Evaluation of Corn Population and Sidedress Applications of Potassium and Nitrogen on Corn Grain Yield
2015-2016 Report

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Abstract

Results of a Midwest population study across five sites show optimum yields were obtained with planted corn populations of 32k-36k plants ac^{-1} based on 30" rows in the Midwest. Higher populations resulted in reduced number of plants with ears and lower grain yields. Side dress nitrogen was site and year specific with an average response of 30 bu ac^{-1} to 50 lbs N ac^{-1} on the most responsive site. Side dress response to K was limited, and the average response to side dress applied K was 10-12 bu ac^{-1} with 50 lbs K ac^{-1}. K source product studies showed K acetate combined with N showed significant grain yield response. Cluster analysis of corn ear leaf nutrients collected at growth stage R1-R2 from 112 grower fields from 2011-2016 across six states, indicate leaf K levels < 1.9% are indicative of lower yields and that K deficient fields show increased Mg accumulation resulting in lower K:Mg ratios. Across five years low ear leaf K clusters average 45.2 bu ac^{-1} less grain yield than those with > 2.0% leaf K. Establish N, K, Mg DRIS ratio norms for corn leaves are an effective tool in diagnosing corn K deficiencies, their impact on grain yield and addressing long term K fertility management of corn.

Introduction

Soil testing is the foundation for nutrient management decisions, the reliability of which is based on a representative sample, an appropriate test method, and the nutrient calibration crop response model. Agronomic corn production practices in the Midwest have advance significantly over the past 30 years, with improved hybrid genetics, decreased tillage, increased plant populations and refined nitrogen management, resulting in higher yields. Over this period corn grain yields have increased an average of 2.5 bushels per acre per year.

While N fertility management has generally kept pace with increased plant populations and yield, that for potassium (K) has remained relatively unchanged. Increasingly K deficiencies have been noted. A survey of ear leaves from Ceres Solutions in Indiana from 2011-2013 indicates K deficiencies ranged from 15.3 - 57.3% (Miller, 2014) and significantly more than any other nutrient. Soil fertility results from a survey of Midwest soil testing labs by the International Plant Nutrition Institute (IPNI) (Fixen, et al 2010) indicate STK values have declined by 24 lbs/ac across the corn producing states over a five year period.

Increasingly corn growers have shown interest in side dress applications of N fertilizers, which improve efficiency and minimize losses. Vegetative growth uptake of N and K are generally paired in a ratio of 1:0.8 (Karlen et al, 1987), thus the application of both of N and K during early vegetative growth stages is likely to improve corn yield than N alone. With increasing yield and greater interest in season nutrient applications, the objective of this project is to evaluate corn response to side dress applications of N and K across a range of corn populations, and to assess types of K application.

The objectives of this research project is to: (1) assess side dress application of N and K on corn grain yield in the Midwest; (2) assess effect of N and K application on corn at three populations and (3) evaluate K broadcast and side dress by depth on grain yield. A secondary objective will be to assess corn K nutrition at multiple sites.

Material and Methods

Dryland research sites were established in grower fields near Sutherland, IA; Dodgeville, WI; Farmer City, IL and an irrigated site at the Colorado State University ARDEK Research farm near Wellington, CO in 2015 and Dodgeville, WI in 2016. Locations selected represent a range of soil types with past crop yield history of > 190 bu ac^{-1}, and STK levels 140 -250 ppm. A N and K product side dress study was established near Linden, WI, Calumet, IA Iowa and Weedman, IL in 2015 and Sutherland, IA and Byron, IL 2016.

