Foliar Fertilization of Corn with Mono-Potassium Phosphate and Urea

Final Research Report

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Optimizing yield is an important component of economical corn production. Managing fertilizer inputs is essential as they can be a significant portion of total crop input costs. Typically, the soil source is key for adequate supply and plant uptake of essential nutrients in Midwest U.S. corn production. Most research focuses on managing fertilization needs through this nutrient supply system.

Of question, however, will supply of nutrients at critical corn growth periods from non-soil sources further enhance plant growth and yield. One such source is foliar application and direct assimilation through corn foliage. Previous research has shown that this method of application has the potential to increase corn yield, but results have not been consistent or predictable (Benson, 1971; Barel and Black, 1979a; Barel and Black, 1979b; Harder et al., 1982; Suwanarit and Sestapukdee, 1989).

The objective of this work is to determine the impact of applying mono-potassium phosphate (MKP) and urea fertilizer to corn foliage at several growth stages on grain yield and grain components.

Materials and Methods

Two sites on the ISU Agronomy Research Farm (located between Ames and Boone, IA) were utilized to run duplicate studies, the Sorenson farm site and Bruner farm site. Each site was located on Canisteo silty clay loam soil. The previous crop was soybean at each site.

Soil tests, at the 0-6 inch depth, for the Sorenson site were: 6.6 pH, Bray P-1 52 ppm , ammonium acetate extractable K 206 ppm, and organic matter 5.8%. Soil tests, at the 0-6 inch depth, for the Bruner site were: 6.1 pH, Bray P-1 26 ppm, ammonium acetate extractable K 163 ppm, and organic matter 5.1%.

Common corn production cultural practices were utilized on each site. Broadcast urea nitrogen was applied preplant at 127 lb N/acre on the Sorenson site and 150 lb N/acre on the Bruner site. No phosphorus or potassium fertilizer was applied as soil test levels were in the high to very high categories. Herbicides (applied at label rates for the soil and crop) used were Balance®, Surpass®, and atrazine applied preplant at the Sorenson site

and postemerge Buctril® and Accent® at the Bruner site. Tillage was disc-field cultivation. The Sorenson site was rotary hoed to aid corn emergence. The corn hybrids used were Dekalb brand DK 512 at the Sorenson site and Dekalb brand DK 580 at the Bruner site.

Treatments were with or without mono-potassium phosphate (MKP, 0-52-34), with or without low-biuret urea (45-0-0), and combination of each foliar applied at the V6–V8 (June 14, 1999), V12–V14 (July 6, 1999), and 50% VT (July 19, 1999) corn growth stages (Ritchie and Hanway, 1982). A complete factorial arrangement of treatments were replicated in a randomized complete block design. The Sorenson farm site had three replications and the Bruner farm site had four replications.

Plot sizes were 15 feet wide (6-30 inch rows) and 50 feet long. The center four rows of each plot were counted for plant stand on June 16, 1999 and hand thinned to a uniform population – 29,300 plant stand at the Sorenson farm site and 31,000 plant stand at the Bruner farm site.

Treatments were applied with a backpack CO_2 spray system (equipped with flat fan nozzles spaced on 30-inch centers) to all six corn rows of each plot. Spray solution application rate was 20 gal/acre. Fertilizer material for each treatment was mixed in one container prior to application. Fertilizer rates were 0 or 5.0 lb MKP product/acre and 0 or 1.7 lb low biuret urea product/acre (the MKP and low biuret urea was supplied by Lidochem, Inc., 20 Village Court, Hazlet, NJ 00730). A surfactant was added with the spray solutions at 0.1% v/v spray mix ("Nutrient Uptake Enhancer" surfactant supplied by Wilbur-Ellis Co., 2903 S. Cedar Ave., P.O. Box 1286, Fresno, CA 93715).

The rain-free period after application was several hours to several days for each application timing. For the V6–V8 (June 14) application, there was no rain the day of application. The next day 0.04 inch of precipitation occurred in the afternoon over a six-hour period. No significant amount of rainfall occurred until June 22-23 (1.25 inch). For the V12–V14 (July 6) application, no rain occurred after application until the end of the day on July 8 (0.35 inch). For the 50% VT (July 19) application, there was 0.37 inch of precipitation beginning at 9:00 p.m. on July 19. No further significant rainfall occurred for 6 days after application (0.35 inch on July 26).

