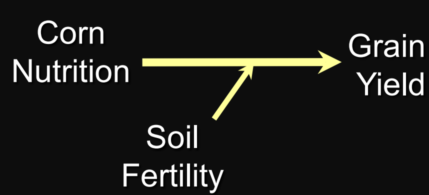
Tissue Analysis - Nutrition

- Ear Leaf K < 1.9% K:Mg < 6, K deficient
  Track <u>four</u> grid points/field, assess Mgt.

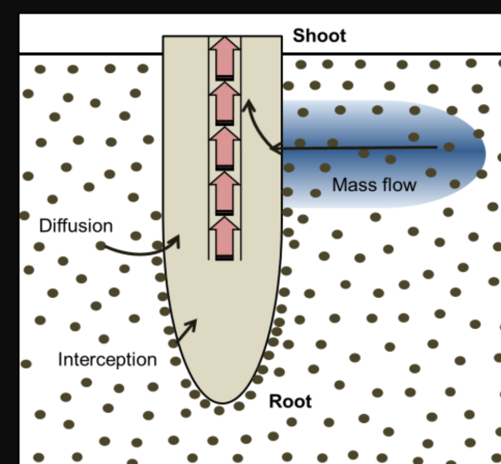
Stalk Analysis

- Stalk K < 1.5%, low plant K uptake.

Root Cause Analysis



A 50% soil moisture stress GS V5-V10 will decrease, K diffusion > 80%, facilitating Mg uptake.



Miller et al, 2018

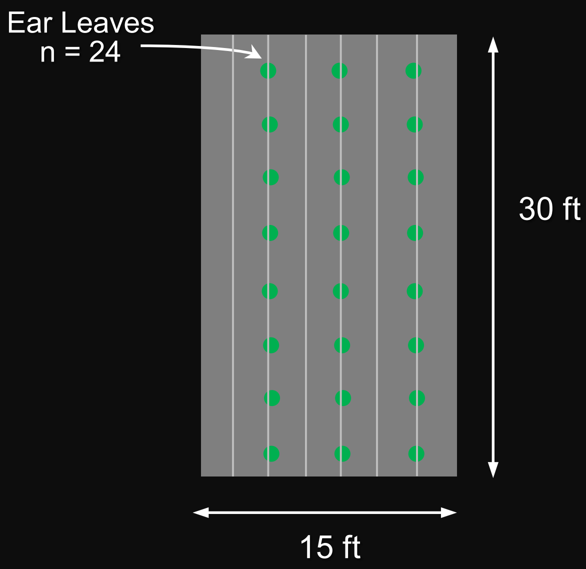
Monitoring K Fertility

Soil Analysis

Recommend 12-15 soil cores 0-8” from an area 20 x 30 feet, 4 cores within 3” of row center and 8 cores > 3“ of row center. Spring sampling.

Plant Analysis

Recommend collection of 24 ear leaves at R1-R2 from an area 15 x 30 feet, every other row. Assess nutrition status. Add stalk analysis.



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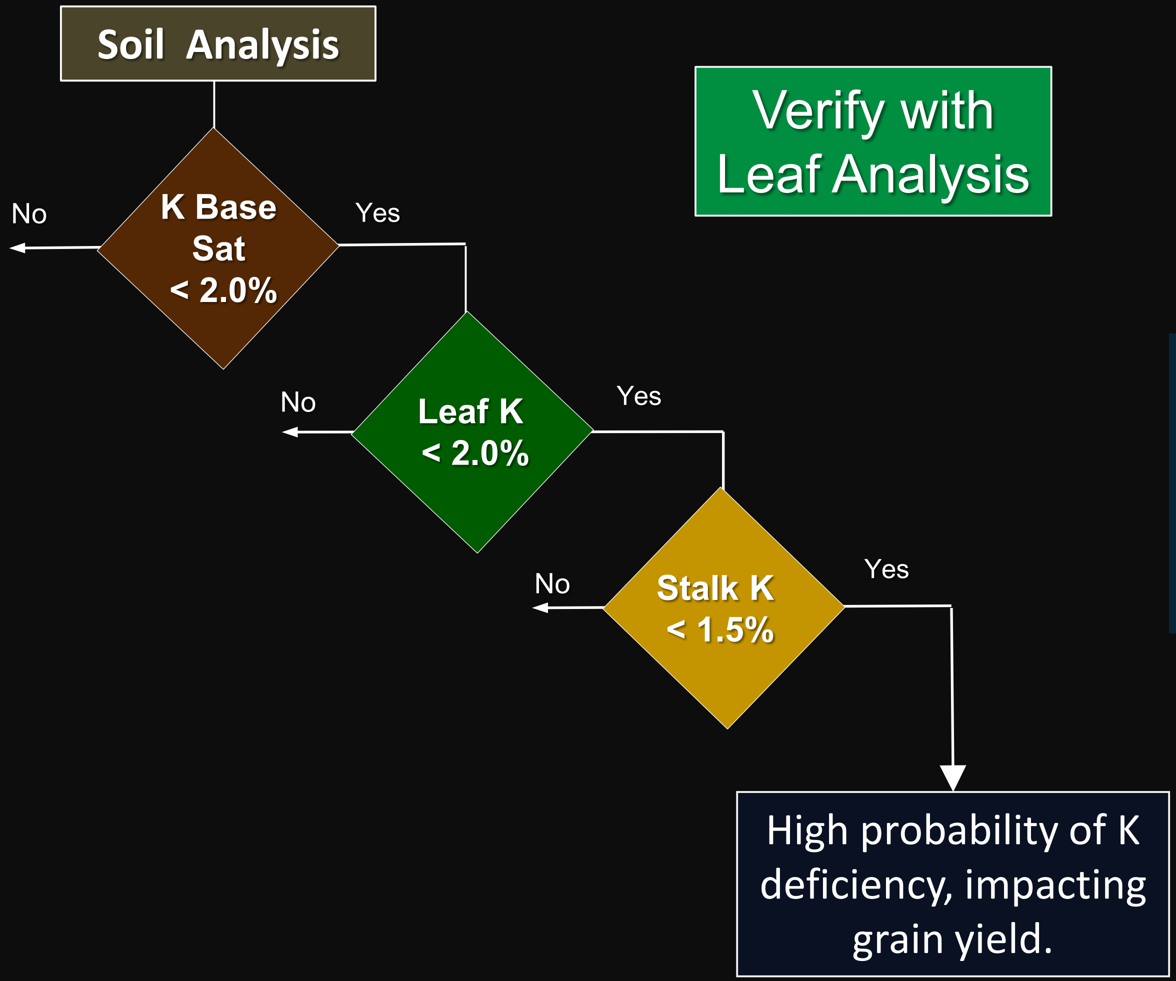
Management Interpretation

