# Evaluation of Soil Potassium Fertility and Potassium Response

Robert O. Miller, Colorado State University
Fort Collins, CO
Tim J. Smith, Crop Smith Inc.,
Monticello, IL
Craig Struve, Soil View,
*Calumet, IA*

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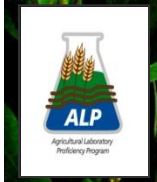
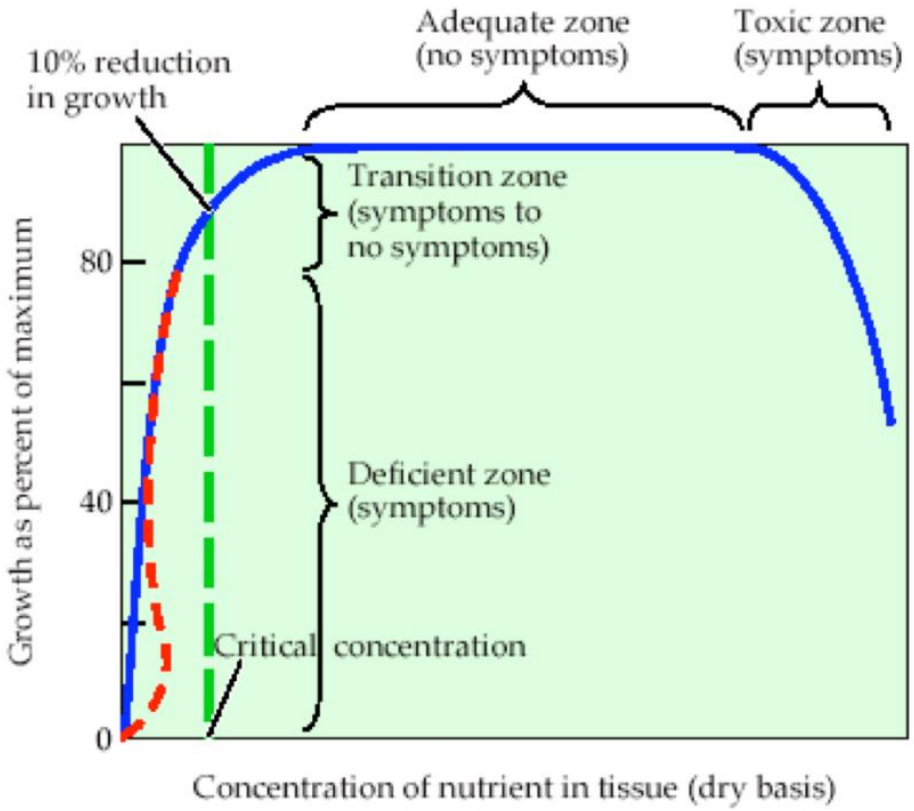
Scottsdale, AZ





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

# 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

Plant nutrient content has been classified in five ranges as it relates to yield.

Corn ear leaf nutrients at growth stage R1 represent a synopsis of plant nutrition at the end of the vegetative growth.

# Plant Essential Nutrients - Corn

| Nutrient | Total Aerial Accumulation (lbs/ac) | Grain Removal [1] 200 bu/ac (lbs/ac) |
|---|---|---|
| C H O | > 1,000 | C - 4,500 |
| N K | 200 - 300 | N - 125<br>K - 32 |
| P S Mg<br>Ca Cl | 30 – 120 | P – 34<br>S, Mg, Ca < 15 |
| Zn B<br>Mn Cu | < 10 | Zn - 0.16<br>B, Mn, Cu < 0.05 |

[1] Binford, G. 2010 19th World Congress of Soil Science, Soil Solutions for a Changing World 1 – 6 August 2010, Brisbane, AU.

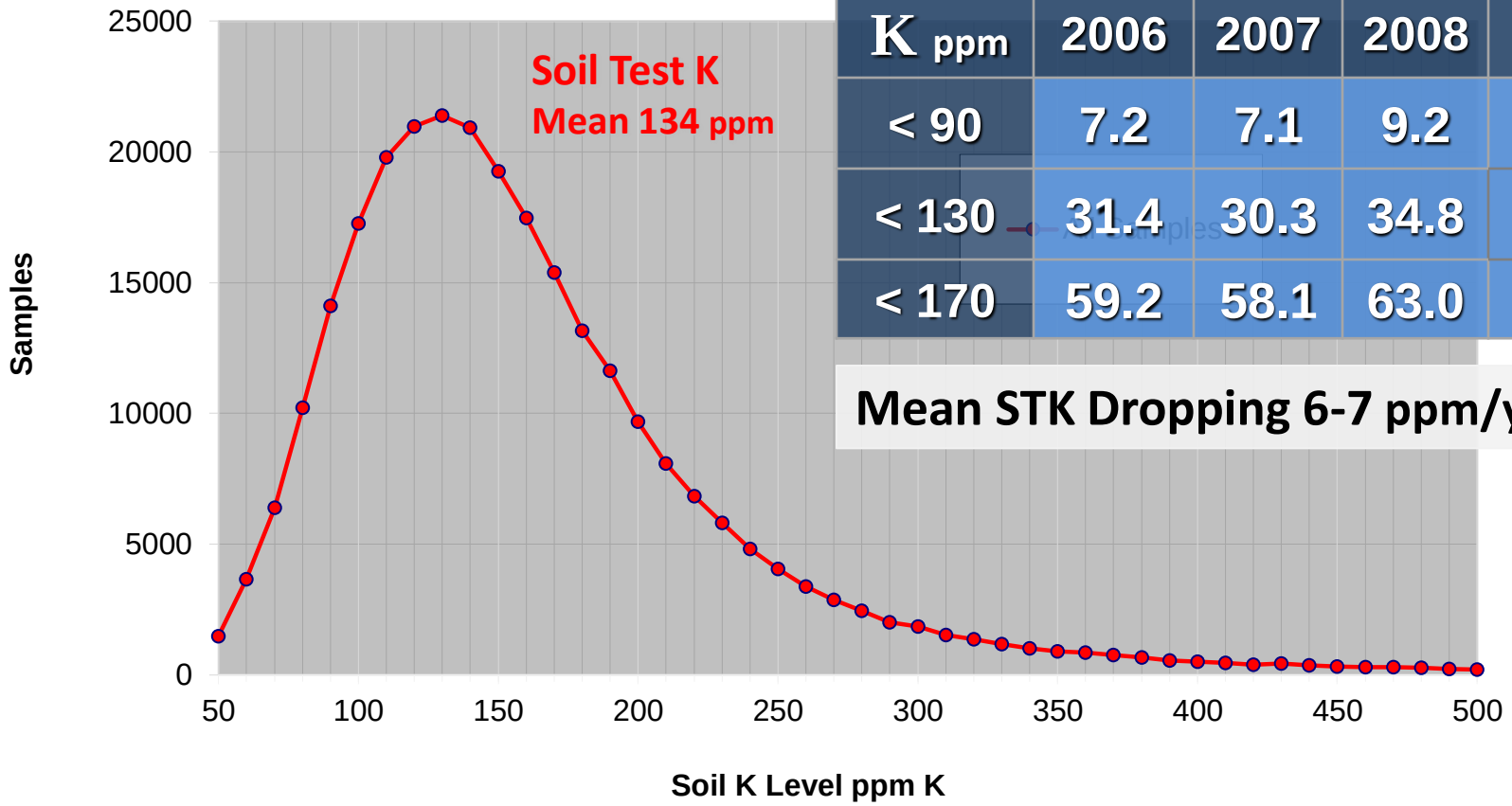
# Lab Soil Test K - Iowa

Potassium
19
K
39.0983

**Observations**

**% Less Than**

**2010 Soil Test K ppm Distribution [1]**




| K ppm | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| < 90 | 7.2 | 7.1 | 9.2 | 12.9 |
| < 130 | 31.4 | 30.3 | 34.8 | 41.6 |
| < 170 | 59.2 | 58.1 | 63.0 | 67.8 |

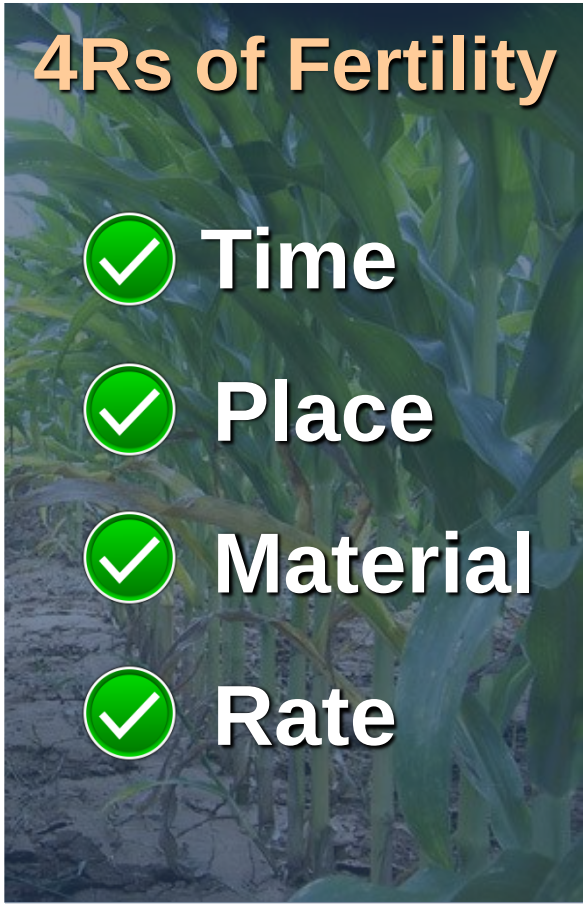
**Mean STK Dropping 6-7 ppm/year**

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

# $K_{RX}$ Corn Research

2011-2014 a study was conducted across 81 sites across six states to evaluate response to K.  K was applied at 0, 50, 100 lbs/ac at growth stage V3 – V5, ranging 18,600 – 42,400 plts/ac, eight replications.

