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Why In-season Tissue K Testing is Important...

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Observational Data Analysis of Soil Fertility and Leaf Analysis on Maize Grain Yield in the Central US

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January 24, 2017
Rome, Italy

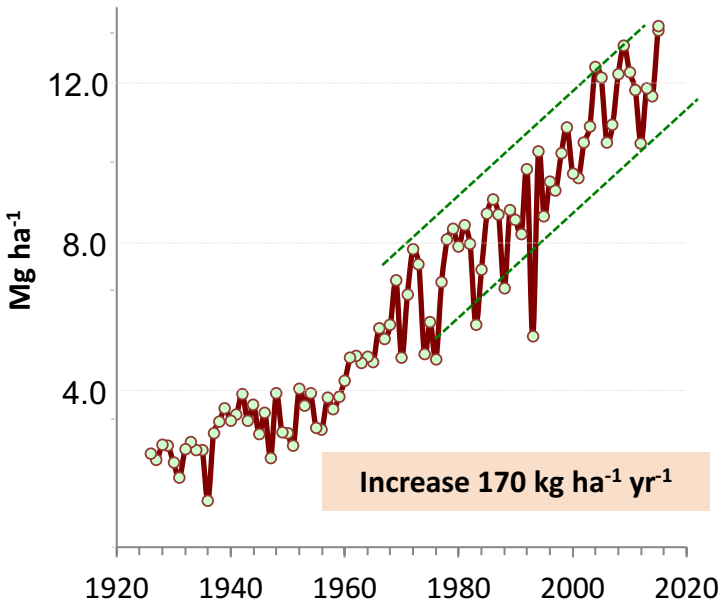
http://gmoanswers.com/sites/default/files/corntatt.jpg/

US Maize Production

Maize grain yields in the central US have increased an average of 170 kg ha^{-1} yr^{-1} (2.6 bu ac^{-1} yr^{-1}) since 1980 due to improved agronomic management and fertility programs, K is removal 0.7 kg ha^{-1} yr^{-1} .

Midwest soil Mehlich 3 K levels have been declining (IPNI, 2010). Results from MVTL laboratory in show 68% of samples with M3-K levels < 180 mg kg^{-1}, 2015.

Maize Yields - 95 years



[1] Corn yield average, North west Iowa
source: http://quickstats.nass.usda.gov/results

STK [2] mg kg^{-1}	Year		
	2013	2014	2015
< 120	17 %	16 %	25 %
< 150	40 %	43 %	47 %
< 180	61 %	64 %	68 %

68% of samples have K Rec

[2] Data MVTL M3-K 238,000 samples.

Maize Leaf Nutrient Deficiencies - IN

Ear Leaf VT-R1, 3670 samples, six years

Nutrient	Deficiency threshold [1]	Percent of samples deficient [2]					
	< Less Than	*2010*	*2011*	*2012*	*2103*	*2014*	*2015*
N (%)	< 2.76	5.1	5.0	33.1	10.5	16.6	44.7
P (%)	< 0.25	0.6	1.1	20.4	2.7	1.1	13.2
K (%)	< 1.75	29.4	15.3	57.3	17.9	21.4	6.9
S (%)	< 0.16	1.1	0.2	8.1	2.4	7.4	23.2
Zn (ppm)	< 19	4.5	7.2	0.6	6.6	3.0	20.4

Six year Average

18.2 %

24.7 %

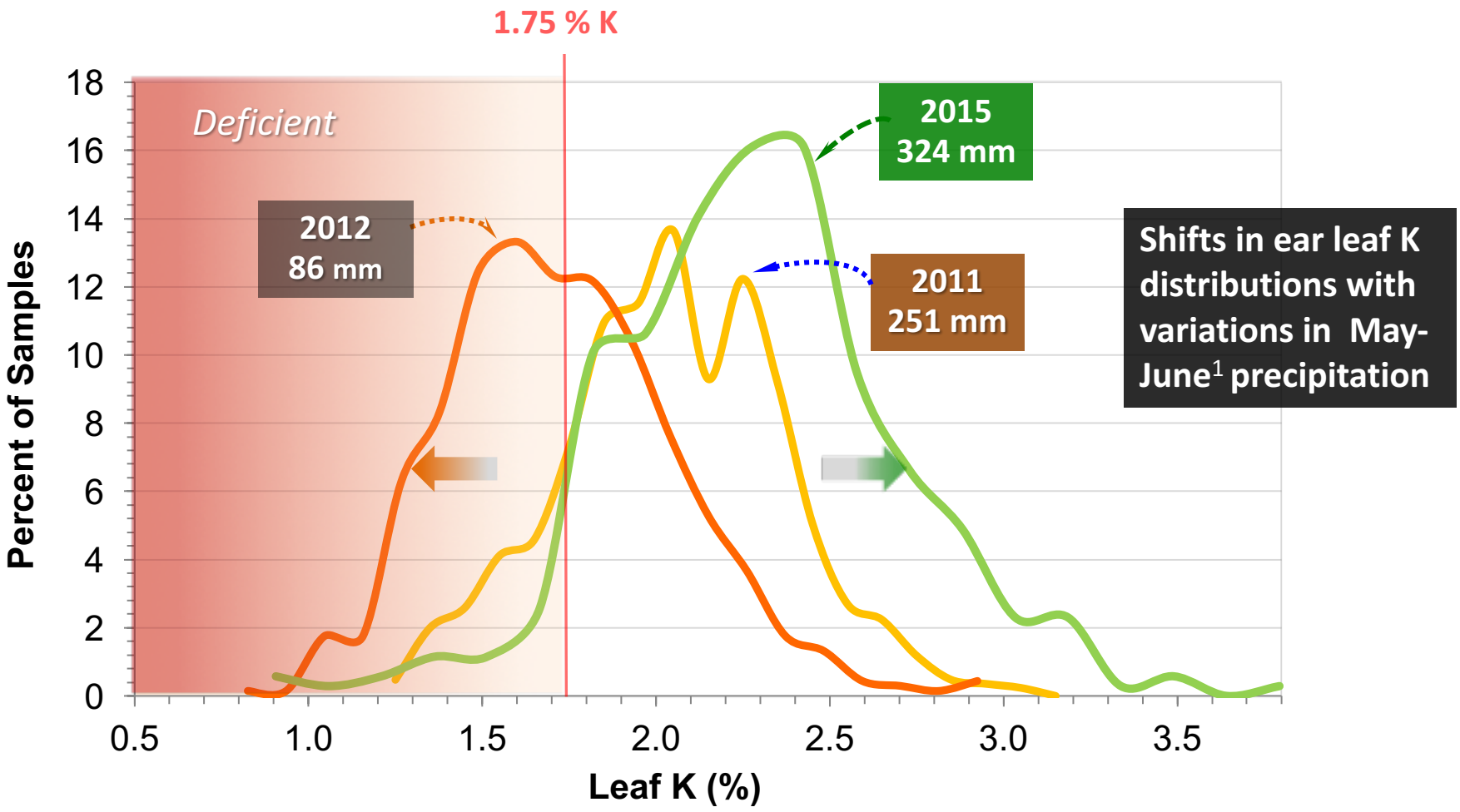
[1] *Critical Nutrient level based on: www.extension.purdue.edu/extmedia/nch/nch-46.html*

CERES SOLUTIONS
Cultivating results.