Population N x K Study. Corn populations of 26k, 32k, 38k and 44k plants ac^{-1} were installed as main plots at three sites (IA, WI and IL) and 34k, 41k and 48k plants ac^{-1} in CO in 2015. In 2016, at the population study was conducted only at the Linden, WI site. Nitrogen was applied pre-plant based on a projected grain yield of 220 bu ac^{-1}. Six sub plot treatments were applied in 2015 at corn growth stage V4-V5 as a side dress application consisting of: check; N 40 lbs ac^{-1}; 50 lbs ac^{-1} K; 40 lbs ac^{-1} of N + 50 lbs ac^{-1} K; VN rate and VN + 50 lbs ac^{-1} K as a liquid solution using a spoke wheel injector system at a depth of 3”, 3” each side of the row. N source was urea and the K source K acetate (K_{ac}). Sub plot treatments were randomize within each population main plot, with six replications. For 2016, side dress treatments consisted of N rates of 0, 50 lbs ac^{-1} and 50 lbs ac^{-1} + 50 lbs ac^{-1} K as K acetate, with six replications. Soils sampled pre-plant at five depth increments to 18", along with in season corn tissue samples at R1-R2. Crop grain yield, harvest population, moisture and test weight data was collected at harvest. Soils were evaluated for pH, NO_3-N, M3-P, M3-K, CEC, Cl, Iowa State University moist soil test K method, at Solum laboratories Ames, IA. Corn tissues were analyzed for N, P, K, Ca, Mg, S, Zn, Mn, Cu and B and nutrient ratios, by Sure-Tech labs, Indianapolis, IN. All sites were machine harvested.

K Source Study. An additional study was conducted in 2015 and 2016 to assess side dress K application method using a spoke wheel injector with treatments of : a check plot: (1) check treatment; (2) 50 lbs ac^{-1} KCl-K_2SO_4; (3); 100 lbs ac^{-1} KCl- K_2SO_4; (4) 50 lbs ac^{-1} K acetate; and (5) pre-plant top dress K_2SO_4 in 2016. Treatments were randomize complete block with six replications on sites with an established corn population of 32k plants ac^{-1}. Ear leaf tissue at VT-R1, crop grain yield, harvest population, moisture and test weight data were collected.

K Observation Study. In 2016, forty-eight observations sites were established in growers fields across six states for the purpose of assessing the impact of soil K and crop nutrition on grain yield. Each site consisted of four check plots each 15 x 40 feet and data collected on soil fertility (pH, P, cations, SOM, CEC, Zn-DTPA), soil nutrient stratification, V2-V4 population, R1-R2 ear leaf nutrients, stalk nutrients, harvest population and hand harvested for grain yield.

Results and Discussion

Population N x K Study

The 2015 plant population study showed optimum grain yield were obtained for planted populations between 32k and 38K plant per acre for three of the four locations (Figure 1). The Farmer City site was impacted by post emergence herbicide drift and as a result the grain yield for the 44k planted population was greatly reduced. The Wellington, CO site, which had planted populations of 34k, 41k and 48k plant per acre, had reduced yields associated with delayed early season irrigation and high spatial heterogeneity associated with imposed treatments from previous research studies conducted in 2012. Population main plot CVs were 14%, 16% and 21% respectively, with grain yields for the check plots ranging from 112 -183 bu/ac for the 48k plants ac^{-1} population across the six plots. The Linden, WI site in 2016 showed yield optimum at a planted population 38k plants ac^{-1} at 255.4 bu ac^{-1}, which had a harvest population with ears of 34,800 plants ac^{-1} (Figure 2).

Observations of the 2015 corn population study showed higher plant populations resulted in an increasing percentage of plants not bearing ears. At the Summerland, IA and Dodgeville, WI sites a planted population of 26k plants ac^{-1} resulted in a 1.7% to 2.0% reduction respectively across the two sites, in plants bearing ears, whereas for the 44k plants ac^{-1} planted population resulted 7.5% and 3.4% reduction in plants bearing ears (see Table 1). Similar results were noted for the Farmers City site, however crusting at emergence greatly reduced stand counts by V3.

Population in 2015 had no impact on grain yield for the 26k and 44k plant populations by side dress nitrogen and potassium fertilizer applications at growth stage V3-V4 at the Sutherland, IA (see Table 2). Only the VN treatment showed significant increased grain yield for the 32k and 38k populations. There was no increase in grain yield over the check treatments with K or in combination with nitrogen. For the Sutherland, IA site it was noted that there was limited rainfall (< 0.25 inches) for two weeks after the side dress fertilizer treatment which may have impacted crop uptake.