Air temperatures varied with application date. The maximum air temperature for the V6–V8 application was 70º F, for the V12–V14 application 81º F, and for the 50% VT application 90º F.

Multiple parameters were measured on each plot. Ear leaf chlorophyll readings were taken with a Minolta SPAD 502 chlorophyll meter (30 readings per plot at growth stage R4, August 18, 1999). Grain was machine harvested on October 20, 1999 from the center two rows of each plot, with calculated yields corrected to 15.5% moisture basis. Number of kernels per ten ears and 100 kernel weight were measured from 10 representative ears per plot. Harvested grain samples were analyzed for protein, oil, starch, and density by the ISU Grain Quality Lab, 1547 Food Science Building. The near

infrared (NIR) equipment used for the analysis were calibrated and standardized by using the procedures and methods found in Rippke et al. (1995). Results are reported on 15% moisture basis.

Results and Discussion

Corn grain production levels were quite high in 1999 at both sites (Tables 1 and 9). Foliar application of MKP and urea had minimal impact on yield. Application of MKP significantly decreased grain yield at both sites – 5 bu/acre at the Sorenson farm site and 6 bu/acre at the Bruner site when averaged across all application timings and application of urea (Tables 1, 9, 17, and 18). There was a significant three way interaction between application of MKP, urea, and timing at the Sorenson farm site. In essence the interaction was an inconsistent response to MKP and urea at the early application timings. No other significant yield response occurred as a result of urea application or timing of foliar spray.

There were no statistically significant effects of MKP or urea application on any of the measured grain properties or ear leaf SPAD chlorophyll meter readings (Tables 2-8, Tables 10-16, and Tables 17-18).

From the data collected, there is no ready explanation for the decrease in grain yield with application of MKP. No visible leaf damage was observed after the foliar fertilizer applications, and no plant or grain measurements indicated reasons for the decrease. On a relative basis, the yield decreases were small (2.8% at the Sorenson and Bruner sites), but consistent at each site. The two sites had different hybrids, but were similar in soil properties and available nutrient supply.

Based on this data, foliar application of MKP, urea, or a combination of the two would not be recommended for corn production. It would be important, however, to determine if these results are consistent across multiple growing seasons and to discern reasons for the measured effects.

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Notes:

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Mention of firm names or trade products does not imply that they are endorsed over other firms or similar products not mentioned.

Table 1. Corn grain yield as influenced by foliar fertilizer application, Sorenson Research Farm Site, 1999.

		Foliar Application Timing*			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - - - - - bu/acre - - - - - - - - - - - - - - - -				
0	0	189	175	183	182	
	1.7	181	181	181	181	
Without MKP Mean		185	178	182		182*
5	0	176	180	182	179	
	1.7	181	177	167	175	
With MKP Mean		179	179	175		177
Without Urea Mean		183	178	183	181	
With Urea Mean		181	179	174	178	
Timing Mean		182	178	178		

* Significant interaction between MKP, urea, and timing of application, Pr > F at 95% level.
* Signifcantly higher yield without MKP, Pr > F at 95% level.
No other significant treatment effects, Pr > F at 95% level.

Table 2. Corn 100 kernel weight as influenced by foliar fertilizer application, Sorenson Research Farm Site, 1999.

		Foliar Application Timing			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - - - g/100 kernels - - - - - - - - - - - - - -				
0	0	28.4	27.2	27.6	27.7	
	1.7	27.5	26.9	27.9	27.4	
Without MKP Mean		27.9	27.0	27.8		27.6
5	0	27.8	27.3	28.4	27.9	
	1.7	27.2	25.9	27.6	26.9	
With MKP Mean		27.5	26.6	28.0		27.4
Without Urea Mean		28.1	27.2	28.0	27.8	
With Urea Mean		27.3	26.4	27.8	27.2	
Timing Mean		27.7	26.8	27.9		

No significant treatment effects, Pr > F at 95% level.

Table 3. Corn kernel number per 10 ears as influenced by foliar fertilizer application, Sorenson Research Farm Site, 1999.

		Foliar Application Timing			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - kernel number/10 ears - - - - - - - - - - -				
0	0	5718	5886	6035	5880	
	1.7	5651	6079	5606	5779	
Without MKP Mean		5685	5982	5821		5829
5	0	5683	5801	5755	5746	
	1.7	5973	5806	5835	5871	
With MKP Mean		5828	5804	5795		5809
	Without Urea Mean	5700	5844	5895	5812	
	With Urea Mean	5812	5943	5721	5825	
	Timing Mean	5756	5893	5808		

No significant treatment effects, Pr > F at 95% level.