Source: Betsy Bower, Ceres Solutions

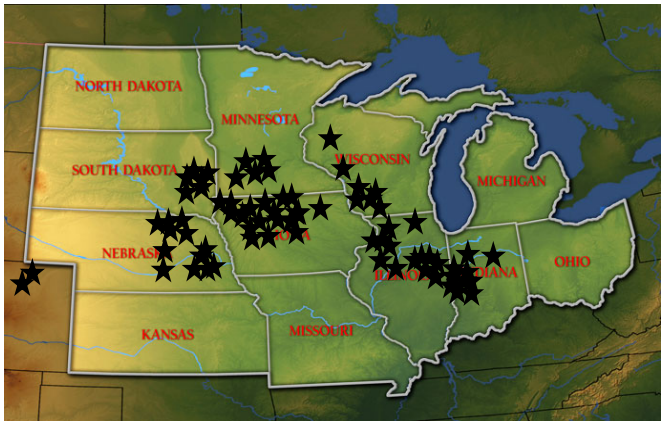
Maize Ear Leaf K Frequency Plot

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



Source: Betsy Bower, Ceres Solutions

K_{RX} Maize Research



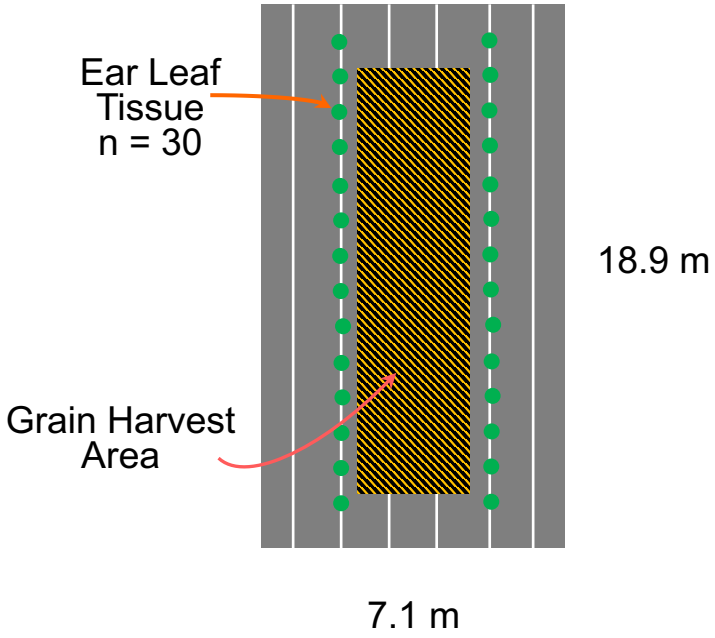
2011-2015, 81 site studies were conducted in grower fields across seven states to evaluate K fertilizer response. Check plot data.

Data collected: soil analysis (pH, P, K, Ca, Mg NO_3-N, P, SOM, 12 core composite); ear leaf GS VT-R1 tissue nutrients; harvest population, grain yield; eight replications per site.

2016, 37 additional sites were conducted in six states, with added data collected on maize stalks. Observational Data Analysis, Cluster comparisons.

Focus on leaf macro Nutrients: N, K, Mg

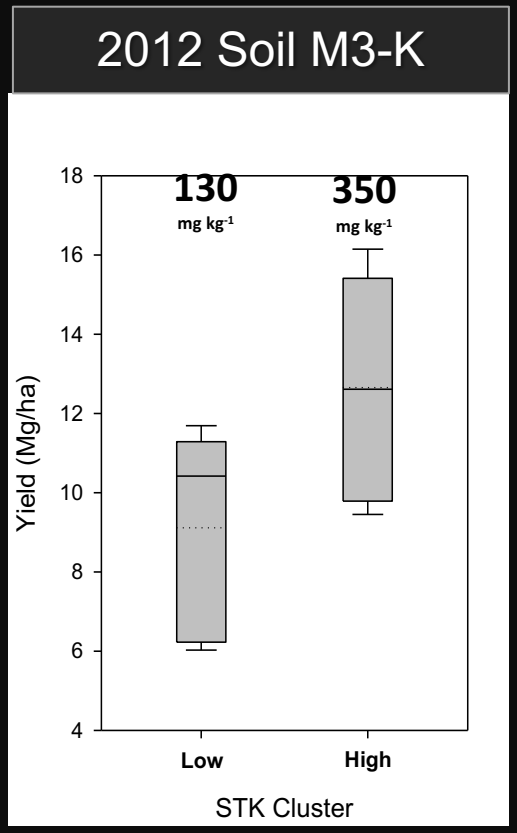
Check plot diagram

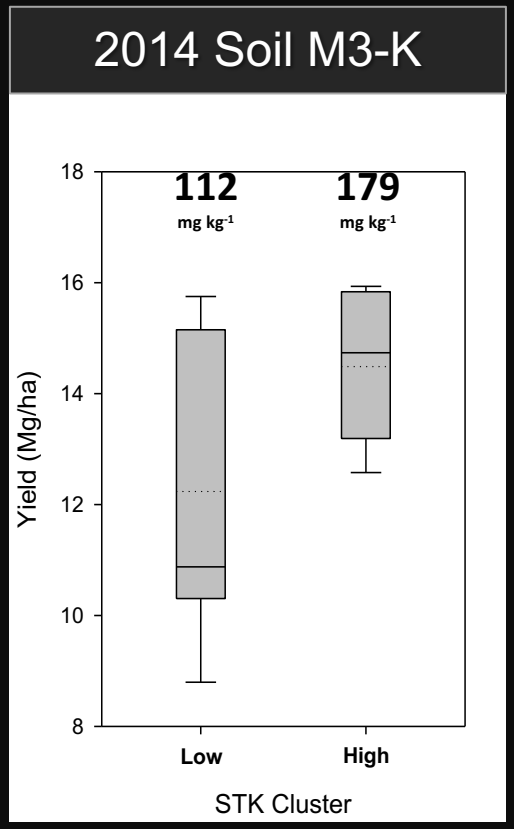


[1] Lab Analysis: LGI, Solum Laboratory and Sure Tech Labs.