Side dress nitrogen and potassium fertilizer applications at growth stage V3-V4 at the Dodgeville, WI site had no statistically significant impact on grain yield within each of the four populations (Table 3). The same was true for the Famer City, IL site (Table 4). It is worth noting that there was a strong trend showing N and K increasing yield for the 44k population, however it was masked by herbicide damage and subsequent variability.

For the Wellington, CO site in 2015 side dress nitrogen (50N) and nitrogen-potassium fertilizer was applied (50N+50K) at growth stage (GS) V4-V5 (Table 5). The application of 50 N alone increased grain yields only for the 48k population treatment. The application of 50N+50K increased yield statistically significantly across all populations and for the 48k population resulted in grain yield of 77.9 bu ac^{-1} over the check plot.

The Linden, WI, populations study site in 2016 showed large increases in grain yield to N and N+K over the check treatments for all three populations, with an average grain yield increase of 28 bu ac^{-1} to side dress N, and 36 bu ac^{-1} to N+K across all populations (Table 6). This site had a lower STK (154 ppm) and had ideal temperature and moisture conditions during corn GS V2-R1.

K Source Study

Nitrogen and potassium source studies were conducted at three Midwest sites in 2015 and one site in 2016. Results for 2015 shows grain yield responses to N alone at two sites and one site to K alone (Table 7). Fertilizer treatments of N + K_{ac} or N +K_{KCl} increased grain yield over the check at these sites, but only over N alone at the Linden, WI site, at an average of 10 bu ac^{-1}, non significantly. In 2016 site in Byron, IL showed a 17.1 bu ac^{-1} response to top dress 100 lbs ac^{-1} K_2SO_4 but no response to side dress K_{ac} at 50 or 100 lbs ac^{-1} applied at GS V3-V4 (Table 8). Yield response to K_2SO_4 may have been to either K or S at the site, although ear leaf analysis of the check plots showed S well with the sufficiency range, whereas leaf K was 1.08%.

K Observation Study

Beginning in 2011 and through 2014 corn ear leaf R1 analysis data has been collect form research check plots at seventy-six sites across six Midwestern states where K fertility studies have been conducted. In 2016 this study was expanded to include forty-eight sites where data was collected on soil analysis, ear leaf nutrients, and stalk nutrients at maturity, population and grain yield, based on four replications within grower fields across the Midwest from which thirty-two sites with complete data sets were selected. This data set is extensive and full analysis is pending. Select data on leaf analysis and grain yield is discussed.

Using this database of thirty-two sites across five Midwestern states cluster analysis comparisons contrasting eight sites with the lowest ear leaf K values and the eight with the highest were conducted (see Table 9). Cluster results show consistent mean leaf N values between clusters and as expected statically significant differences in mean leaf K, along with elevated mean leaf Mg for the low K cluster. Large differences were noted in mean leaf N:K, K:Mg and N:Mg ratios, with the low leaf K cluster having macro nutrient ratios outside corn DRIS optimum ranges as defined by Elwali et al, 1985 (see Table 10). Most significant was that low ear leaf K cluster had significantly lower mean yield, by 48.2 bu ac^{-1}. Further analysis of low vs high ear leaf K clusters for 2011-2014 indicate that lower grain yields are associated with lower leaf K and that K:Mg ratios are consistently lower with K deficiencies ear leaves (See Table 11). Over the five years, cluster analysis shows sites with low ear leaf K and K:Mg ratios < 6.0 have averaged 45.5 bu ac^{-1} lower yields relative to clusters which have K and K:Mg ratios falling within optimum ranges.

These results show a strong interaction of corn ear leaf K and Mg for corn at growth stage R1, and when K deficiencies $< 1.9\%$ occur there is a subsequent increase in ear leaf Mg, resulting in lower K:Mg and N:Mg ratios. Based on DRIS ratios the relationship of N, K and Mg is best shown in the theorized diagram Figure 3 where the optimum ratios are achieved at the center of the triangle. With the onset of K deficiencies and subsequent increased Mg uptake, ratios of K:Mg and N:Mg shift to the lower right, and results in a consequent impact grain yield. Although these results are preliminary, observations data analysis of five years of field data shows a strong relationship between ear leaf K nutrition and grain yield.