STK sampled at planting, corn ear leaves were sampled at GS R1, and grain yield and moisture determined based on 3/1000th acre of each plot at black layer.



# $KR_X$ Corn Yield Response

## 2012 Project Yield Results

| Site | STK | Check | +K | Increase |
|---|---|---|---|---|
| County / State | ppm | bu/ac | | |
| Pocahontas, IA | 163 | 172 | 165 | - 7 |
| Palo Alto, IA | 196 | 152 | 185 | + 33* |
| Calhoun, IA | 126 | 166 | 171 | + 5 |
| Wright, IA | 135 | 155 | 175 | + 21* |
| Cherokee, IA | 290 | 211 | 227 | + 9 * |
| Hardin, IA | 147 | 204 | 216 | + 12* |

K effect on ear fill



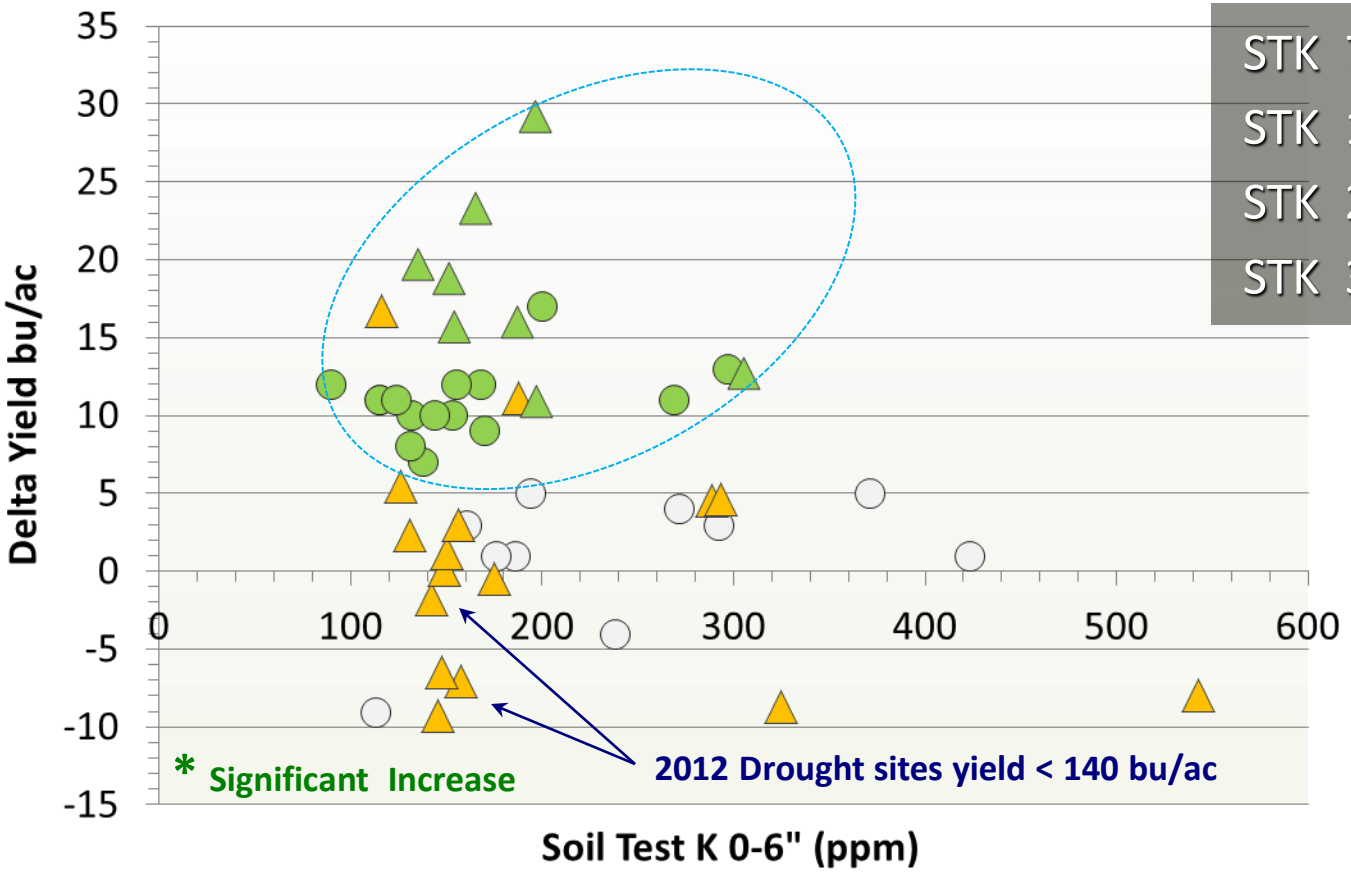
**K increased yield on soils STK - 200 ppm**

# $KR_X$ Corn Yield vs STK 3 years


A K application[1] of 50 lbs/ac improved grain yield at twenty-seven of sixty locations.

**Probability of yield response**

| | | |
|---|---|---|
| STK 75 to 150 | - | 58% |
| STK 150 to 200 | - | 56% |
| STK 200 to 300 | - | 38% |
| STK 300 to 600 | - | 20% |

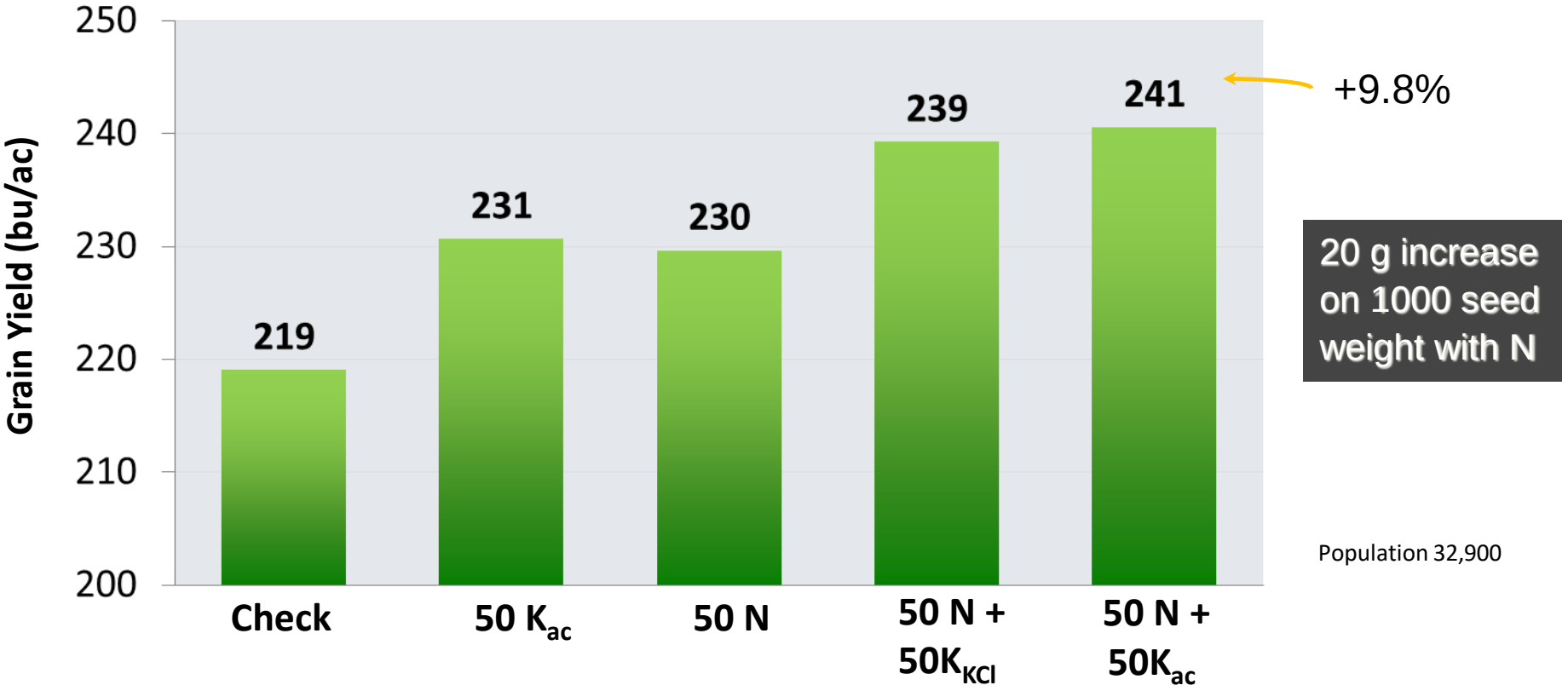



**Ave yield increase**
**11 bu/ac**

[1] $KCl/K_2SO_4$ applied at GS V3-V5.

