KRx 2021 Mosaic Report

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Special points of interest:

- A fertility study was carried out across two sites in Iowa and Minnestoa.
- All sites exhibited low STK K and K base saturatuion and showed stratification with soil depth.
- Ear leaf tissue analysis inccated K deficiency at both locations and low K:Mg ratios.
- Corn yield increases were noted at one site with grain yield increaseof 9.6 bu ac^{-1} to K plus a B foliar treatment.

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Overview

A potassium (K) fertilizer research study was conducted on grower fields in the summer 2021 at two sites across Minnesota and Iowa to assess corn ear leaf nutrition, and grain yield. Research was supported by Mosaic and carried out with Soil View and with collaboration with Trace Genomics Laboratory Ames, IA and Sure-Tech Laboratory, Indianapolis, IA.

Introduction

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

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

The KRx project was established in 2011 to evaluate soil test methods for assessing soil K fertility and fertilizer response. Based on field results over the previous nine years the focus of the 2021 research was to assess soil test parameters (i.e. pH, STK, SOM etc.), corn leaf nutrition, corn stalk nutrients and the effect of Dosco products and KCl fertilizer on ear leaf nutrition and corn grain yield.

Material and methods

Two corn production sites were selected in Iowa and Minnesota. Sites were selected based on yields history, past K fertility levels and grower participation interest. Sites were soil sampled in late May-early June to evaluate fertility based on 0-8" depth and sub sampled for stratification based on depths of 0-2", 2-4", 4-6" and 6-8". At each location treatments were applied in early June as a side dress treatments on plots of six rows width (15 feet) and by 40 feet in length.

Material and methods (Continued)

Research site locations were as follows: Calumet, IA; and Adrian, MN. Soil textures were silty clay loam. Corn hybrids and planting dates varied by grower. Previous crop at all locations were soybeans, on reduced tillage systems and corn plant populations ranged from 30k, - 33k plts ac $^{-1}$ in 30" rows. Corn was planted April 28th for the Calumet site and May 4, for the Adrian site. Grower applied P rates were in sufficient amounts as not to be limiting. N application consisted of: 200 lbs ac^{-1} N at the Sutherland site; and 135 lbs ac^{-1} N pre-plant + 50 lbs ac^{-1} side dress at the Adrian site, made in split applications.

Figure 1. Soil sampling Sutherland, IA.

Treatments were: a control; applications of Mosaic Aspire at rates of 30, 60, 90, 120 lbs K_2O ac^{-1}; 60 lbs K_2O ac^{-1} as KCl; 60 lbs K_2O ac^{-1} as KCl + 0.5 lbs ac^{-1} Granubor and 60 lbs K_2O ac^{-1} as KCl + foliar B at 0.5 lbs ac^{-1} per acre at GS V5. All treatments were applied as a side dress application at GS V4-V5 unless otherwise noted. Treatments were arranged as a RCBD, six replications and applied as a liquid using a disk opener with knife injection 3" either side of the corn row at a depth of 2-3" at corn GS V4-V5, late May 2021. Foliar treatments were applied with a hand sprayer at V5-V6 with 25 gal ac^{-1} deionized water.

Population stand counts were taken at GS V5. A 20 corn ear leaf composite was sampled at GS V5-V6 and R1-R2 based from non harvest rows and submitted for laboratory nutrient analysis (N, P, K, S, Mg, Ca, B, Zn, Mn, and Cu), six replications per site. At maturity corn grain was harvested from two rows of individual plot reps representing 0.23% of an acre. Ears were hand harvested, harvest population determined, and ear grain percentage determined. Corn stalk samples were collected based on an eight stalk composite representing 8" segment taken 6" above the ground (Binford, 2006) and analyzed for P, K, S, Mg, Ca, Zn, and NO_3-N. Grain mass, test weight, and moisture was recorded. Grain yield was determined based on the harvested plot area and corrected to 15.5% grain moisture content.

Soil and tissue results

Soil tests showed pH values ranged from 5.91 to 6.32 across the sites, results presented in table 1. Soil K values were very similar across all sites and Base Sat values were low (< 2.0%) for 0-6" depth. Soil P, K, K Base Sat and K:Mg ratios show significant stratification at all sites, whereas SOM was not, table 2. Soil K Base sat below 4" were less than 1.2 at all sites. Soil M3 K:Mg ratios were very low, < 0.08 for all depths below the 4".