http://extension.missouri.edu/explore/images/ipm1007crabgrasslarge01.jpg



Verify with Leaf Analysis

2016 data shows 89% of K Base sat < 2% had ear leaf K < 2% and 95% of stalks K < 1.5%.

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K Fertilizer

https://mir-s3-cdn-cf.behance.net/project_modules/disp/4d2cca13665729.562769ef7f2f6.jpg

Seven years of research shows side dress application of K fertilizers marginally effective at correcting ear leaf K deficiency and improving yield on reduced till systems.

Rates, K products (KCl, K_2SO_4 or K acetate), and timing all show limited effectiveness, with mean yield responses of 9-31 bu/ac.

Pre-plant surface banding 100 lbs/ac (6” band equivalent 500 lbs/ac) improved yield 17 bu/ac, and was cost effective alternative.

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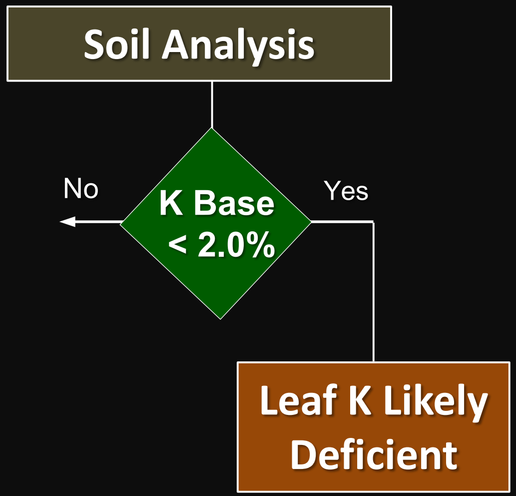
Soil Analysis Assessment

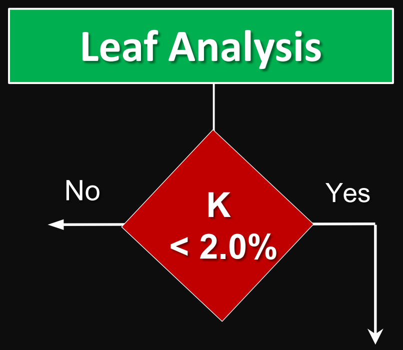


- Avoid K surface broadcast. Not effective.
- Over the row banding, 100 lbs/ac, pre-plant.
- Deep banding, 2x2, 2x4 at 50-100 lbs/ac.
- Irrigation, 10-15 lbs/ac per circle, GS V4-V12.

Note: It's difficult to supply fertilizer K during GS V4-V12 to meet a demand of 10-12 lbs/ac/day. For dryland added impact of moisture stress. Assess ear leaf K status and fertilizer effectiveness with tissue testing.

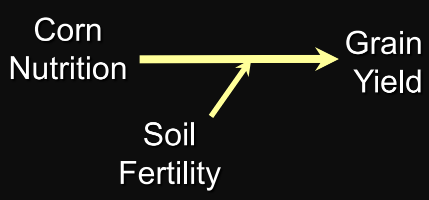
Miller et al, 2018

Take Home Message



If your focused solely on soil fertility and not managing crop nutrition, then your missing the keys to higher yields!

Root Cause Analysis



https://www.youtube.com/watch?v=9u05RwfwtQw

Miller et al, 2018

Thanks to our Grower Cooperators, Students and Staff who have assisted with this project.

Research continues in 2018

Miller et al, 2018

SoilView™

Special thanks to Soil View for their collaboration over the past seven years.

[1] Formerly Midwest Independent Soil Samplers.

Sponsors

KRx Prescription Potassium

WinField Solutions

The Climate Corporation

Fluid Fertilizer Foundation

Nachurs Alpine Solutions — Nachurs, Alpine, NASi

Wilbur-Ellis

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ALP

Thank you for your time and attention

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