# $KR_X$: N x K Corn Yield Response

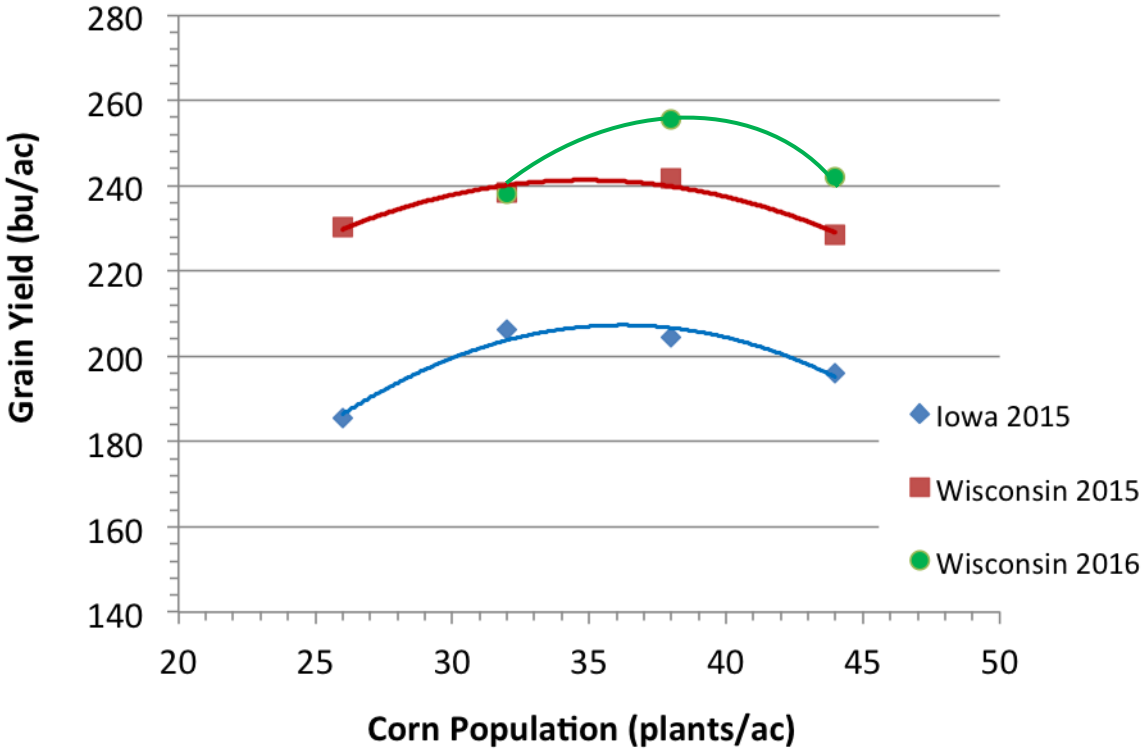
KR*x* Project  Dodgeville, WI 2015




Fertilizer: UAN 32 and K acetate (Nachurs); applied spoke wheel injector at V3-V4 growth stage, 2-3” depth, 4” both sides of row, eight replications.  Soil STK 182 ppm.

# Population and Yield Response

Plant populations, three sites 2015-2016




Yield max occurred between 32k and 38k

No response to applied K across population, yield increase to N, and NxK.

Significant loss of stalks with ears with increasing population, 16% loss at 44k population, vs 6.2% at 26k, WI and IA sites.

[1] *Yields average overall all treatments, corn 15.5% moisture, six replications*

# Side Dress N and K 2016


Grain yield response to side Dress N and K across three populations.

| | 32,000 Plts/ac | | 36,000 Plts/ac | | 44,000 Plts/ac | |
|---|---|---|---|---|---|---|
| Treatment [1] | Yield | Delta | Yield | Delta | Yield | Delta |
| | bu/ac | | bu/ac | | bu/ac | |
| Check | 220.1 | - | 234.6 | - | 216.4 | - |
| 50 N | 240.8 | + 20.7* | 266.6 | + 32.0* | 247.2 | + 30.8* |
| 50 N + 50K[1] | 256.4 | + 36.3* | 274.6 | + 40.0* | 261.4 | + 45.0* |

[1] Fertilizer applied GS V3-V4, N Source Urea lbs/ac, K Source K acetate lbs/ac.

# Summary

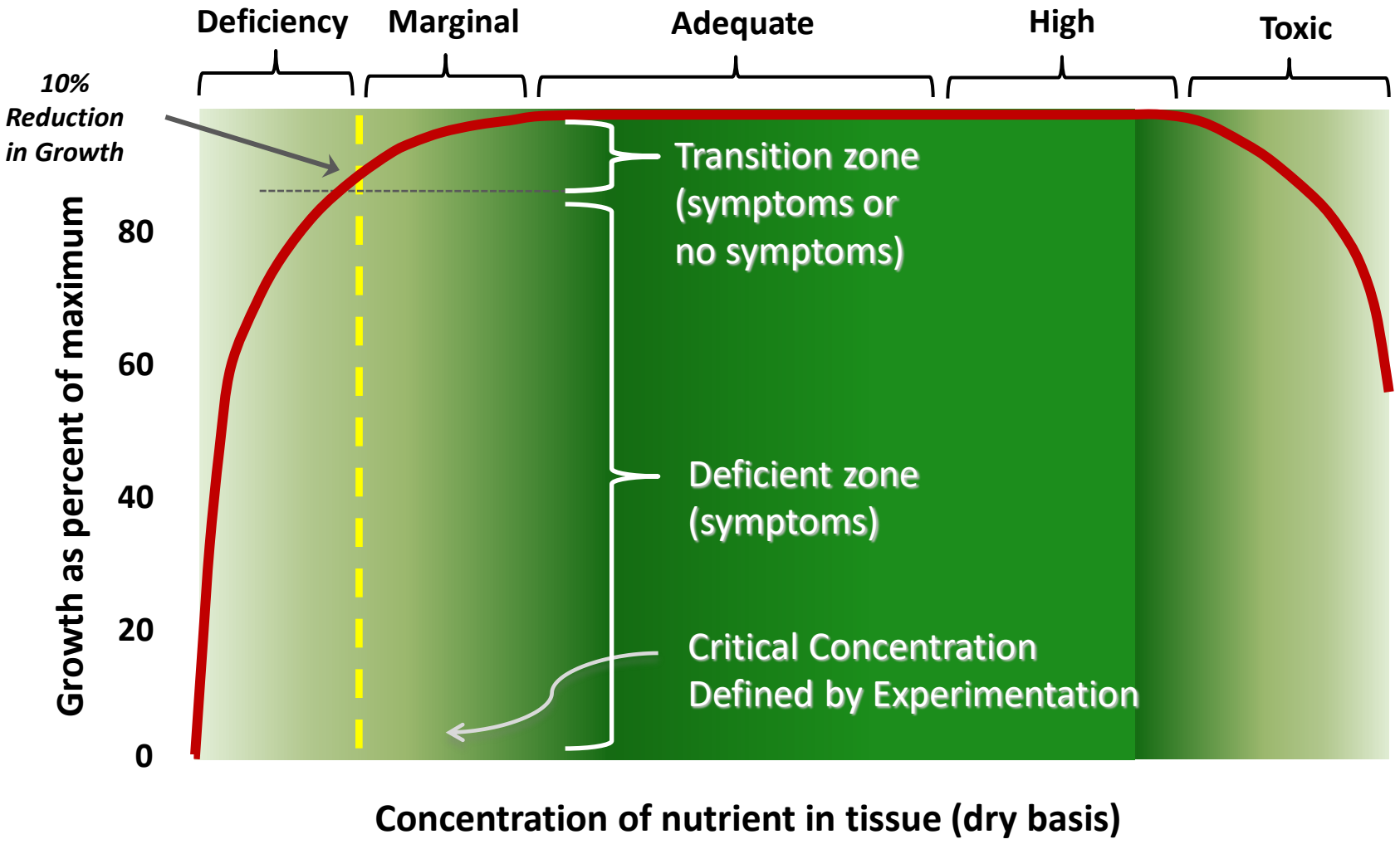
Results show side dress K response at 46% of 81 research sites, yield response 8 – 33 bu/ac in Midwest. K applications had limited impact on leaf K.