Summary

Results of the population study show optimum yields are obtained with planted populations of 32k-36k plants ac^{-1} based on 30" rows in the Midwest. Higher populations resulted a reduced number of plants with ears and decreased yields. Grain yield response to population and side dress nitrogen was site specific in 2014, with only a response to the VN treatment at the Sutherland, IA site and responses a the Wellington CO site. 2016 results showed brain yield responses at to both N and K at the Linden, WI site. Grain yield response to K source studies indicate site and product specific differences across four site years research was conducted. Interactions with N were noted, and the average response to side dress applied K was 10-12 bu ac^{-1}.

Observational data analysis of corn ear leaf tissue nutrients, based on check plot established in grower fields from 2011-2016, indicate leaf K levels < 1.9% are indicative of lower yields and that with K deficiencies corn leaves show increase Mg accumulation resulting in lower K:Mg ratios and substantially lower grain yields. Establish N, K, Mg DRIS ratio norms are an effective tool in diagnosing corn K deficiencies and addressing K fertility management of corn. Further research is needed to develop predictive models of corn K nutrition based on soil test methods and weather variables.

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Figure 1. Impact of corn population on mean grain yield for four sites 2015.

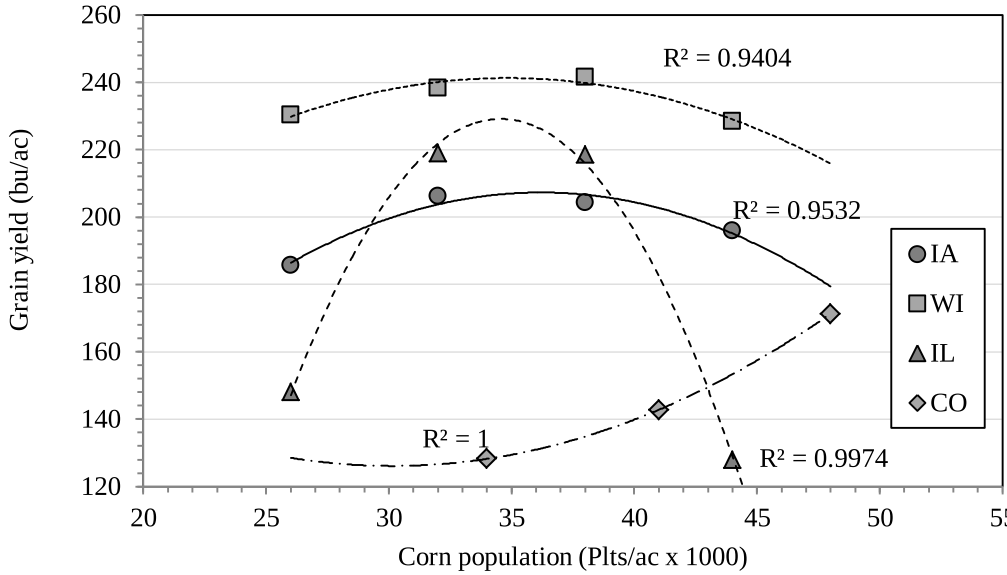


Figure 2. Impact of corn population on mean grain yield for Wisconsin site 2016.