Soil Test K Cluster Analysis and Yield

Box Whisker plot STK cluster[1] comparisons
Variable grain yield, size - five sites each

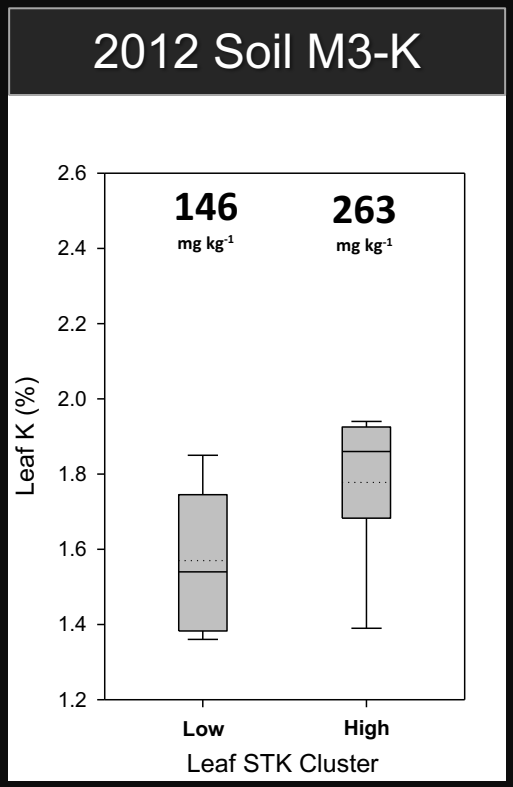


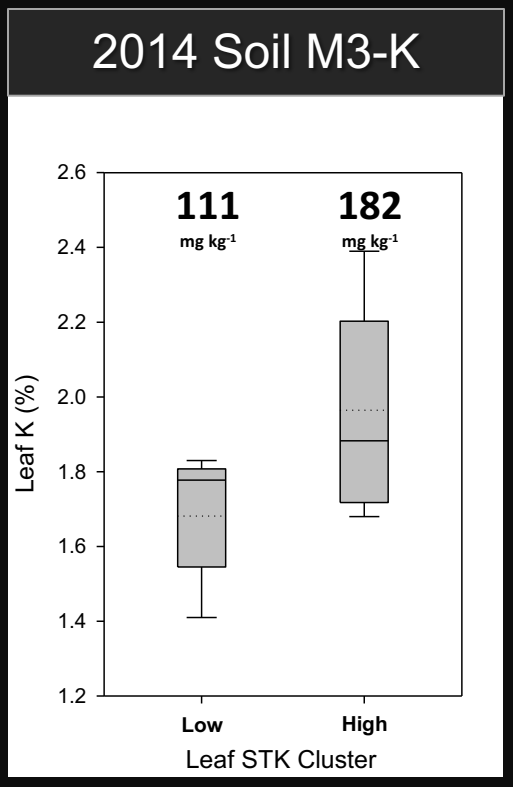


[1] Cluster analysis contrasting five lowest sites and highest sites for Mehlich 3 STK 0-15 cm response variable grain yield.

Leaf K Cluster Analysis and STK

Box Whisker plot STK cluster[1] comparisons
Variable ear leaf K, size - five sites each