Yield max population was between 32k and 38k per acre at three locations. Side dress N x K treatment increased grain yields STK at 5 of 6 sites 2015-2016.

Higher populations (> 38k) had substantial lower populations at harvest (> 10%).

# Corn Ear Leaf Nutrition

Knowledge




Concentration below which yield is compromised and/or deficiency symptoms observed

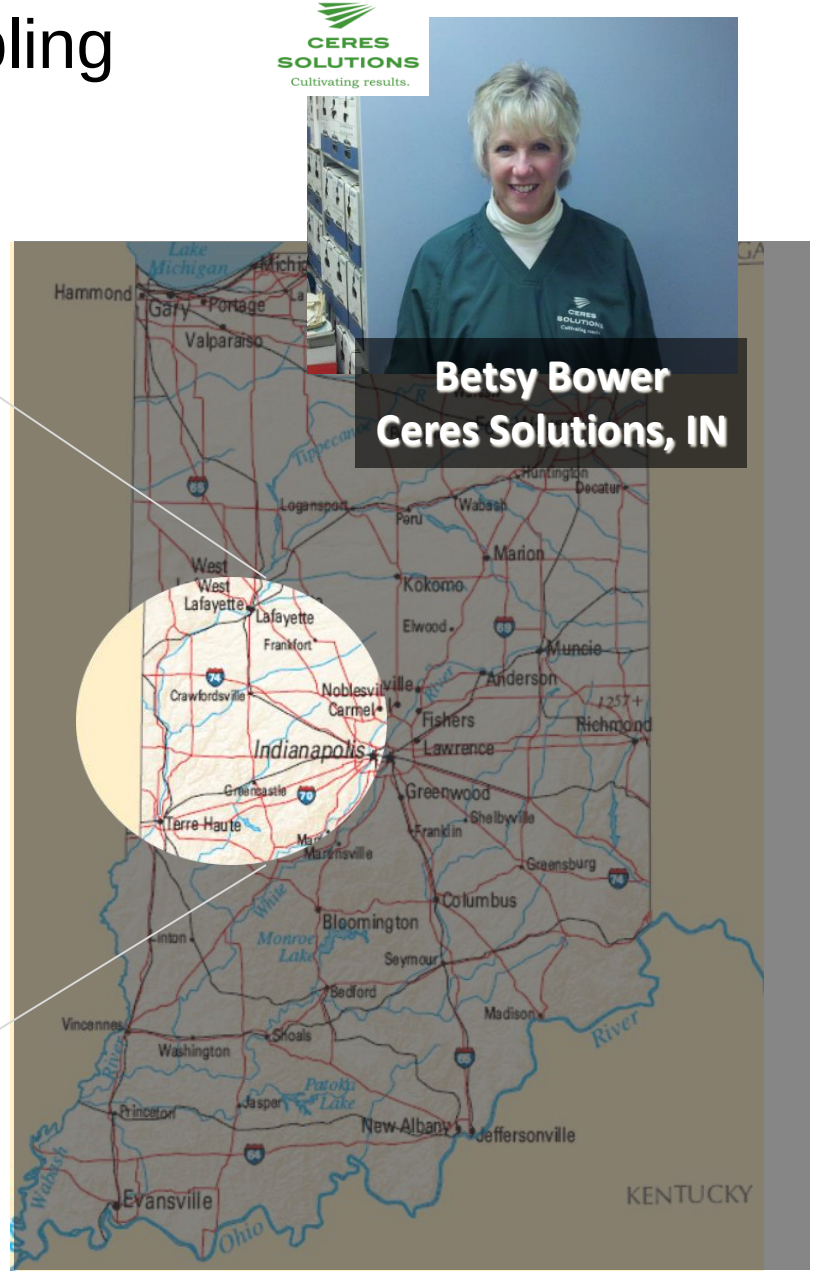
Modified from Reuter and Robinson, 1997.

# Ceres Solutions Corn Leaf Sampling

In 2010 Ceres Solutions serving growers in Western Indiana began intensive sampling of corn ear leaves GS R1 for nutrient status.

Sampling:  Area < 0.20 ac, 40 plants.  Fields ranged in: soil type, hybrid, population, fertility and crop management systems. Analysis N, P, K, Mg, Ca, S, Zn, Mn, Fe, Cu, and B.

Project has continued through 2016.




Miller, Smith and Bower, 2015

# Maize Leaf Nutrient Deficiencies - IN


## Ear Leaf R1, 3670 samples, six years

| Nutrient | Deficiency threshold [1] | Percent of samples deficient [2] | | | | | | Six year Average |
|---|---|---|---|---|---|---|---|---|
| | *< Less Than* | *2010* | *2011* | *2012* | *2103* | *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*

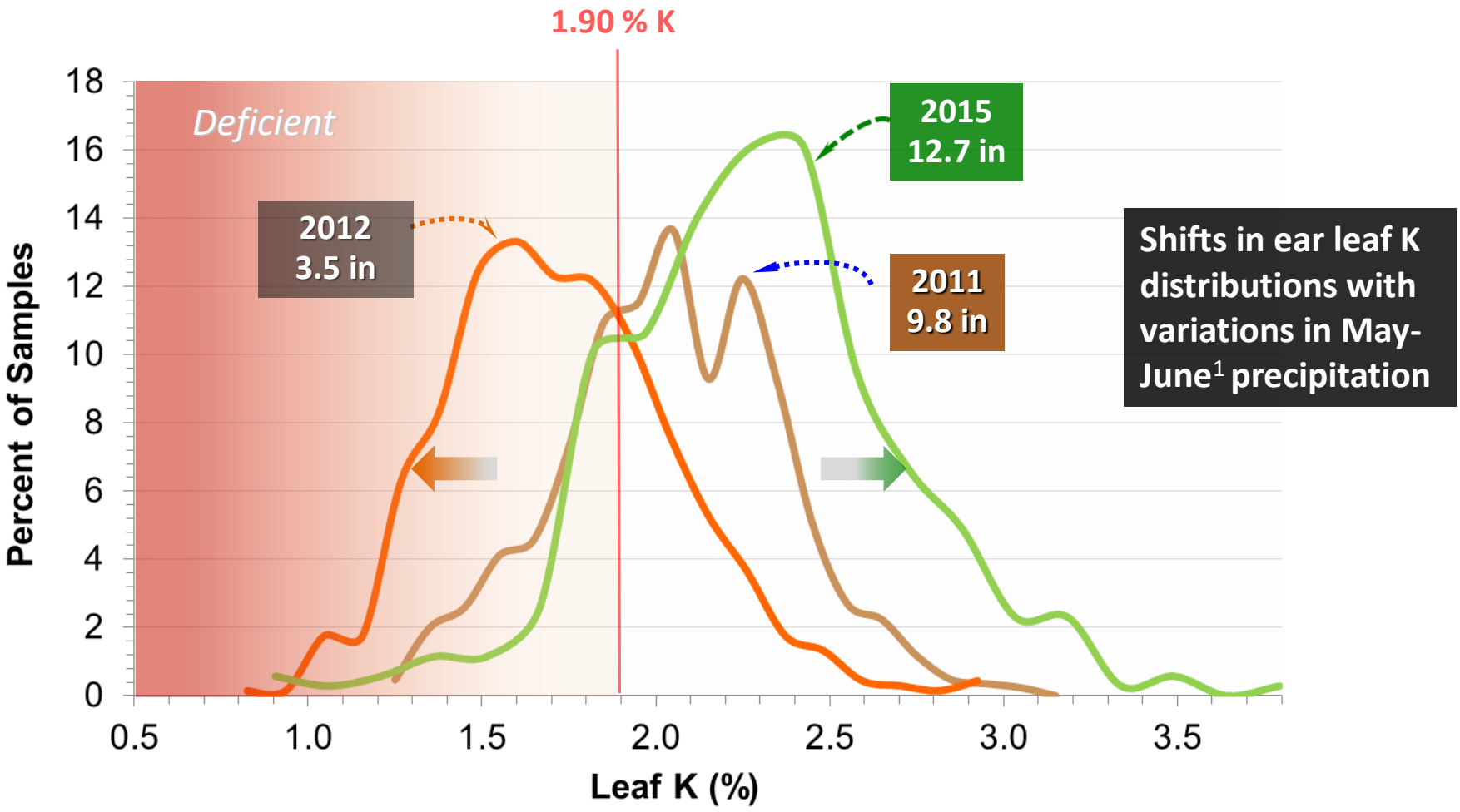
[2] *Data: Ceres Solutions, Lafayette, IN, corn ear leaf R1*

CERES SOLUTIONS
Cultivating results.