Table 4. Corn grain protein as influenced by foliar fertilizer application, Sorenson Research Farm Site, 1999.

		Foliar Application Timing			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - - - - - - - - % - - - - - - - - - - - - - - - - - - -				
0	0	6.23	6.43	5.97	6.21	
	1.7	6.13	6.13	5.90	6.06	
Without MKP Mean		6.18	6.28	5.93		6.13
5	0	6.47	6.12	6.20	6.28	
	1.7	5.57	6.23	5.97	5.92	
With MKP Mean		6.02	6.20	6.08		6.10
	Without Urea Mean	6.35	6.30	6.08	6.24	
	With Urea Mean	5.85	6.18	5.93	5.99	
	Timing Mean	6.10	6.24	6.01		

No significant treatment effects, Pr > F at 95% level.

Table 5. Corn grain oil as influenced by foliar fertilizer application, Sorenson Research Farm Site, 1999.

		Foliar Application Timing			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - - - - - - - % - - - - - - - - - - - - - - - - - -				
0	0	3.63	3.80	3.73	3.72	
	1.7	3.70	3.90	3.80	3.80	
Without MKP Mean		3.67	3.85	3.77		3.76
5	0	3.57	3.63	3.73	3.64	
	1.7	3.67	3.83	3.73	3.74	
With MKP Mean		3.62	3.73	3.73		3.69
	Without Urea Mean	3.60	3.72	3.73	3.68	
	With Urea Mean	3.68	3.87	3.77	3.77	
	Timing Mean	3.64	3.79	3.75		

No significant treatment effects, Pr > F at 95% level.

Table 6. Corn grain starch as influenced by foliar fertilizer application, Sorenson Research Farm Site, 1999.

		Foliar Application Timing			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - - - - - - - % - - - - - - - - - - - - - - - - - -				
0	0	62.2	61.8	62.1	62.0	
	1.7	62.1	62.2	62.2	62.2	
Without MKP Mean		62.2	62.0	62.1		62.1
5	0	62.0	62.2	61.9	62.0	
	1.7	62.5	62.0	62.3	62.3	
With MKP Mean		62.2	62.1	62.1		62.1
	Without Urea Mean	62.1	62.0	62.0	62.0	
	With Urea Mean	62.3	62.1	62.2	62.2	
	Timing Mean	62.2	62.0	62.1		

No significant treatment effects, Pr > F at 95% level.

Table 7. Corn grain density as influenced by foliar fertilizer application, Sorenson Research Farm Site, 1999.

MKP	Urea	Foliar Application Timing V6 - V8	V12 - V14	50% VT	Urea Mean	MKP Mean
lb product/acre		- - - - - - - - - - - - - - - - - - g/cc - - - - - - - - - - - - - - - - - -				
0	0	1.24	1.24	1.23	1.24	
	1.7	1.23	1.24	1.23	1.23	
Without MKP Mean		1.24	1.24	1.23		1.24
5	0	1.24	1.24	1.23	1.23	
	1.7	1.23	1.21	1.23	1.23	
With MKP Mean		1.24	1.23	1.23		1.23
	Without Urea Mean	1.24	1.24	1.23	1.24	
	With Urea Mean	1.23	1.23	1.23	1.23	
	Timing Mean	1.24	1.23	1.23		

No significant treatment effects, Pr > F at 95% level.

Table 8. Corn ear leaf SPAD chlorophyll meter units (R4 growth stage) as influenced by foliar fertilizer application, Sorenson Research Farm Site, 1999.

MKP	Urea	Foliar Application Timing V6 - V8	V12 - V14	50% VT	Urea Mean	MKP Mean
lb product/acre		- - - - - - - - - - - - - - - - - - g/cc - - - - - - - - - - - - - - - - - -				
0	0	56	57	56	56	
	1.7	57	57	57	57	
Without MKP Mean		57	57	57		57
5	0	57	56	56	57	
	1.7	57	56	56	56	
With MKP Mean		57	56	56		57
	Without Urea Mean	57	57	56	56	
	With Urea Mean	57	57	56	57	
	Timing Mean	57	57	56		

No significant treatment effects, Pr > F at 95% level.

Table 9. Corn grain yield as influenced by foliar fertilizer application, Bruner Research Farm Site, 1999.