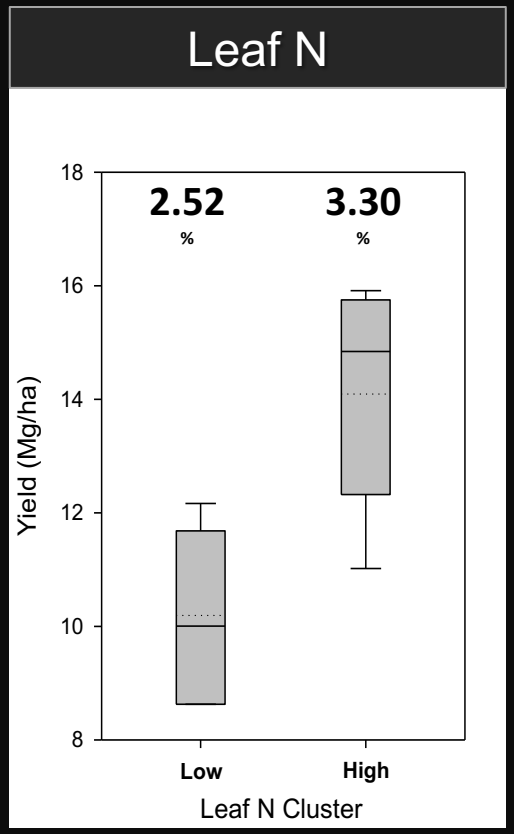


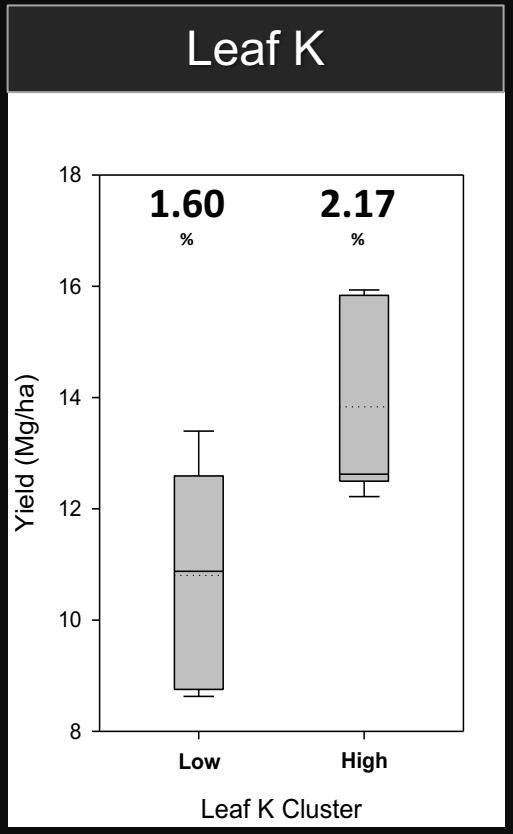


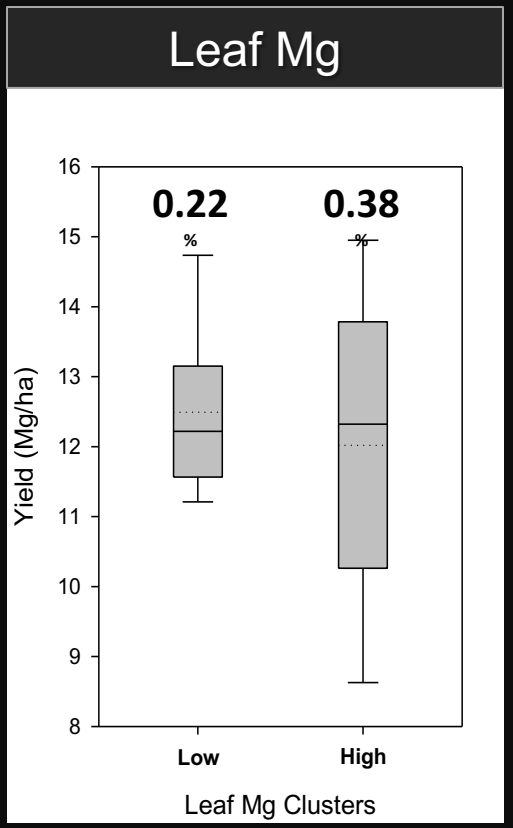
[1] Cluster analysis contrasting five lowest sites and highest sites for Mehlich-3 STK 0-15 cm response variable grain yield.

2014 Leaf Cluster Analysis

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





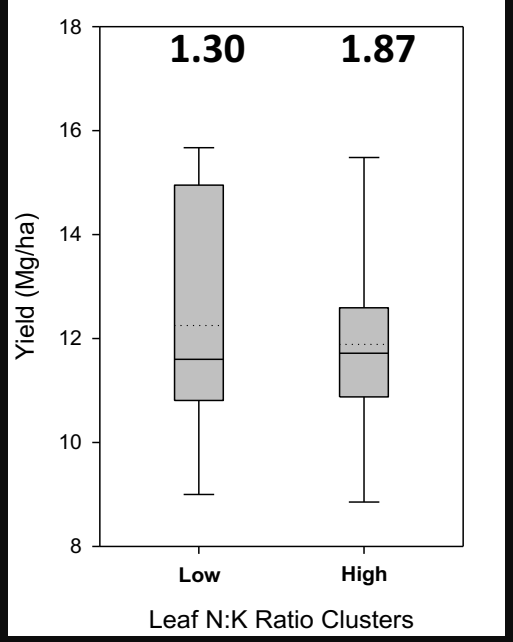


[1] Cluster analysis based on five lowest sites and highest sites for each test parameter (Leaf N, K and Mg), response variable grain yield.

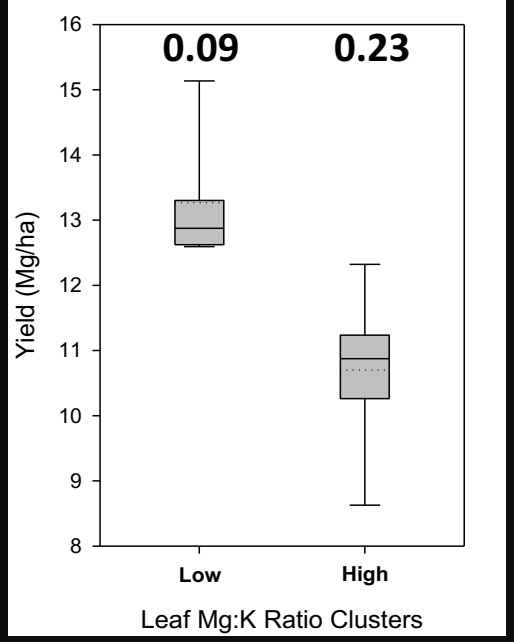
2014 Leaf Cluster Analysis

Box Whisker plot cluster [1] leaf nutrient ratio comparisons
Variable grain yield – 2014, 16 sites, cluster size - five sites each

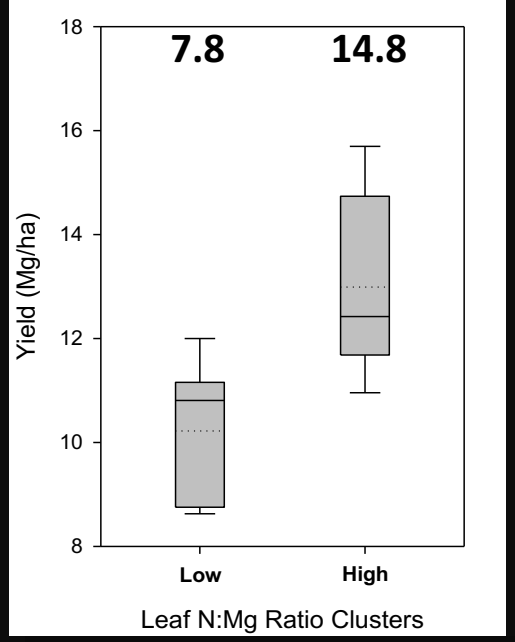
Leaf N:K



Leaf Mg:K [2]