Source: Betsy Bower, Ceres Solutions

# Corn Ear Leaf K Frequency Plot

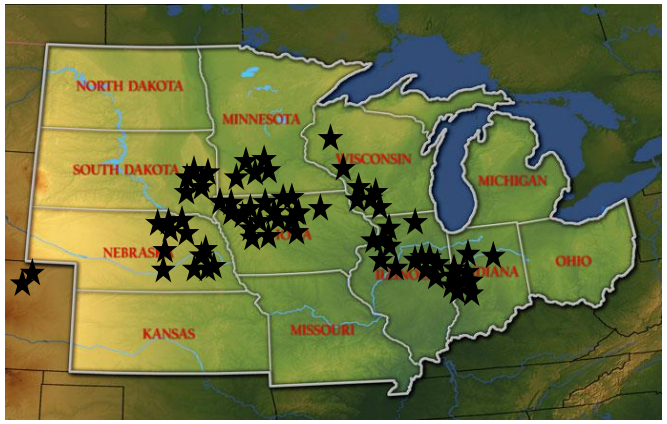
Observations three years, GS VT-R1 Western Indiana: 1883 samples




CERES SOLUTIONS
Cultivating results.

Source: Betsy Bower, Ceres Solutions

# $K_{RX}$ Corn Research

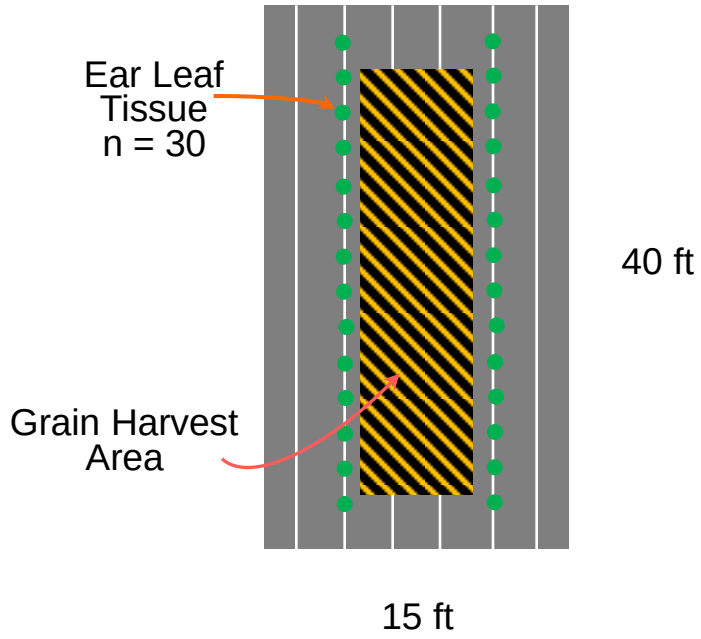



2011-2015, 81 site studies conducted on grower fields across seven states to evaluate K fertilizer response. Check plot data.

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

2016, 48 additional sites were conducted in six states, with added data collected on maize stalks. Observational Data Analysis, cluster comparisons.

**Check plot diagram**

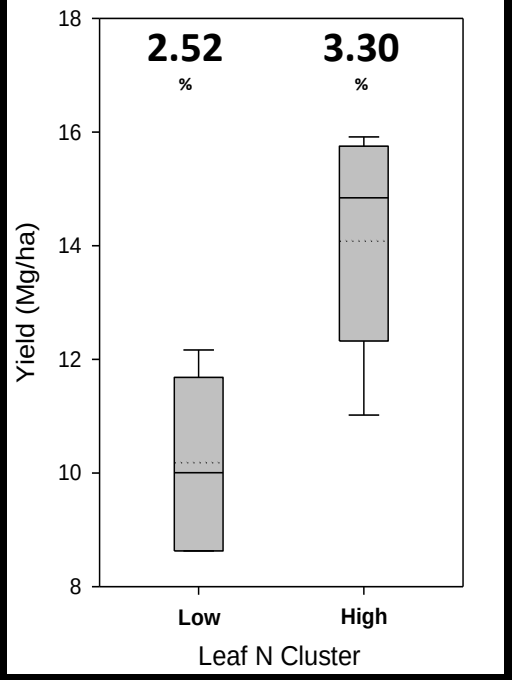



[1] Lab Analysis: LGI, Solum Laboratory and Sure Tech Labs.

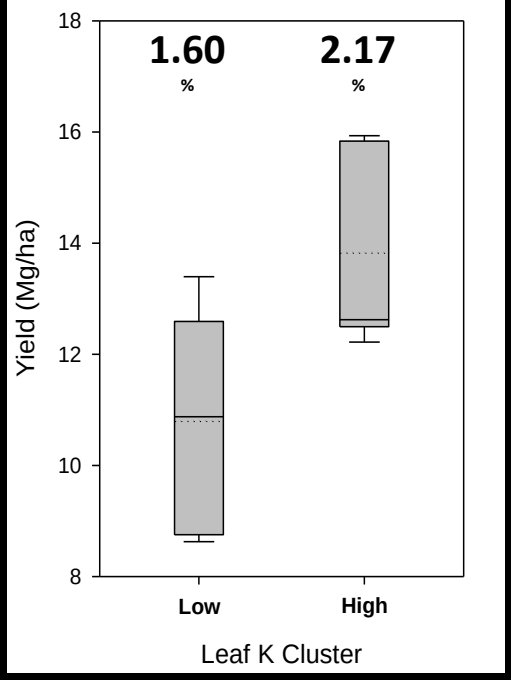
# 2014 Leaf Cluster Analysis

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

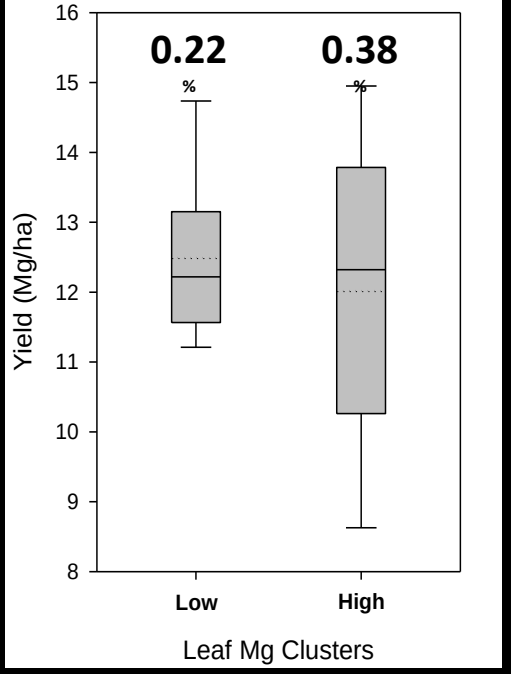
## Leaf N




## Leaf K




## Leaf Mg




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

# Leaf K Cluster Analysis 2014

**Cluster [1] comparisons 16 sites, cluster size 5 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$^{-1}$** | 160 | *24* | 207* | *27* |

[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.

# Corn Stalk Analysis 2016

## Five sites, 2016 nutrients and yield

| Site | N | K | Mg | Mg:K | $NO_3$-N | Yield (bu/ac) | |
|---|---|---|---|---|---|---|---|
| | % | | | | ppm | Ave | Stdev |
| Stubbs | 0.99 | 3.27 | 0.07 | 0.02 | 600 | 236 | *3.9* |
| Kott R4 | 0.97 | 2.71 | 0.07 | 0.03 | 5900 | 276 | *5.1* |
| O'Neil #38 | 0.99 | 1.96 | 0.07 | 0.04 | 9900 | 264 | *5.6* |
| O'Neil D6 | 0.95 | 1.03 | 0.19 | 0.19 | 9300 | 247 | *9.6* |
| Tiez-1 | 0.68 | 0.37 | 0.22 | 0.57 | 230 | 166 | *4.7* |

[1] Stalks sampled at black Layer, 8" segment 6" above ground, 8 stalk composite, four replications.

# Cluster Analysis Yield Summary

## 132 Sites, 2011 – 2016 mean comparisons

| Year | *Low K cluster* [1] | | *High K cluster* | | Delta Yield |
|---|---|---|---|---|---|
| | K % | Mg:K | K % | Mg:K | bu ac $^{-1}$ |
| 2011 | 1.77 | 0.17 | 2.64* | 0.09* | 40.9* |
| 2012 | 1.52 | 0.31 | 1.91 | 0.15* | 58.1* |
| 2013 | 1.67 | 0.33 | 1.95 | 0.12* | 34.5 |
| 2014 | 1.60 | 0.21 | 2.17* | 0.10* | 48.2* |
| 2015 | - | - | - | - | - |
| 2016 | 1.47 | 0.28 | 2.93* | 0.07* | 44.1* |
| | | | | | 45.2 ← Five year mean |

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

Cluster yield differences were consistent.