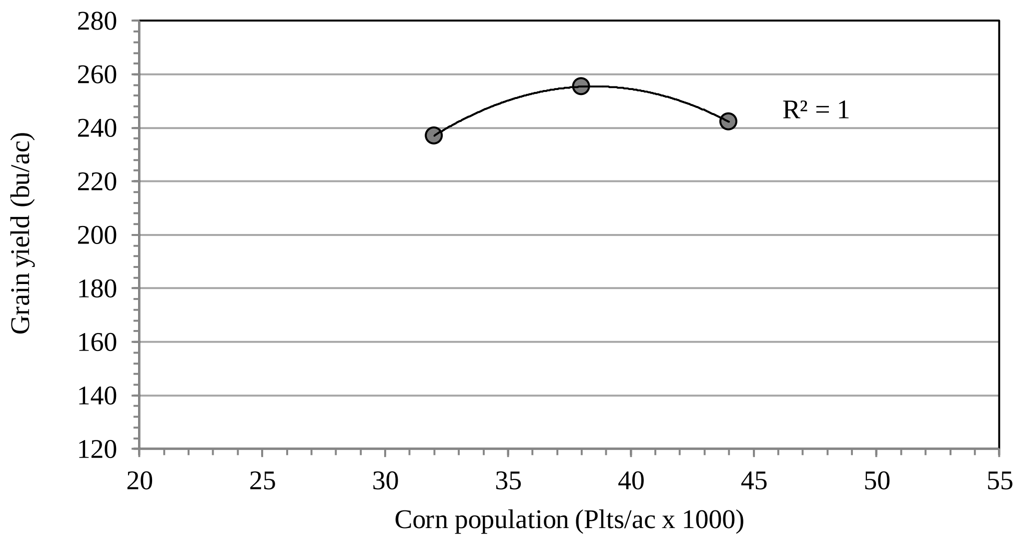


Table 1. Corn harvest populations for three sites 2015 for four plant populations.

Planted Population (Plts ac^{-1} x 1000) [1]	Grain Yield (bu ac^{-1})					
	Summerland, IA		Dodgeville, WI		Farmers City, IL	
	Ave	Stdev	Ave	Stdev	Ave	Stdev
26 k	25,650	1160	25,480	800	20,850	2810
32 k	30,860	1010	30,370	1950	27,980	1680
38 k	36,385	1180	35,950	1110	33,090	2550
44 k	40,730	1190	41,550	1340	36,730	4260

[1] Planted population based on planter seed John Deere counter, harvest population based on stand counts 3/1000th of an acre of plants with ears at black layer.

Table 2. Influence of fertilizer N and K on grain yield across four corn populations at Sutherland, IA site 2015.

Treatment [123]	Grain Yield (bu ac^{-1})			
Plants ac^{-1} x 1000	26 k	32 k	38 k	44 k
Check	192.9	201.1	204.3	194.6
40 N	196.4	206.8	204.5	197.8
50 K	181.6	205.2	198.3	188.8
40 N + 50 K	196.4	206.1	204.8	199.8
VN	189.0	214.2 *	216.7 *	196.6
VN + 50 K	186.0	203.2	211.4	198.7

[1] Fertilizer sources: Nitrogen urea; and K acetate rates lbs ac^{-1}.

[2] VN variable N rate adjusted as function of population, increasing 7.0 lbs per thousand plts ac^{-1} above 26k.

[3] Results followed by (*) are significant at the 0.05 level from the check treatment, six replications.

Table 3. Influence of fertilizer N and K on grain yield across four corn populations at Dodgeville, WI site 2015.

Treatment [123]	Grain Yield (bu ac^{-1})			
Plants ac^{-1} x 1000	26 k	32 k	38 k	44 k
Check	235.3	237.1	237.2	226.1
40 N	236.1	240.1	242.1	224.7
50 K	237.7	242.9	239.1	236.5
40 N + 50 K	238.0	241.4	244.2	231.8
VN	243.7	236.9	241.7	223.0
VN + 50 K	232.7	238.6	241.8	229.7

[1] Fertilizer sources: Nitrogen urea; and K acetate rates lbs ac^{-1}.

[2] VN variable N rate adjusted as function of population, increasing 7.0 lbs per thousand plts ac^{-1} above 26k.

[3] Results followed by (*) are significant at the 0.05 level from the check treatment.

Table 4. Influence of fertilizer N and K across grain yield four corn populations at Farmer City, IL site 2015.