Leaf N:Mg

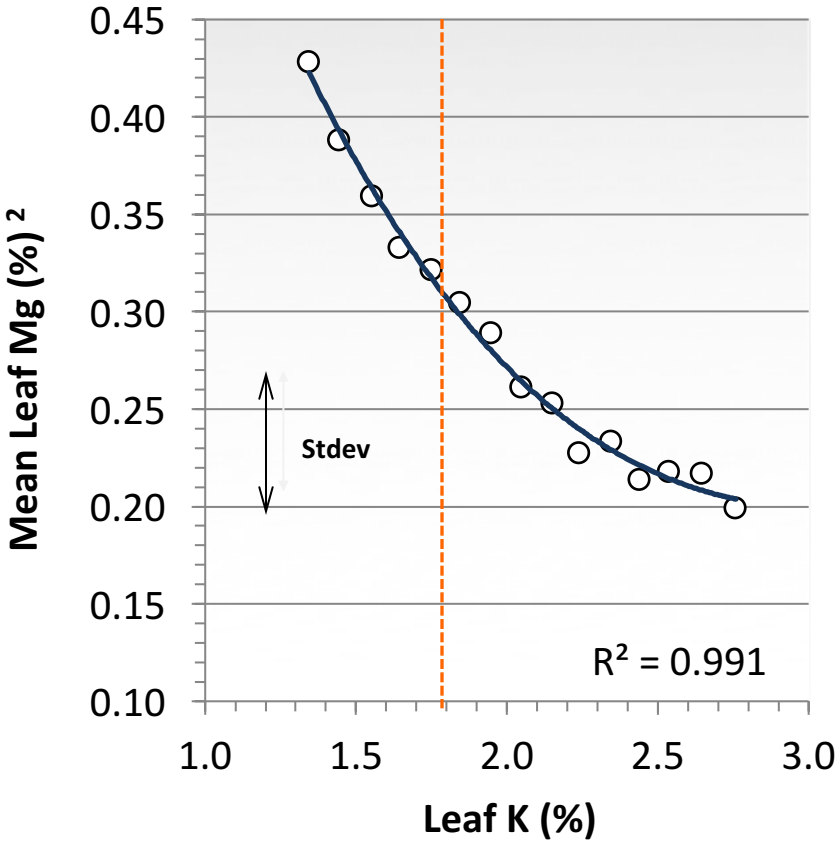


[2] Nutrient ratios based on DRIS

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

Ear Leaf K and Mg Interactions

Maize ear leaf observations[1] show with decreased K, exponential increase in Mg.



Seggeweiss and Jungk, (1988), have shown ryegrass Mg uptake increased when K < 50 uM in soil-grown systems.

Thus with the onset of maize K deficiency, ear leaf Mg increases. No association with soil Mehlich-3 Mg levels.

[1] Source: Ceres Solutions 2011 western, IN, ear Leaf GS VT-R1 851 samples, N limited: 2.76 > N < 4.0

[2] Ear leaf data parsed ⍟0.05% K, vs mean Mg content.

Seggeweiss, B. and A. Jungk. 1988.. Z. Pflanzenernaehr. Bodenk 151(2):91-96.

Leaf K Cluster Analysis 2014

Cluster [1] comparisons – 2014 Sites
16 sites, cluster size - five 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*
N:K	1.76	*0.35*	1.36	*0.16*
Mg:K	0.21	*0.02*	0.10*	*0.02*
N:Mg	8.4	*1.5*	13.3*	*1.7*
Yield Mg ha^{-1}	10.7	*1.6*	13.9*	*1.8*

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

Cluster comparisons of leaf K show significant increases in Mg, Mg:K and N:Mg declines associated with lower grain yields.

Elwali et al. (1985), reported maize ear leaf DRIS normal range Mg:K of 0.10 ± 0.06 and N:Mg value 14.1 ± 3.7 . Low leaf K clusters Mg:K and N:Mg are outside normal range.

Elwali et al. 1985. Agron J. 77:506-509.

2012 Cluster Mg:K Ratio Analysis

Mg:K Cluster [1] comparisons – 2012 Sites
Cluster size - five sites

High leaf Mg:K ratio

Site [1]	Mg:K [2]	N:Mg[3]	Yield
	Ratio	Ratio	Mg ha $^{-1}$
GIB 12	0.23	9.1	7.4
NEL 17	0.25	8.7	11.6
NIE 9	0.30	7.1	10.4
BLA 11	0.33	6.8	9.6
NEL 18	0.44	5.3	10.0
Mean	0.31	7.4	9.6
stdev	*0.08*	*1.5*	*1.4*

Low leaf Mg:K ratio

Site	Mg:K	N:Mg	Yield
	Ratio	Ratio	Mg ha $^{-1}$
BEK 27	0.11	14.4	16.1
BEC 25	0.14	12.5	11.4
LAR 10	0.15	10.2	12.9
CAL 22	0.16	13.2	14.3
CAL 23	0.18	10.2	15.2
Mean	0.15*	12.1*	14.3*
stdev	*0.02*	*1.9*	*1.4*

← Low population Site (45,000 plts ha $^{-1}$)

Difference 4.7 Mg ha $^{-1}$

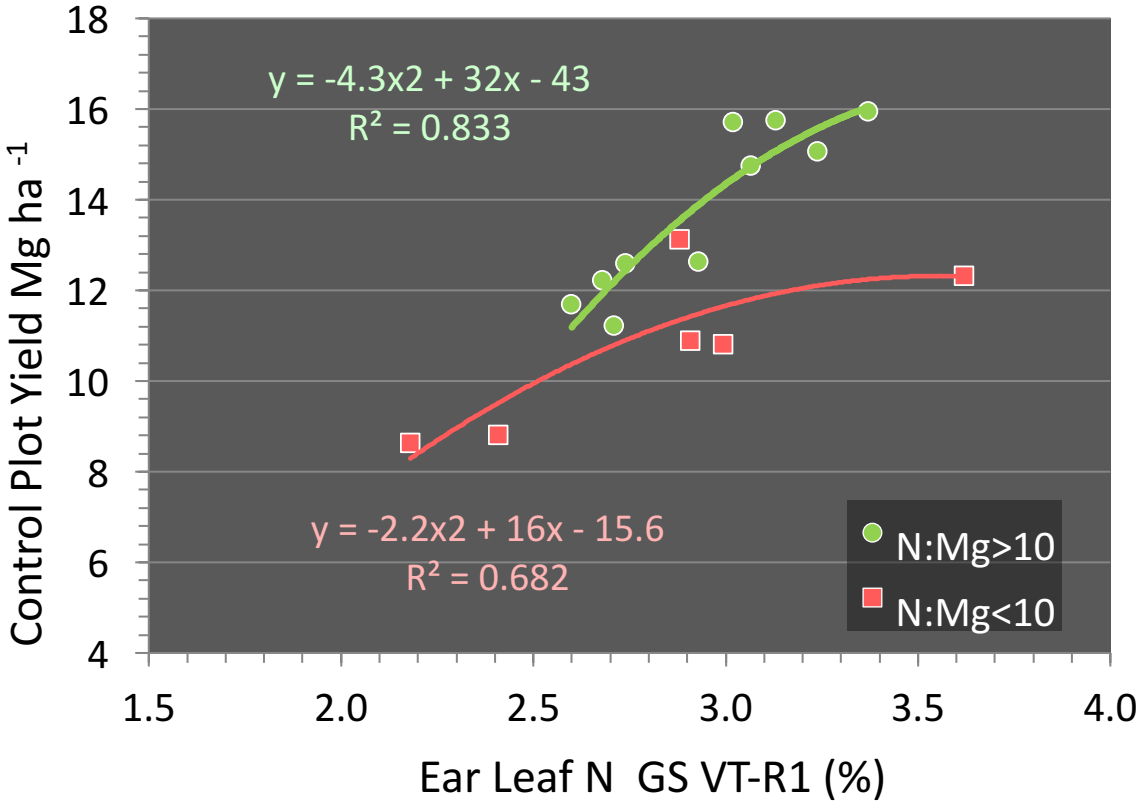
[1] Sixteen sites, Leaf N > 2.9%, from three states.