# Conclusions

Additional Research is planned for 2017 in IA, IL, MN, and WI.

- 131 site years, ear leaf K clusters unrelated to STK and were affected by V4-V12 precipitation.
- Corn ear leaf K cluster > 1.9% associated with higher grain yields, averaging 45 bu $ac^{-1}$ over < 1.9% K, five years.
- Ear leaf K (< 1.9%) were associated with elevated Mg, higher Mg:K, and lower N:Mg ratios. Supports DRIS ratios of Elwali et al. (1985) assessing corn macro nutrient deficiencies.
- Leaf N concentrations > 3% showed greater yield differences associated with low K.
- Ear leaves with low K showed low stalk K and elevated Mg, resulting in stalk Mg:K: ratios > 0.10 and lower yields.

# Corn Macro Nutrient Impact

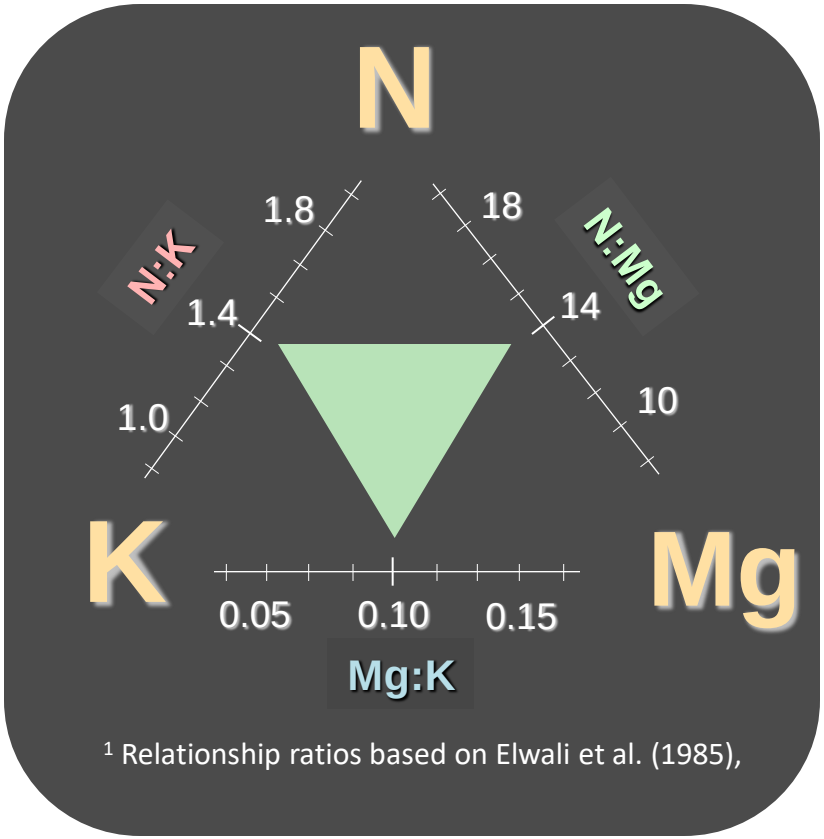
Nitrogen, population and temperature drive maize N and K demand during growth stages V4-V12.

When 2-8 in depth soil volumetric $H_2O$ is limited, soil rhizosphere K diffusion / release slows, and Mg uptake intensifies.

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),

# Potassium Nutrition

## Observations

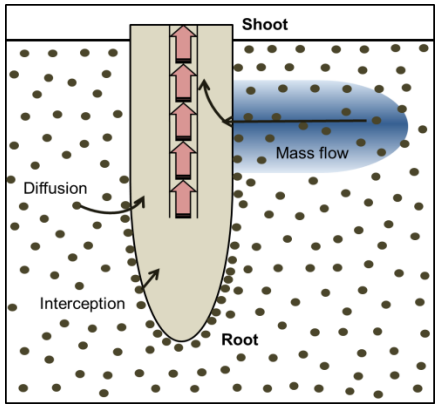
Across a range of STK levels, corn ear leaf nutrition shows K < 1.9% associated lower yields. Elevated Mg levels are a symptom of suboptimal K.

Applications of fertilizer K at V3-V5 have limited impact on increased leaf K and yields (8-20 bu/ac).

## Challenge

K strategy to meet corn demand of 8-12 lbs/ac/day during GS V6-V12, and overcome limited K diffusion.

An effective soil test K method that measures K release rate, placement method and products to meet crop demand.



# if soil K fertility were meant to be easy there would be an app for it….


http://blog.ayrstone.com/wp-content/uploads/iphone_map_notifications.png

https://ksr-ugc.imgix.net/assets/011/718/498/283919b25e97b32c20f4ceea602efd81_original.jpg?w=1552&h=873&fit=fill&bg=000000&v=1463687249&auto=format&q=92&s=a936cd7dda1aa7e67eda25a28a0a8be6

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*Jodi Jaynes*, Sure-Tech Laboratories, IN

*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

# University of Illinois Publication

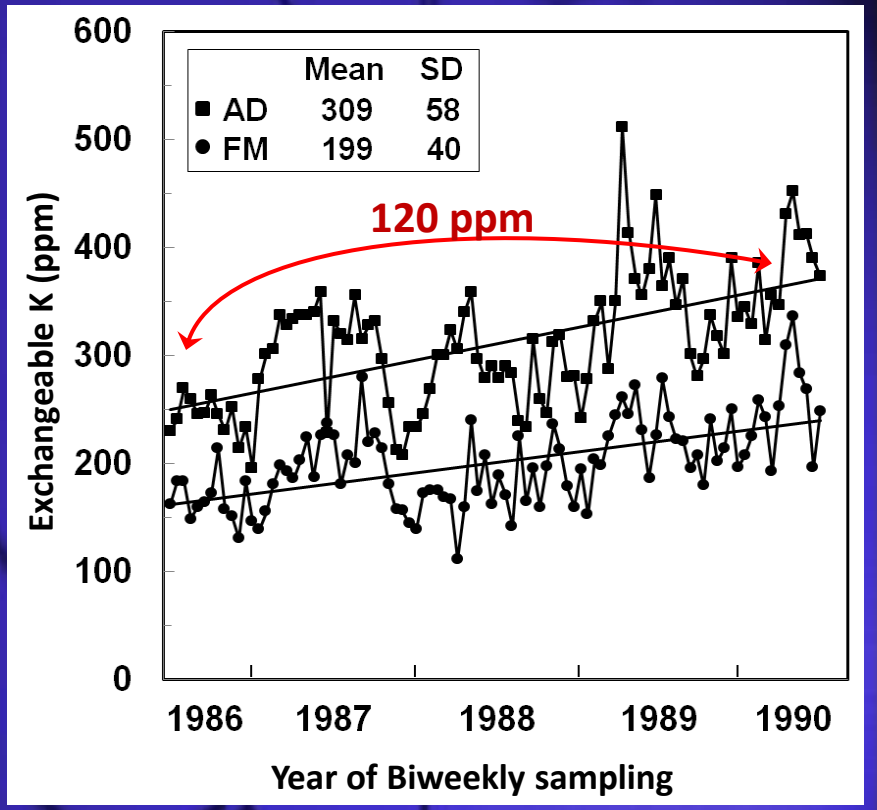

## The potassium paradox: Implications for soil fertility, crop production and human health

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.
*Corresponding author: potassiumparadox@gmail.com

*"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 , 2014

# **STK** Interpretation

KRx Prescription Potassium

(1) Low soil test K – deficient (<80 ppm), responsive.

(2) STK – 120-240 ppm adequate soil K, but low supply power (lbs/ac/day) during peak demand (corn V5-V12) leads to low leaf K.

(3) STK – 120-300 ppm adequate soil K and supply power with soil moisture > 0.25 $cm/cm^3$. With decreased moisture (V5-V12), diffusion slows, leads to low leaf K. No issue under irrigation.

Robert Nielsen, 2009

http://a1.sphotos.ak.fbcdn.net/hphotos-ak-snc6/58602_151587434865720_111267718897692_355055_4317263_n.jpg

# US Corn Production

Corn grain yields in the central US have increased an average of 2.6 bu $ac^{-1}$ $yr^{-1}$ since 1980 due to improved agronomic management and fertility programs, K is removal 0.4 lbs $ac^{-1}$ $yr^{-1}$ .