Treatment [123]	Grain yield (bu ac^{-1})			
Plants ac^{-1} x 1000	26 k	32 k	38 k	44 k
Check	144.2	171.7	177.4	78.9
40 N	142.5	182.7	175.3	88.9
50 K	151.8	182.3	170.4	86.1
40 N + 50 K	146.4	178.4	172.4	79.8
VN	153.8	173.0	194.4	111.8
VN + 50 K	135.2	175.6	185.5	109.7

[1] Fertilizer sources: Nitrogen urea; and K acetate rates lbs ac^{-1}.
[2] VN variable N rate as function of population, increasing 7.0 lbs per thousand plts ac^{-1} above 26k.
[3] Results followed by (*) are significant at the 0.05 level from the check treatment.

Table 5. Influence of fertilizer N and K grain yield across three corn populations at Wellington, CO site 2015.

Treatment [123]	Grain yield (bu ac^{-1})		
Plants ac^{-1} x 1000	34 k	41 k	48 k
Check	112.9	116.7	129.4
50 N	130.0	151.8	168.2*
50 N + 50 K	141.8*	156.8*	207.3*

[1] Fertilizer sources: Nitrogen urea; and K acetate rates lbs ac^{-1}.
[2] VN variable N rate as function of population, increasing 7.0 lbs per thousand plts ac^{-1} above 26k.
[3] Results followed by (*) are significant at the 0.05 level from the check treatment.

Table 6. Impact of population and side dress N and K source on grain yield for Linden, WI 2016.

Treatment [123]	Grain yield (bu ac^{-1})					
Plants ac^{-1} x 1000	32k		38k		44k	
Check	220.1	Delta Yield	234.6	Delta Yield	216.4	Delta Yield
50 N	240.8	20.7 *	266.7	32.1 *	247.2	30.8 *
50 N + 50 K_{ac}	256.1	36.3 *	274.6	40.0 *	261.4	45.0 *

[1] Soil test K level 156 ppm.
[2] Fertilizer sources: Nitrogen urea; K acetate, rates lbs ac^{-1}.
[3] Mean results followed by (*) are significant at the 0.05 level from the check treatment.

Table 7. Impact of side dress N and K Source on corn grain yield for three Midwest sites 2015.

Treatment [123]	Grain Yield (bu ac^{-1})		
	Calumet, IA	Linden, WI	Weedman, IL
Check	194.1	219.0	183.2
50 N	217.1 *	229.6	200.2 *
50 K_{ac}	205.9	230.6 *	187.4
50 N + 50 K_{ac}	212.1 *	239.2 *	195.4 *
50 N + 50 K_{KCl}	204.1	240.5 *	203.8 *

[1] Soil Test K levels by site: 192, 178 and 184 ppm, respectively.
[2] Fertilizer sources: nitrogen urea; K acetate and KCl, rates lbs ac^{-1}.
[3] Results followed by (*) are significant at the 0.10 level from the check treatment.

Table 8. Impact of side dress and top dress K on grain yield for Byron, IL 2016.

Treatment [123]	Grain Yield (bu ac^{-1})	
	Mean	Stdev
Check	225.3	11.8
50 K_{ac} – Spoke Wheel	222.7	7.8
100 K_{ac} – Spoke Wheel	220.1	14.7
100 K_2SO_4 Top Dress	242.5*	13.7

[1] Soil Test K levels by site: 132 ppm, respectively.
[2] Fertilizer application: top dress dry pre-emergence over row; spoke wheel side dressed V3-V4 rates lbs ac^{-1}.
[3] Column means followed by (*) are significant at the 0.05 level from the check treatment (7 reps).

Table 9. Cluster comparisons of corn GS R1 ear leaf N, K, K:Mg, N:Mg and yield 2016.