[2] Mg:K and N:Mg ratios based on maize ear leaf at GS VT-R1 8 reps.

[3] Elwali et al. (1985), normal range leaf GS VT Mg:K 0.10 ± 0.06; N:Mg value 14 ± 3.7

2014 Leaf N vs Grain Yield

83% of grain yield is a function of leaf N for N:Mg > 10 (green) at ten sites. 68% for six sites N:Mg < 10 (red), 3.8 Mg ha^{-1} lower yields, for N< 2.9%.



Results indicate that low N:Mg ratios, associated supra optimal Mg (result of K deficiency) impact grain yield.

Grimme and Nemeth, (1974), reported decreased K diffusion increased oat Mg uptake and reduced yield 60%.

Citation can be found in proceedings

Summary Cluster Analysis

118 Sites, 2011 – 2016 mean comparisons

Year	*Low K cluster* [1]		*High K cluster*		Delta Yield
	K %	Mg:K	K %	Mg:K	Mg ha $^{-1}$
2011	1.77	0.17	2.64*	0.09*	2.7*
2012	1.52	0.31	1.91	0.15*	3.9*
2013	1.67	0.33	1.95	0.12*	2.3
2014	1.60	0.21	2.17*	0.10*	3.2*
2015	-	-	-	-	-
2016	1.47	0.28	2.93*	0.07*	2.9*
					3.0 ← Five year mean

Cluster comparisons show mean leaf K and Mg:K ratios vary, by annual growing conditions.

Cluster yield differences were consistent.

Conclusions

- Soil test M3-K, minor association with maize ear leaf K and grain yield five years.
- 118 site years, leaf N by K interaction. K cluster concentrations were affected by V4-V12 precipitation.
- Maize ear leaf K cluster > 1.9% associated with increased grain yield, averaging 3.0 Mg ha^{-1} over five years.
- Ear leaf K (< 1.9%) were associated with elevated Mg, higher Mg:K, and lower N:Mg ratios. Supports ratios of Elwali et al. (1985) assessing maize macro nutrient deficiencies.
- Maize grain yield optimum, Mg:K 0.07 - 0.12 and N:Mg 12 - 16, sites outside these ranges show diminished yields.

Maize Macro Nutrient Impact

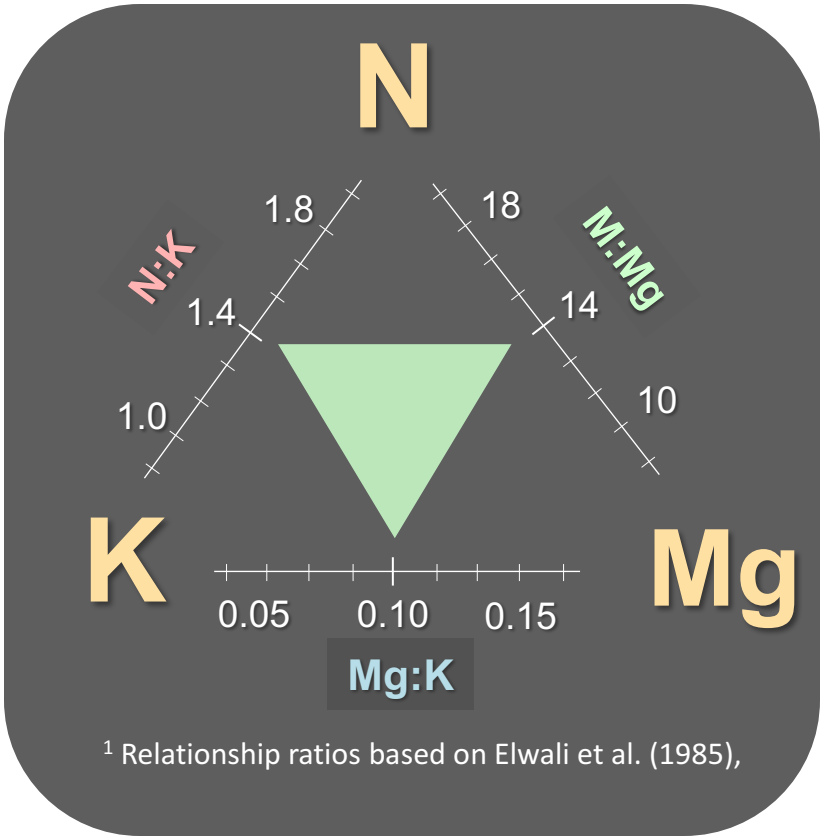
Nitrogen, population and temperature drive maize N and K demand during growth stages V4-V12.

When 5-15 cm depth soil volumetric H_2O is limited, soil rhizosphere K diffusion / release slows, Mg uptake intensifies during V5-V12.

Ultimately, K deficiency and/or supra-optimal Mg, impacts vegetative growth and grain production.

Optimum triple interaction of ear leaf N, K and Mg on grain yield.