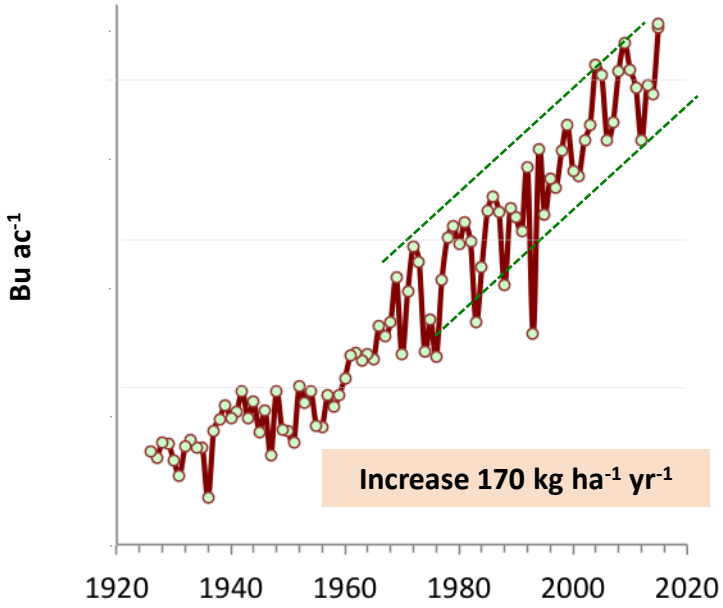
Midwest soil Mehlich 3 K levels have been declining (IPNI, 2010). Results from MVTL laboratory show 68% of samples with M3-K levels < 180 mg $kg^{-1}$, 2015.

| 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.

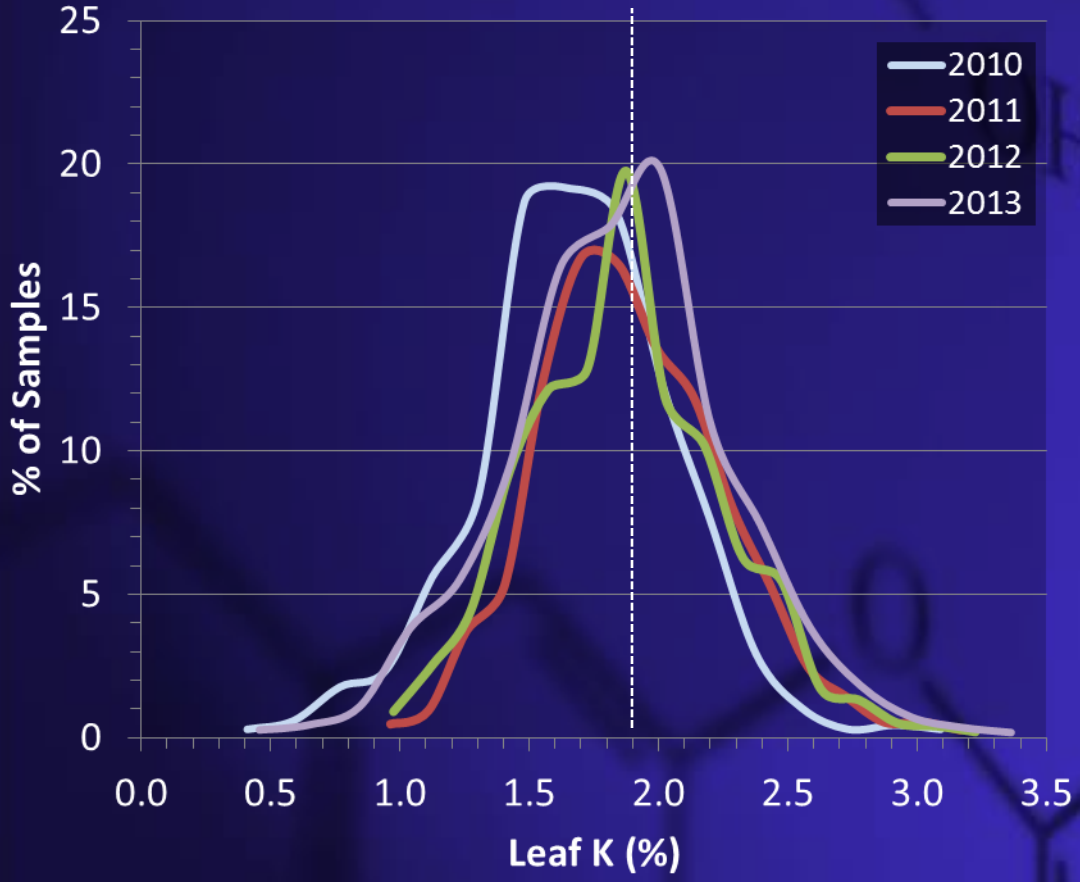
**Maize Yields - 95 years**




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

# Corn Ear Leaf Potassium - MN


## Ear Leaf VT-R1 4241 samples, 4 years [1]




Over four years K deficiency [2] in Minnesota constituted 47.3 – 68.8% of ear leaf tissue samples, whereas N deficiency average was 33.5% of samples.

[1] *Source Winfield Solutions 2010-2014, Randy Brown, Tim Eyerich*

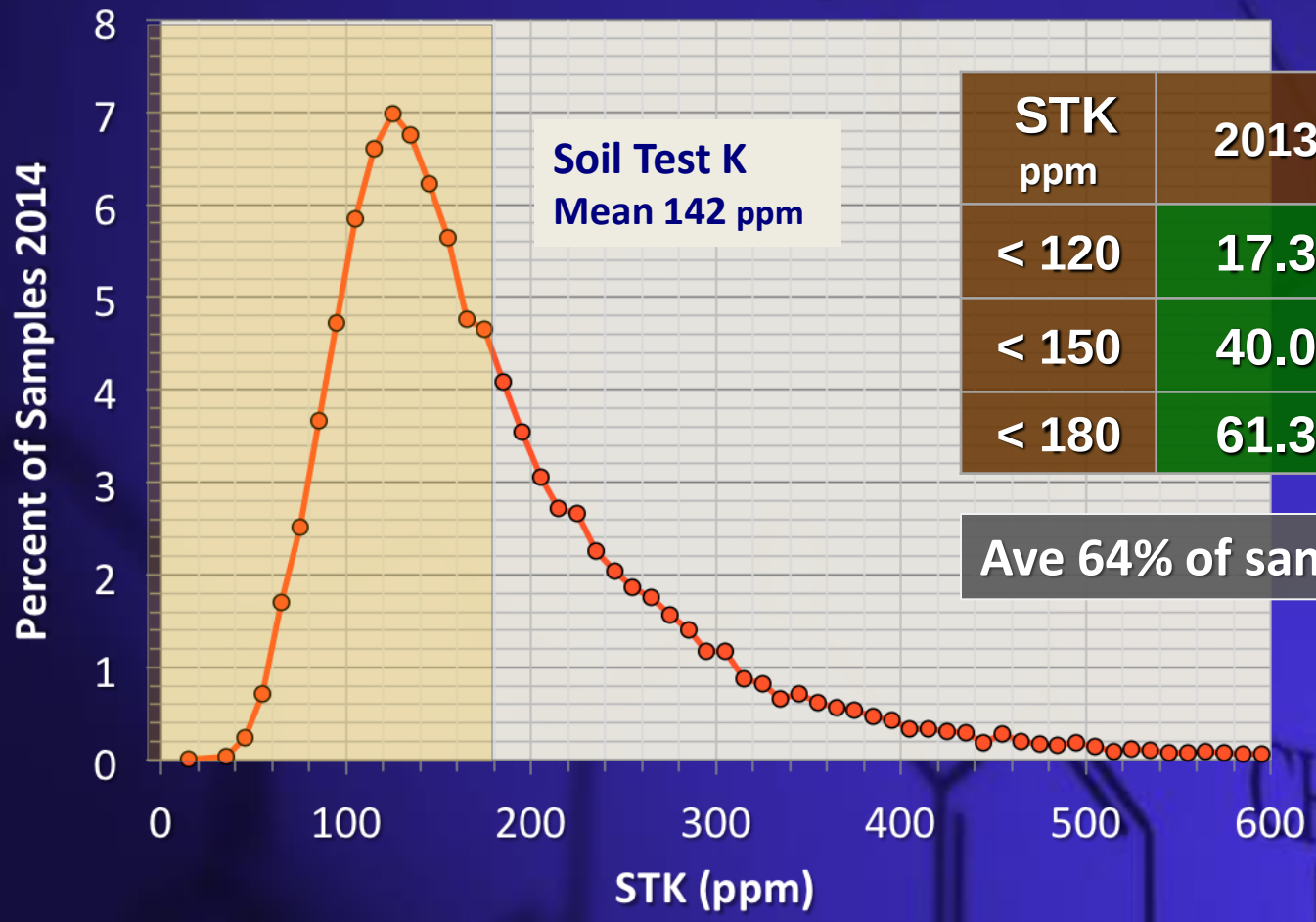
[2] *http://www.extension.purdue.edu/extmedia/nch/nch-46.html*

WINFIELD™ SOLUTIONS

Miller et al, 2016

# Lab Soil Test K: IA and MN

Observations 245,000 samples




| STK ppm | 2013 | 2014 | 2015 |
|---|---|---|---|
| < 120 | 17.3 | 16.4 | 24.8 |
| < 150 | 40.0 | 43.1 | 47.3 |
| < 180 | 61.3 | 63.6 | 69.4 |

Ave 64% of samples have K Rec

**What Does Plant Analysis Show**

[1] Source: MVTL MN-IA, Mehlich 3 K

Miller et al, 2016

# $KR_X$ Corn Research 2015

KRx Prescription Potassium

2015 research expanded to include population component and N x K treatments. Four populations 26k, 32k, 38k and 44k plants per acre. at four sites: WI, IA, IL and CO. Fertilizer treatments consisted of side dress N, K and N x K, six replications.