		Foliar Application Timing			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - - - - - bu/acre - - - - - - - - - - - - - - - -				
0	0	218	210	212	213	
	1.7	210	206	212	209	
Without MKP Mean		214	208	212		211*
5	0	207	207	204	206	
	1.7	203	207	203	204	
With MKP Mean		205	207	204		205
Without Urea Mean		212	209	208	210	
With Urea Mean		206	206	208	207	
Timing Mean		209	208	208		

* Signifcantly higher yield without MKP, Pr > F at 95% level.
No other significant treatment effects, Pr > F at 95% level.

Table 10. Corn 100 kernel weight as influenced by foliar fertilizer application, Bruner Research Farm Site, 1999.

		Foliar Application Timing			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - - - - g/100 kernels - - - - - - - - - - - - - - -				
0	0	27.2	26.6	26.9	26.9	
	1.7	26.7	27.6	26.5	26.9	
Without MKP Mean		26.9	27.1	26.7		26.9
5	0	26.2	27.6	26.6	26.8	
	1.7	26.3	26.7	26.9	26.6	
With MKP Mean		26.2	27.1	26.7		26.7
Without Urea Mean		26.7	27.1	26.7	26.8	
With Urea Mean		26.5	27.1	26.7	26.8	
Timing Mean		26.6	27.1	26.7		

No significant treatment effects, Pr > F at 95% level.

Table 11. Corn kernel number per 10 ears as influenced by foliar fertilizer application, Bruner Research Farm Site, 1999.

		Foliar Application Timing			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - kernel number/10 ears - - - - - - - - - - -				
0	0	6468	6499	6401	6456	
	1.7	6436	6371	6612	6473	
Without MKP Mean		6452	6435	6506		6464
5	0	6161	6081	6533	6258	
	1.7	6310	6386	6395	6363	
With MKP Mean		6235	6234	6464		6311
Without Urea Mean		6314	6290	6467	6357	
With Urea Mean		6373	6379	6503	6418	
Timing Mean		6344	6334	6485		

No significant treatment effects, Pr > F at 95% level.

Table 12. Corn grain protein as influenced by foliar fertilizer application, Bruner Research Farm Site, 1999.

		Foliar Application Timing			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - - - - - - - - % - - - - - - - - - - - - - - - - - - -				
0	0	5.68	6.20	5.75	5.88	
	1.7	5.58	5.78	5.68	5.68	
Without MKP Mean		5.63	5.99	5.71		5.78
5	0	5.50	5.40	5.75	5.55	
	1.7	5.53	5.60	5.95	5.69	
With MKP Mean		5.51	5.50	5.85		5.62
Without Urea Mean		5.59	5.80	5.75	5.71	
With Urea Mean		5.55	5.69	5.81	5.68	
Timing Mean		5.57	5.74	5.78		

No significant treatment effects, Pr > F at 95% level.

Table 13. Corn grain oil as influenced by foliar fertilizer application, Bruner Research Farm Site, 1999.

		Foliar Application Timing			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - - - - - - - % - - - - - - - - - - - - - - - - - -				
0	0	3.60	3.63	3.63	3.62	
	1.7	3.55	3.60	3.60	3.58	
Without MKP Mean		3.58	3.62	3.62		3.60
5	0	3.70	3.50	3.70	3.63	
	1.7	3.50	3.63	3.53	3.55	
With MKP Mean		3.60	3.56	3.61		3.60
Without Urea Mean		3.65	3.56	3.66	3.63	
With Urea Mean		3.53	3.61	3.56	3.57	
Timing Mean		3.59	3.59	3.61		

No significant treatment effects, Pr > F at 95% level.

Table 14. Corn grain starch as influenced by foliar fertilizer application, Bruner Research Farm Site, 1999.

		Foliar Application Timing			Urea	MKP
MKP	Urea	V6 - V8	V12 - V14	50% VT	Mean	Mean
lb product/acre		- - - - - - - - - - - - - - - - - - % - - - - - - - - - - - - - - - - - -				
0	0	62.4	62.2	62.3	62.3	
	1.7	62.6	62.5	62.5	62.5	
Without MKP Mean		62.5	62.3	62.4		62.4
5	0	62.6	62.7	62.4	62.5	
	1.7	62.6	62.7	62.1	62.4	
With MKP Mean		62.6	62.7	62.2		62.5
Without Urea Mean		62.5	62.5	62.3	62.4	
With Urea Mean		62.6	62.6	62.3	62.5	
Timing Mean		62.5	62.5	62.3		

No significant treatment effects, Pr > F at 95% level.