Theorized optimum maize ear leaf ratios[1]



[1] Relationship ratios based on Elwali et al. (1985),

Sponsors

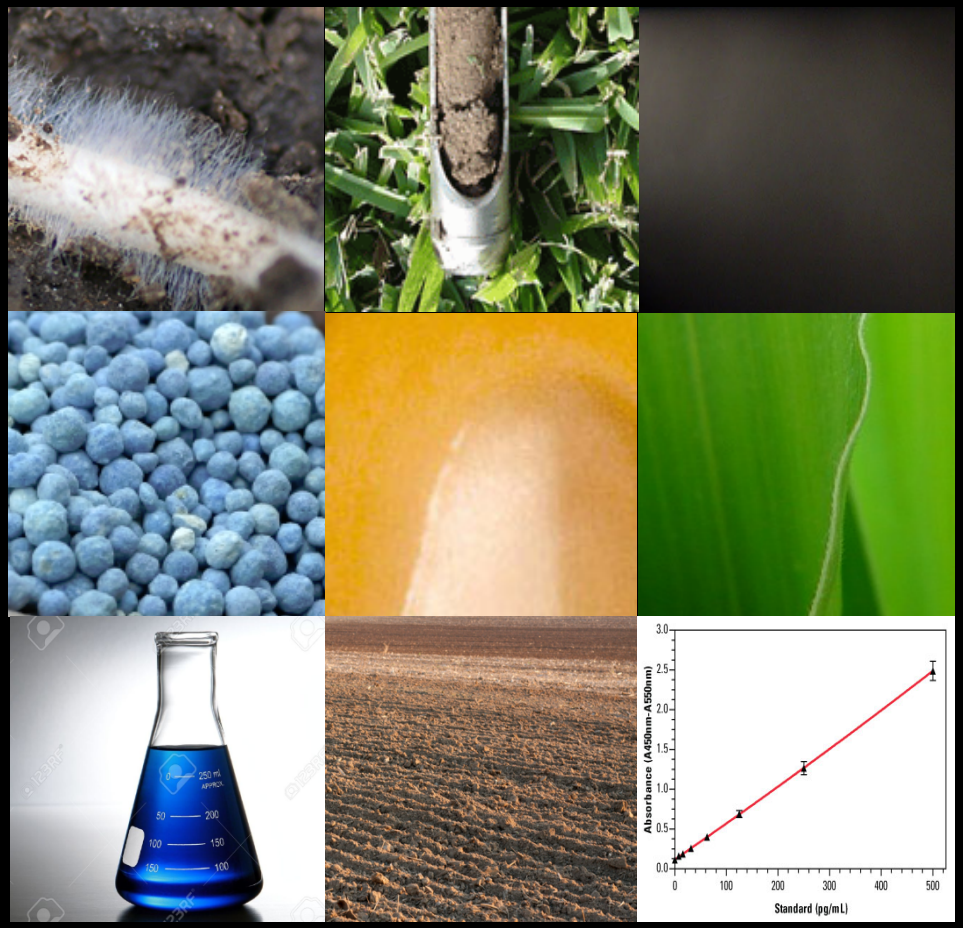
KRx Prescription Potassium

Acknowledgements

Mike Lindaman, Ag Source – LGI Lab, IA
Tom McGraw, MISS, IA *retired*
Larry May, Lincoln, NE
Nick Koshnick, Climate Corp, CA
Robert Beck, Winfield Solutions, IL
Dave Mowers, Consulting, IL
Jodi Jaynes, Sure-Tech Laboratories, IN
Mark David, Compass Minerals, ID
Tommy Roach, Nachurs, TX
Tim Eyrich, Agri-Trend, SC
Ray Ward, Ward Laboratories, NE
Jim Fredericks, Ag Source Lab, IA

Thank you for your time
and attention

Observational Analysis



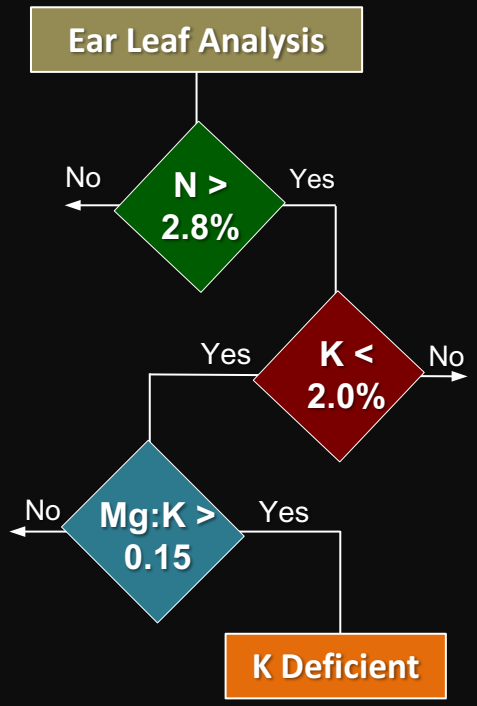
By collecting observational data, through analysis we develop and refine relationships

Moving from the unknown, to the known

Miller, Bower, & Smith, 2015

Leaf Analysis Interpretation

K Deficiency Assessment



2012 - 2014, 52 Sites.

Parameter	Number of sites	Probability of K deficiency
N > 2.8%	16	43.8%
K < 2.0%	10	70.0%
Mg:K > 0.15	7	85.7%
N:Mg > 10	6	83.3%
Yield		51 bpa