Corn plant N and P at GS V6 indicated all sites had adequate N fertility, and the Adrian site had adequate K (Table 3). Corn ear leaf N and P at GS R1 results for the Adrian site averaged 3.05 % and 0.32% respectively (Table 4). Results for K ranged from 1.62 - 1.76 % and Mg 0.48 - 0.52%. Ear leaf K:Mg ratios ranged from 3.2 - 3.5, with values < 8 suggesting mild K deficiencies and had supra-optimal tissue Zn. The Calumet site averaged 2.70% and 0.28% ear leaf N and P at GS R1 respectively (Table 5), and had deficiencies in K, Zn and excessive Mg. Treatment affects on ear leaf K were non significant. Corn stalk nutrient results were summarized, Table 6. All sites had very low stalk K, elevated stalk Mg and very low stalk K:Mg ratios. Ideal corn stalk K is > 2.5%, Mg content < 0.10 % and stalk K:Mg rations > 15.

Table 1. Soil analysis[1] mean results 0-6" sample two KRx sites 2021.

Site ID	pH	Buf pH	SOM	M3-P	M3-K	M3-Mg	M3-B	K Base Sat	K:Mg Ratio
			%	ppm	ppm	ppm	ppm	%	
Adrian, MN	5.91	6.62	5.13	38.1	193	904	1.1	1.5	0.06
Calumet, IA	6.32	6.67	4.60	52.6	197	650	0.7	1.8	0.09

[1] Soil data provided by Trace Genomics Laboratory, mean of 6 reps.

Table 2. Soil depth analysis[1] two KRx sites 2021.

Site ID	Depth	pH	SOM	M3-P	M3-K	M3-Mg	M3-B	K Base Sat	K:Mg Ratio
			%	ppm	ppm	ppm	ppm	%	
Adrian, MN	0-2"	6.3	5.8	85.1	225	780	1.1	2.1	0.09
	2-4"	6.4	5.0	29.7	90.1	699	1.0	1.0	0.04
	4-6"	6.3	5.0	16.3	57.2	723	0.9	0.6	0.02
	6-8"	6.3	4.7	10.5	58.5	886	0.9	0.6	0.02
Calumet, IA	0-2"	6.4	6.0	135	464	828	1.0	4.1	0.17
	2-4"	5.1	4.5	23.8	145	703	0.8	1.1	0.06
	4-6"	4.7	4.4	10.8	85	632	0.6	1.1	0.04
	6-8"	5.4	4.2	9.0	71	759	0.6	0.6	0.03

[1] Soil data provided by Trace Genomics Laboratory.

Table 3. KRx 2021 control plot, mean corn ear leaf nutrients GS V6, two sites.

Site ID	N	P	K	Mg	S	B	Cu	Zn	K:Mg
	%	%	%	%	%	ppm	ppm	ppm	
Adrian, MN	3.98	0.42	3.71	0.43	0.27	11.5	14.2	39.5	8.6
Calumet, IA	3.96	0.45	2.53	0.54	0.24	11.7	15.7	36.2	4.7

Corn plant GS V6 nutrient analysis provided by Sure-Tech Laboratories based on mean of six reps per site.

Table 4. KRx 2021 Adrian Site mean corn ear leaf nutrients corn GS R1.

Treatment	N	P	K	Mg	S	B	Cu	Zn	K:Mg
	%	%	%	%	%	ppm	ppm	ppm	ppm
Control	3.03	0.32	1.63	0.50	0.195	9.2	13.4	31.7	3.3
60 lbs K_2O KCl	3.05	0.33	1.70	0.50	0.201	9.3	13.3	32.5	3.4
60 lbs K_2O KCl + B	3.06	0.33	1.68	0.48	0.202	9.7	13.7	30.7	3.5

Corn plant ear leaf R1 nutrient analysis provided by Sure-Tech Laboratories based on mean of six reps per site.

Table 5. KRx 2021 Calumet Site mean corn ear leaf nutrients corn GS R1.

Treatment	N	P	K	Mg	S	B	Cu	Zn	K:Mg
	%	%	%	%	%	ppm	ppm	ppm	ppm
Control	2.68	0.27	1.28	0.91	0.162	8.7	9.8	16.2	1.4
60 lbs K_2O KCl	2.73	0.27	1.43	0.77	0.163	8.6	8.3	18.0	1.8
60 lbs K_2O KCl + B	2.70	0.28	1.51	0.77	0.171	9.6	10.3	22.5	2.0

Corn plant ear leaf R1 nutrient analysis provided by Sure-Tech Laboratories based on mean of six reps per site.

Table 6. KRx 2021 control plot mean corn stalk nutrient content at maturity, two sites.