Additional studies were conducted at five locations evaluating K sources and in combination with N and B, applied side dress at V4-V5, eight replications. Ear leaves were sampled at VT-R1.

Robert Nielsen, 2009

http://a1.sphotos.ak.fbcdn.net/hphotos-ak-snc6/58602_151587434865720_111267718897692_355055_4317263_n.jpg

*Miller et al, 2016*

# $KR_X$: N x K Corn Yield Response

Grain Yield Response to N and K (two sources)

| Treatment (lbs/ac) | *Iowa* Sutherland | *Wisconsin* Dodgeville | *Illinois* Farmer City |
|---|---|---|---|
| STK (ppm) | 192 | 178 | 154 |
| Check | 194.1 | 219.0 | 183.2 |
| 50 $K_{ac}$ | 205.9 | 230.6 * | 187.4 |
| 50 N | 217.1 * | 229.6 * | 200.2 * |
| 50 N + 50 $K_{ac}$ | 212.1 * | 239.2 * | 195.4 * |
| 50 N + 50 $K_{KCl}$ | 204.1 | 240.5 * | 203.8 * |

[1] *Significant at p 0.1 level, 8 reps*

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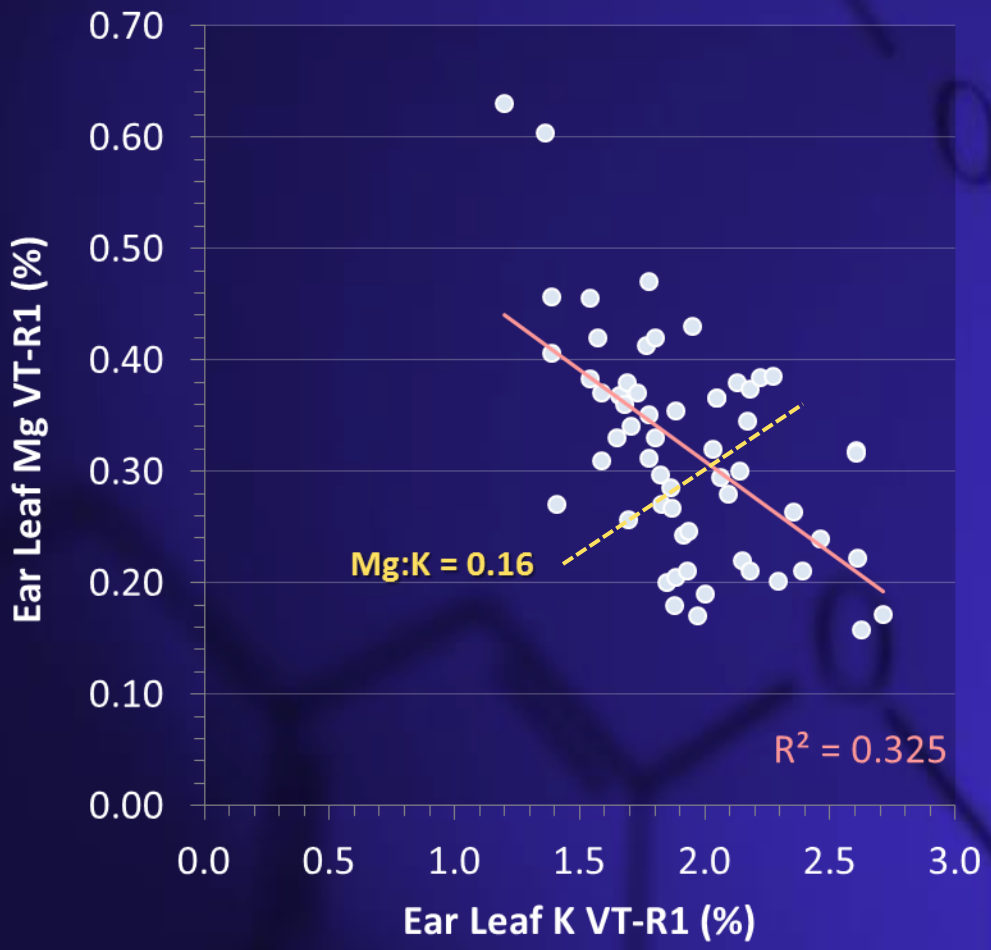
# Corn Ear Leaf VT-R1 K vs Mg

64 K*Rx* sites, across 7 states 2011-2015.




| Variable Average | Cluster [3] | |
|---|---|---|
| | *Low K* | *High K* |
| Yield (bu/ac) | 159 | 202 |
| N % | 2.92 | 2.89 |
| K % | 1.48 | 2.40 |
| Mg % | 0.42 | 0.29 |
| Mg:K | 0.29 | 0.12 |
| N:K | 1.99 | 1.20 |

[3] Clusters based on 12 sites each.

1 Each site represents the mean of 4 check plots, across 7 states.

2 Mg:K > 0.16 K deficient, Elwali ,1984 Agron J.

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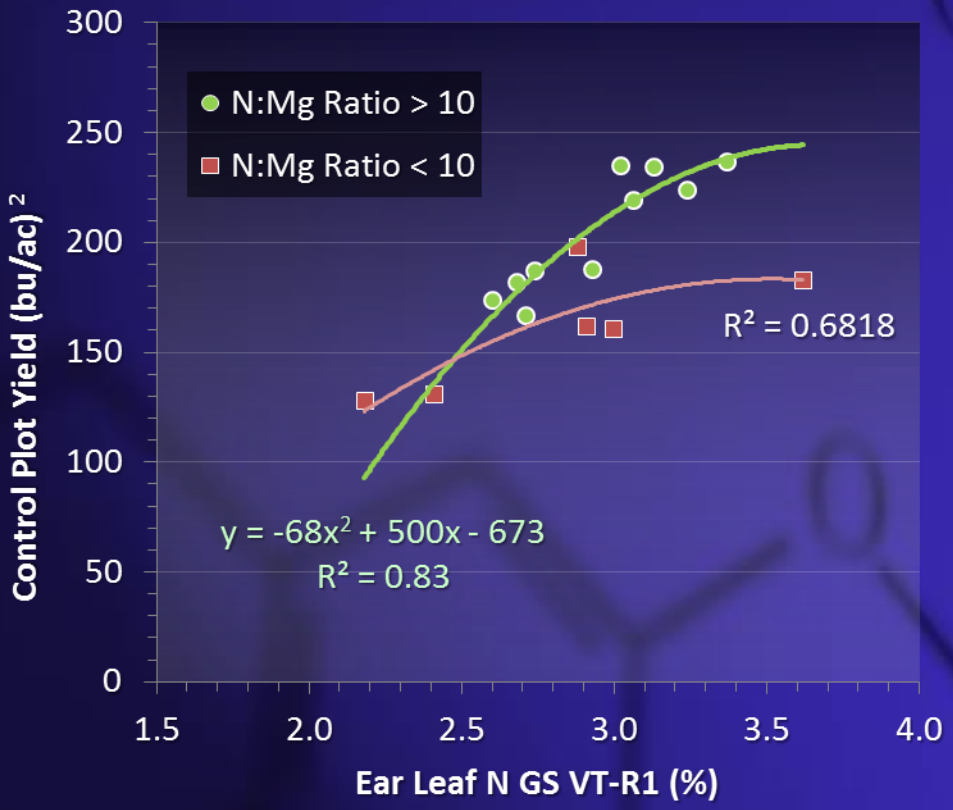
# Leaf Nutrition vs Grain Yield 2014

Parsing maize grain yield[1] by ear leaf ratios, shows 83% of yield is explained by leaf N, N:Mg > 10 (green) at ten sites. Six sites with N:Mg < 10 (red), averaged 44 bu/ac lower yields.




| Analysis | N:Mg Ratio [3] | |
|---|---|---|
| | *< 10* | *> 10* |
| N % | 2.90 | 2.95 |
| K % | 1.65 | 2.02 |
| Mg | 0.35 | 0.23 |
| Mg:K | 0.22 | 0.12 |
| N:Mg | 8.1 | 13.3 |
| Yield bu/ac | 204 | 159 |

[3] Mean results based on N:Mg Ratio.

[1] 2014 KRx control plot grain yields 16 sites, 4 states, 8 replications.

[2] Sites vary in hybrids, tillage, soil types and crop history.

Miller et al, 2015