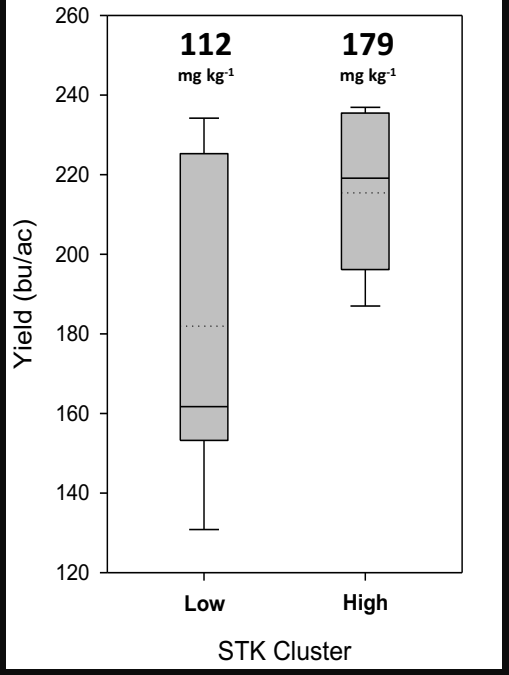
Miller et al, 2017

K_{RX} 2014 Cluster Analysis

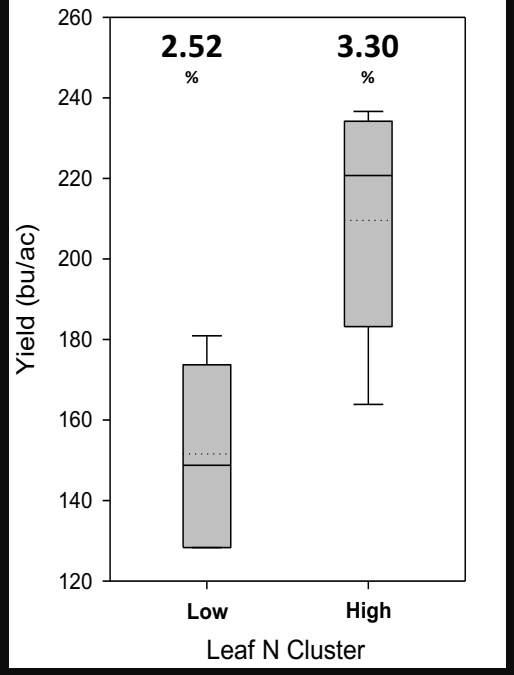
www.hear.org/starr/images/image/?q=080914-9918&o=plants

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

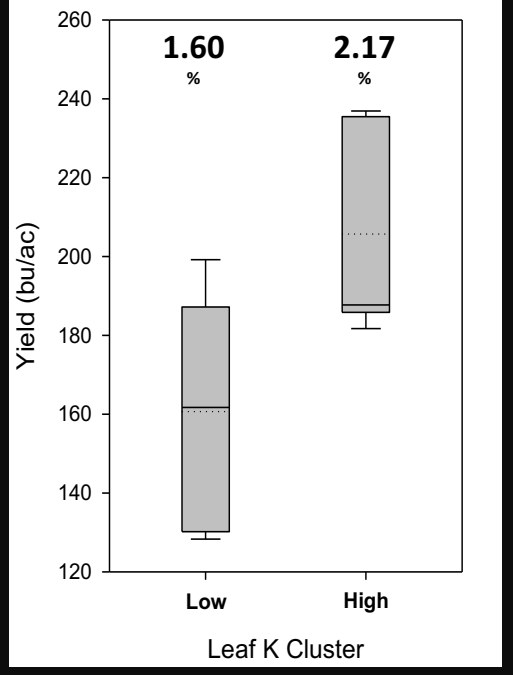
Soil Test K



Leaf N



Leaf K



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Miller et al, 2017

Leaf K Cluster Analysis and STK

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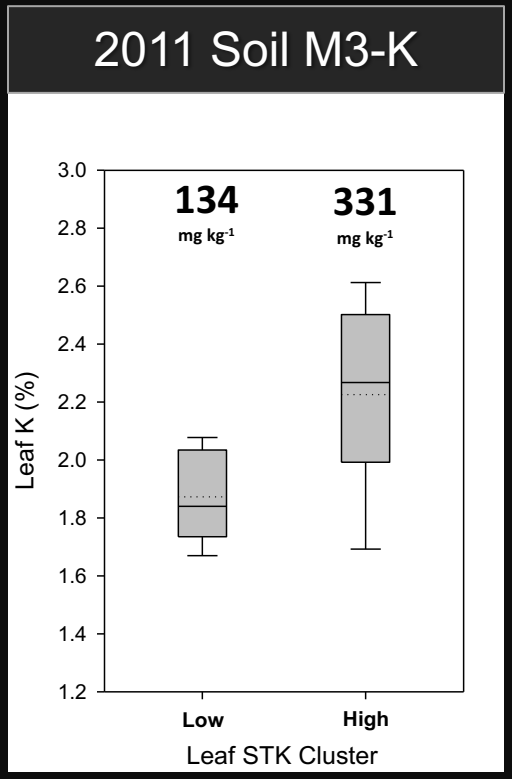
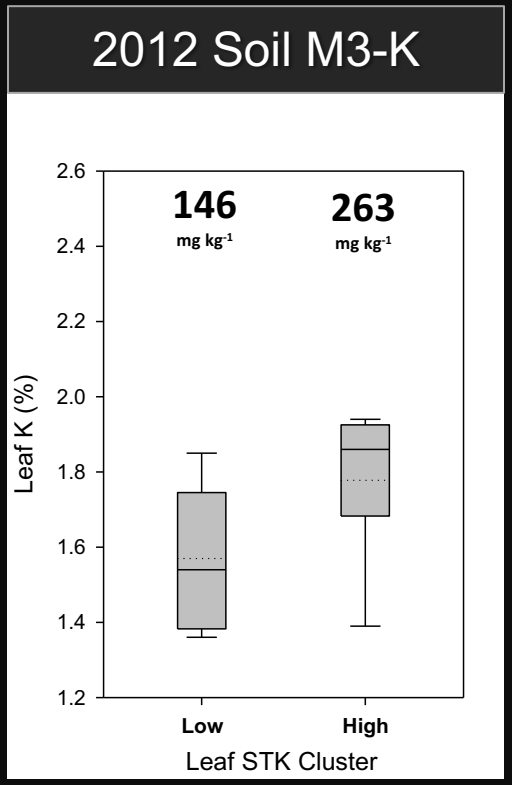
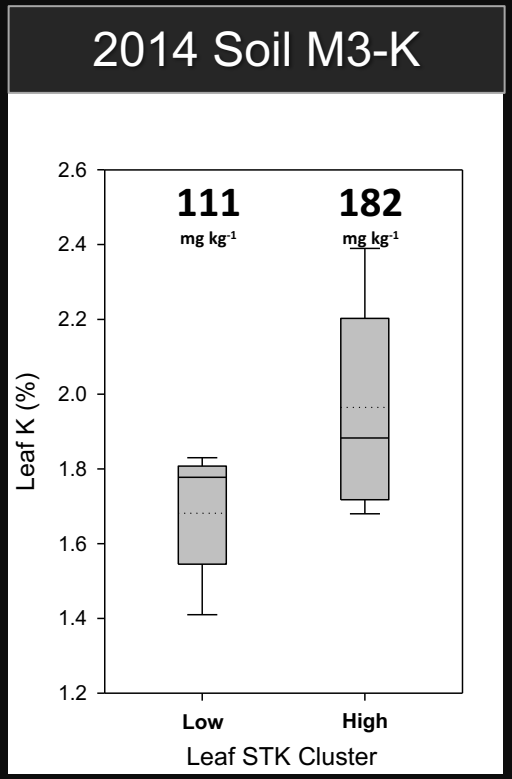
Variable ear leaf K, size - five sites each







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