Treatment	NO_3-N	P	K	Mg	S	Zn	K:Mg
	ppm	%	%	%	%	ppm	ppm
Adrian, MN	54	0.04	0.50	0.25	0.035	12.2	2.0
Calumet, IA	630	0.04	1.03	0.31	0.032	7.0	3.3

Stalk nutrient analysis provided by Sure-Tech Laboratories, based on mean of six reps per site.

Grain yield and analysis

Both Adrian, MN and Calumet, IA research sites experienced drought conditions in 2021 between early June and mid August, however the former site provided excellent yields. The Calumet site had low stored soil moisture and only received 4.4" from June 1 - August 1 during corn GS V5- R3 and thus had lower grain yields.

Results for the Adrian site showed a very consistent harvest populations across all five treatments averaging 32,700 plants per acre, Table 7. Harvest grain test weights averaged 57.7 lbs per bushel with an average harvest grain moisture of 18.6 %. Across Aspire product treatments grain yields were very similar ranging from 230.7.2 to 235.6 bu ac^{-1}.

Grain yield standard errors across treatments ranged from 1.8 to 4.6 bu ac^{-1}, and as a result there were no statistical significant yield differences between the control and all Aspire treatments at the Adrian site. It was noted that a side dress treatment of 60 lbs K_2O ac^{-1} as KCl + a foliar treatment of 0.5 lbs ac^{-1} B did significantly increase grain yield 9.6 bu ac^{-1} over the control. The general lack of yield treatment response to applied K is likely associated with drought conditions that followed application of side dress treatments in late May.

Table 7. KRx corn harvest data - Adrian, MN site, 2021.

Treatment	Ear harvest population	Grain moisture	Grain test weight	Grain yield (bu ac^{-1}) [1]	
	Plts ac^{-1}	%	lbs bu^{-1}	Average	Std Error [2]
Control	33,000	18.9	57.3	232.9	1.8
30 lbs K_2O ac^{-1}, Aspire	32,100	18.4	58.0	230.7	4.6
60 lbs K_2O ac^{-1}, Aspire	32,900	18.5	57.6	234.3	2.8
90 lbs K_2O ac^{-1}, Aspire	32,000	18.5	57.8	235.6	2.6
120 lbs K_2O ac^{-1}, Aspire	32,100	18.5	57.3	233.2	3.7
60 lbs K_2O ac^{-1}, KCl	32,500	18.7	57.6	238.5	3.9
60 lbs K_2O ac^{-1} , KCl + B	33,000	18.6	57.7	238.8	2.5
60 lbs K_2O ac^{-1} , KCl + B foliar	32,900	18.5	57.5	242.5	2.1

[1] Yield based 0.23 % of an acre hand harvest, grain yield corrected 15.5% moisture content. Six replications.
[2] * Difference significant from the control at the 0.05 level.

Table 8. KRx corn harvest data - Calumet, IA site, 2021.

Treatment	Ear harvest population	Grain moisture	Grain test weight	Grain yield (bu ac^{-1}) [1]	
	Plts ac^{-1}	%	lbs bu^{-1}	Average	Std Error [2]
Control	33,200	17.4	60.0	206.3	7.8
30 lbs K_2O ac^{-1}, Aspire	32,400	17.2	59.9	212.4	4.9
60 lbs K_2O ac^{-1}, Aspire	32,800	17.1	59.7	211.5	9.8
90 lbs K_2O ac^{-1}, Aspire	31,900	17.5	59.6	216.4	7.7
120 lbs K_2O ac^{-1}, Aspire	32,300	17.1	59.5	221.7	9.4
60 lbs K_2O ac^{-1}, KCl	32,100	17.5	59.7	212.7	9.4
60 lbs K_2O ac^{-1} , KCl + B	32,600	17.5	60.0	210.3	8.6
60 lbs K_2O ac^{-1} , KCl + B foliar	32,900	17.1	59.8	209.2	4.8

[1] Yield based 0.23 % of an acre hand harvest, grain yield corrected 15.5% moisture content. Six replications.
[2] * Difference significant from the control at the 0.05 level.

The Calumet site showed very consistent harvest populations across all five treatments averaging 32,500 plants per acre, with an average harvest moisture content of 17.7%, Table 8. The control plot average yield was 206.3 bu ac^{-1}. Across Aspire product treatments grain yield ranged from 211.5 to 221.7 bu ac^{-1}, increasing with Aspire application rate, with standard errors ranging from 4.9 - 9.8 bu ac^{-1}. However, none of the seven treatments, Aspire or KCl, showed statistical significant yield response over the control.