Parameter	Low Leaf K Cluster [123]		High Leaf K Cluster	
	Mean	Stdev	Mean	Stdev
N %	2.51	0.26	2.83	0.18
K %	1.50*	0.22	2.76	0.35
Mg %	0.41*	0.05	0.17	0.04
N:K	1.71*	0.21	1.05	0.15
K:Mg	3.6*	0.7	17.1	3.8
N:Mg	6.0*	0.9	17.7	3.5
Yield (bu ac^{-1})	196.1	37.2	241.7	23.1

[1] Ear leaf K, Mg and yield measurements based for 32 sites, 4 reps per site, across five states.
[2] Cluster analysis comparison of eight lowest and highest ear leaf K.
[3] Cluster means within a parameter followed by (*) are significant at the 0.05 level.

Table 10 Corn leaf nutrient DRIS norms.

Nutrient Ratio [1]	Average	Stdev
N:P	9.03	2.14
N:K	1.46	0.43
N:Mg	14.1	4.1
N:S	11.9	2.2
K:Mg	9.6	3.6

[1] Ratios based on research of Elwali et al. 1985.

Table 11. Cluster comparisons of corn GS R1 ear leaf K, K:Mg and yield over five years, 112 sites.

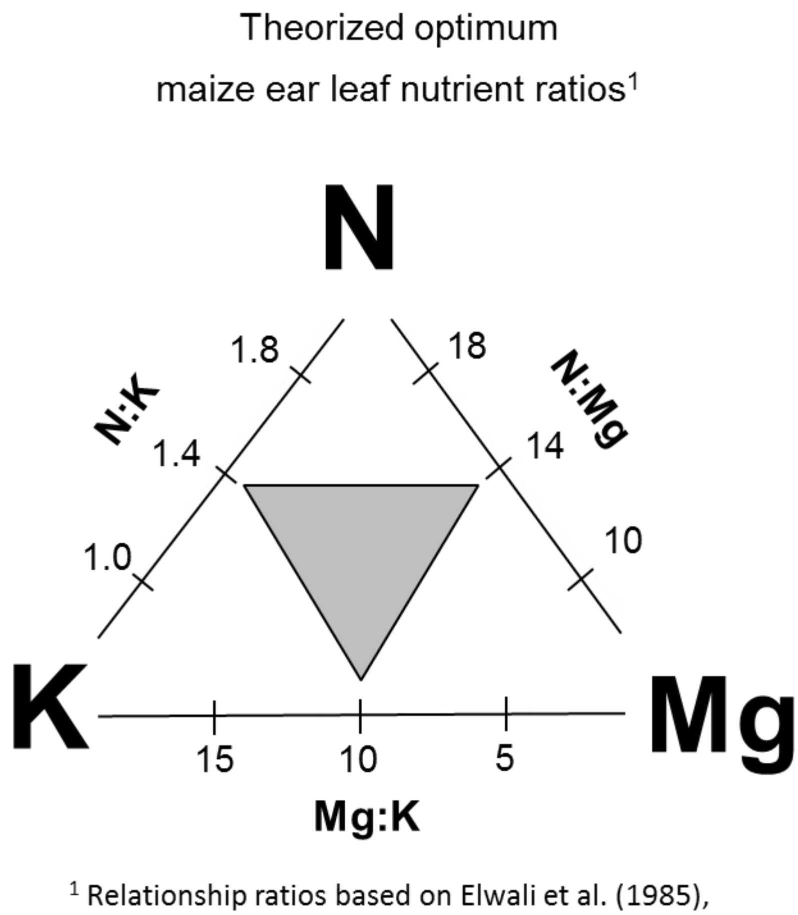
Year	Low K Cluster [123]		High K Cluster		Delta Yield
	K (%)	K:Mg	K (%)	K:Mg	(bu/ac)
2011	1.77*	5.9*	2.64	11.1	40.9*
2012	1.52*	3.2	1.91	6.7	58.1*
2013	1.67	3.0*	1.95	8.3	34.5
2014	1.60*	4.7*	2.17	10.1	48.2*
2015	-	-	-	-	-
2016	1.50*	3.6*	2.93	14.3	45.6

[1] Ear leaf K, Mg and yield measurements for 112 sites, 4-8 reps per site, across seven states.

[2] Cluster analysis of five lowest and highest ear leaf K, 16 to 32 sites. Number of sites per year, yearly dependent.