Table 15. Corn grain density as influenced by foliar fertilizer application, Bruner Research Farm Site, 1999.

MKP	Urea	Foliar Application Timing			Urea Mean	MKP Mean
		V6 - V8	V12 - V14	50% VT		
lb product/acre		- - - - - - - - - - - - - - - - - - g/cc - - - - - - - - - - - - - - - - - -				
0	0	1.24	1.24	1.24	1.24	
	1.7	1.24	1.24	1.24	1.24	
Without MKP Mean		1.24	1.24	1.24		1.24
5	0	1.24	1.24	1.23	1.24	
	1.7	1.24	1.24	1.24	1.24	
With MKP Mean		1.24	1.24	1.23		1.24
	Without Urea Mean	1.24	1.24	1.23	1.24	
	With Urea Mean	1.24	1.24	1.24	1.24	
	Timing Mean	1.24	1.24	1.24		

No significant treatment effects, Pr > F at 95% level.

Table 16. Corn ear leaf SPAD chlorophyll meter units (R4 growth stage) as influenced by foliar fertilizer application, Bruner Research Farm Site, 1999.

MKP	Urea	Foliar Application Timing			Urea Mean	MKP Mean
		V6 - V8	V12 - V14	50% VT		
lb product/acre		- - - - - - - - - - - - - - - - - - g/cc - - - - - - - - - - - - - - - - - -				
0	0	59	59	60	59	
	1.7	60	59	58	59	
Without MKP Mean		59	59	59		59
5	0	58	59	59	59	
	1.7	58	57	59	58	
With MKP Mean		58	58	59		58
	Without Urea Mean	58	59	59	59	
	With Urea Mean	59	58	59	59	
	Timing Mean	59	59	59		

No significant treatment effects, Pr > F at 95% level.

Table 17. Partial analysis of variance for Sorenson Research Farm Site, 1999.

				100 Kernel	Kernels	Grain			
Source	df	Yield	SPAD	Weight	10 ears	Protein	Oil	Starch	Density
					Mean Squares				
Rep	3	74.105	0.260	9.921	133761.083	0.373	0.020	0.020	0.00010
MKP	1	175.563*	1.361	0.340	3761.778	0.010	0.040	0.018	0.00023
Urea	1	66.423	0.490	3.547	1320.111	0.588	0.071	0.360	0.00023
Timing	2	48.444	1.020	3.910	57326.083	0.166	0.072	0.084	0.00012
MKP*Urea	1	14.823	2.778	1.034	114921.000	0.090	0.001	0.018	0.00007
MKP*Timing	2	55.761	0.919	0.445	77671.528	0.081	0.006	0.005	0.00011
Urea*Timing	2	76.028	0.256	0.322	78340.194	0.135	0.010	0.006	0.00018
MKP*Urea*Timing	2	164.136*	0.169	0.507	100568.083	0.256	0.005	0.319	0.00019
Error	33	31.884	2.205	1.414	32784.871	0.205	0.059	0.147	0.00015

* Significant at the 95% probability level.

Table 18. Partial analysis of variance for Bruner Research Farm Site, 1999.

				100 Kernel	Kernels	Grain			
Source	df	Yield	SPAD	Weight	10 ears	Protein	Oil	Starch	Density
					Mean Squares				
Rep	3	210.732	6.452	6.419	41328.611	0.091	0.025	0.200	0.000028
MKP	1	449.092*	7.680	0.460	283054.083	0.285	0.001	0.083	0.000075
Urea	1	150.974	2.613	0.060	44896.333	0.010	0.041	0.041	0.000008
Timing	2	21.541	0.601	1.286	114373.146	0.206	0.003	0.214	0.000133*
MKP*Urea	1	6.194	0.441	0.152	22968.750	0.350	0.008	0.333	0.000033
MKP*Timing	2	81.442	2.297	0.726	37346.021	0.396	0.006	0.263	0.000025
Urea*Timing	2	24.362	4.166	0.063	2773.771	0.031	0.036	0.035	0.000033
MKP*Urea*Timing	2	12.435	1.498	2.298	159172.313	0.066	0.030	0.004	0.000008
Error[1]	33	85.196	4.246	2.107	141424.793	0.234	0.029	0.181	0.000032

[1] 31 df for yield due to missing data.

* Significant at the 95% probability level.