Supplemental Information. Appendix A attached lists results of corn plant leaf analysis collected at GS R1 for three locations over three years in the Western Corn belt, for N, P, K, Zn and B (Tables 9-11). Results show that the upper plant three leaves have N, P and K concentrations very similar to that of the ear leaf across all locations. However, concentrations of Zn and B were consistently higher in the upper three leaves relative to the ear leaf. B concentrations were 100-250% higher relative to the ear leaf and Zn concentrations 34 – 140% higher. Based on ear leaf analysis interpretation B was deficient at the Sutherland and O'Neil sites (critical value 10 ppm) and Zn deficient at the Sutherland and Adrian sites (critical value 24 ppm). Corn yields for the three respective sites were 246.2, 257.2 and 296.6 bu ac^{-1}, respectively. These results indicate leaves of the upper corn crop canopy likely has a higher critical concentration of these two micro nutrients and are critical during ear grain fill.

Conclusions

A study of Mosaic Aspire along with KCl fertilizer with and without B was conducted at two sites, near Adrian, Minnesota and a 2nd near Sutherland, Iowa on grower fields. Soils properties at both sites indicated at both sites were silty clay loam texture, slightly acid and adequate phosphorus fertility. Potassium soil tests indicated highly stratification near the soil surface and low K based saturation. Grower applied adequate nitrogen nd fungicide during the cropping season. Growing conditions were near normal at planting, but rainfall was limited during vegetative growth V4-R1. Late grain fill had near optimal moisture.

Fertilizer application consisted of: Aspire at rates of 0, 30, 60, 90 and 120 lbs of K_2O per acres; KCl at 60 lbs of K_2O per acre with and without B, plus B applied as a foliar treatment at GS V5. Whole plant tissue samples were taken at V5-V6, ear leaf at GS R1 and stocks at physiological maturity.

Plant Analysis results at V6 show adequate plant N and P at GS V6 at both sites, but deficiencies were noted at GS R1 for K at both sites, with the greatest noted for the Calumet site. Supra high Mg (>0.6%) was noted with K deficiencies a the Calumet site. All sites had very low stalk K, elevated stalk Mg and very low stalk K:Mg ratios. There was no differences in ear leaf nutrient concentrations associated with any treatments, although there was a trend of decrease ear leaf Mg associated with KCl over the control.

Grain yield results showed no statistical significant response to applications of Aspire over the control at either location, although there was trend response to higher applications at the Calumet site. It was noted that an application of foliar B with a side dress application KCl at 60 lbs of K_2O per acre significantly increased yield at the Adrian site. Drought stress during corn GS V5-R3 at the Calumet site likely impacted nutrient availability associated with side dress and foliar treatments and impacted corn grain yield resulting in no treatment affects over the control.

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Appendix A

Table 9. Corn plant nutrient distribution GS R1, Sutherland, IA, 2019 (dry land).

Leaf Position	N	P	K	B	Zn
	%	%	%	ppm	ppm
Flag leaf	2.85	0.33	1.56	32.5	44.7
1 leaf below flag leaf	3.22	0.37	1.59	23.0	36.1
2 leaves below flag leaf	3.12	0.41	1.71	15.0	32.1
Ear leaf	3.16	0.43	2.00	6.3	17.0

[1] Tissue analysis provided by Sure-Tech Laboratories, Indianapolis, IN. Ten plant composite.

Table 10. Corn plant nutrient distribution GS R1, Adrian, MN, 2020 (dryland).

Leaf Position	N	P	K	B	Zn
	%	%	%	ppm	ppm
Flag leaf	2.74	0.36	1.83	45.6	41.1
1 leaf below flag leaf	2.82	0.35	1.88	36.2	38.3
2 leaves below flag leaf	2.89	0.33	1.77	28.1	34.8
Ear leaf	2.90	0.37	2.15	10.2	17.5

[1] Tissue analysis provided by Sure-Tech Laboratories, Indianapolis, IN. Ten plant composite.

Table 10. Corn plant nutrient distribution GS R1, O'Neil, NE, 2021 (irrigated).

Leaf Position	N	P	K	B	Zn
	%	%	%	ppm	ppm
Flag leaf	2.32	0.34	2.25	23.7	42.8
1 leaf below flag leaf	3.02	0.34	2.42	16.3	35.8
2 leaves below flag leaf	3.18	0.34	2.42	13.2	35.0
Ear leaf	3.04	0.33	2.46	7.4	26.5

[1] Tissue analysis provided by Sure-Tech Laboratories, Indianapolis, IN. Ten plant composite.

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