[3] Cluster means within a year followed by (*) are significant at the 0.05 level.

Figure 3. Diagram of theorized optimum maize ear leaf nutrient ratios based on Elwali et al (1985).



Introduction

Soil test potassium (STK) values have declined across the cornbelt over the past decade as reported by IPNI (2010). Significant declines in STK have been observed in growers' fields in Iowa, Minnesota, Illinois, Nebraska, Wisconsin and Indiana since 2005.

With continued improvement in corn and soybean production practices (i.e. hybrids, crop populations and tillage); and commodity price incentives, there are questions in the industry if current fertility methods and recommendations are meeting crop production requirements.

The KRx project was established to: (1) evaluate alternative soil test methods for assessing soil K fertility; (2) conduct a field study of corn K response in grower fields; and (3) evaluate new soil test technologies as they relate to soil potassium availability and related soil test methods. The following report is on results of the 2014 field research study.

Sixteen sites were selected across four Midwestern states. Sites were provided by Midwest Independent Soil Samplers and KRx collaborators and were soil sampled in May to evaluate fertility. Sites were selected for research based on past yields, K fertility levels and grower participation interest. Of these sites one was in South Dakota, three in Minnesota, eight in Iowa, and four in Illinois.

Hybrids, planting date, populations, and tillage systems varied across grower fields as the research was conducted. The sites and selection criteria can be seen in Table 1. For most locations growers used reduced tillage systems or strip till systems and applied nitrogen and phosphorus in sufficient amounts as not to be limiting. Soil testing showed pH values ranged from 5.40 to 7.77. Low P values (< 25.0 ppm) were noted for three sites. STK values ranged from 89 to 194 ppm. STK moist and dry results by soil depth are shown in Table 2.

Potassium was applied at all sites at corn growth stages V3-V6 at rates of 0, 50 and 100 lbs/ac potassium (K) as KCL-K_2SO_4 blend using a spoke wheel injector (See Figure 1) at a depth of 3.0" - 3.5", one ach side of the corn row in plots measuring 15 x 40 feet with eight replications of each treatment. <u>Note:</u> eight replications were employed to more accurately evaluate a statistical significant yield response to potassium application. Soils were sampled at five depths (0-2", 2-6", 6-12", 12-18") and population counts were taken at harvest. At corn growth stage VT (location dependent) composite corn leaf samples of the ear leaf were taken at sixteen locations and submitted for laboratory nutrient analysis (N, P, K, S, Ca, Mg, B, Fe, Mn, Zn, and Cu). At maturity 3/1000th of an acre areas of individual plots were harvested using two rows from each treatment replication. Ears were hand harvested, harvest population determined, and grain shelled. Grain weight, test weight moisture was recorded and grain yield determined based on the harvested plant area. Results were corrected to 15.5% grain moisture content.

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Miller, R.O. 2014. Corn Tissue Survey. Soil and Plant Analyst Newsletter. Spring Issue.

Table XI. Impact of side dress and top dress K on grain yield for Byron, IL 2016.

Nutrient Ratio	Average	Stdev
N:P	9.03	2.14
N:K	1.46	0.43
N:Mg	14.1	4.1
N:S	11.9	2.2
P:K	0.169	0.054
P:Mg	1.56	0.53
P:S	1.42	0.34
K:Mg	9.6	3.6
K:S	8.8	1.78
S:Mg	1.20	0.40

Table XK. Cluster comparisons of corn GS R1 ear leaf N, K, K:Mg, N:Mg and yield 2014.

Parameter	Low Leaf K Cluster[123]		High Leaf 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	1.75	0.21	1.36	0.18
K:Mg	4.7*	0.7	10.1	2.3
N:Mg	8.4*	1.5	13.3	1.7
Yield (bu ac^{-1})	160	24	207	27

[1] Ear leaf K, Mg and yield measurements based for 16 sites, 8 reps per site, across five states.
[2] Cluster analysis comparison of five lowest and highest ear leaf K.
[3] Cluster means within a parameter followed by (*) are significant at the 0.05 level.