CHLORIDE RESPONSE OF CORN AND GRAIN SORGHUM

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ABSTRACT

Research in several states in the United States and in Canada has documented positive small grain responses to chloride (Cl) fertilization, yet little research has been done on corn or grain sorghum. Field research was conducted in Kansas evaluating Cl fertilization on corn and grain sorghum. Chloride rates and sources were evaluated at several farmer-cooperator sites. Corn and grain sorghum yields were consistently increased with Cl fertilization when soil Cl levels were low (6 ppm or less). At higher soil Cl levels (> 6 ppm), Cl fertilization had minimal effects on corn and sorghum grain yields. Chloride fertilization consistently and significantly increased plant Cl concentrations in both crops, regardless of soil Cl levels. All Cl sources evaluated performed similarly. Based on this and previous work, Kansas State University now recommends Cl application on wheat, corn and grain sorghum whenever soil Cl levels are 6 ppm or less (0-24" sample).

INTRODUCTION

Chlorine, or more correctly, chloride (Cl) was determined to be an essential nutrient in 1954 by Broyer, et al. Specific metabolic roles for Cl include functions in noncyclic photophosphorylation and in the riboflavin phosphate pathway of cyclic photophosphorylation reactions in photosynthesis. These reactions are responsible for the capture and storage of light energy in the form of high-energy phosphate bonds.

Chloride deficiency symptoms for crops are hard to describe as very few have been observed under field conditions. Plants suffering from severe Cl deficiency have demonstrated chlorosis and necrosis of leaf areas. Leaf tips wilt followed by development of bronze coloration followed by necrosis. Engel et al., 1997, described a leaf spot complex, commonly called "physiological leaf spot", that results in leaf tissue necrosis in selected winter wheat cultivars in Montana. Their research indicates this problem results from inadequate chloride nutrition. They found the leaf spot where soils were <1 ppm Cl and also determined that leaf spot damage was minimal when whole plant Cl at heading is >0.10%.

Several researchers (Lamond et al., 1997; Lamond et al., 2000; Christensen et al., 1981; Powelson and Jackson, 1978; Fixen et al., 1986; and Goos, 1984) have documented positive yield responses of wheat and barley to Cl fertilization. Some of these responses were attributed to disease suppression with Cl fertilization while other responses appeared to be nutritional. Earlier work in Kansas (Bonczkowski, 1989) documented positive yield effects with Cl fertilization.

Heckman and Bruulsema, 1996, reported yield responses of 8 to 26 bu/acre on corn in New Jersey. They also reported that Cl fertilization significantly reduced stalk rot in corn. Sweeney, et al., 1995, reported an interaction between N and Cl fertilization on grain sorghum in Kansas. Without Cl, yields were not increased by N fertilization but with Cl yield was increased by 24 bu/acre with N. Adding Cl also reduced the number of nodes/plant with stalk rot symptoms regardless of N rate. Lamond, et al., 1998, summarized Cl fertilization work in Kansas on corn and sorghum. They concluded Cl responses on these crops were inconsistent, but Cl responses were most likely when soil Cl levels were less than 3-4 ppm (0-24"). Since relatively little Cl work has been done on corn and grain sorghum, research was continued in Kansas.

MATERIALS AND METHODS

Field studies were conducted from 1998 through 2001 in Kansas. Over the course of this work, several Cl sources (potassium chloride, KCl; calcium chloride, $CaCl_2$; and sodium chloride, NaCl) and rates (0, 20, 40) were evaluated (sources and rates varied with location). All chloride treatments were applied surface broadcast either preplant or shortly after planting. Nitrogen and other needed nutrients were balanced on all treatments. Leaf samples were taken at tassel/boot stages for Cl analysis. Grain yields were determined by either hand or machine harvest. Plant disease observations were taken at most locations; however disease pressure was non-existent to slight at all locations.

RESULTS AND DISCUSSIONS

Results of Cl fertilization work on corn and grain sorghum from 1998 through 2001 are summarized in Tables 1 and 2 and Figures 1-4. Crop yields varied among sites and years, but were average to excellent for dryland production.

Chloride fertilization, regardless of source, consistently and significantly increased leaf Cl concentrations for both crops. Leaf Cl concentrations were more dramatically affected when soil Cl levels were 6 ppm or less compared to greater than 6 ppm, although leaf Cl increases with Cl application were significant even at higher soil Cl levels. All Cl sources evaluated performed similarly in terms of increasing leaf Cl concentrations.

The effects of Cl fertilization on corn and grain sorghum yields were also very consistent. At every site where soil Cl levels were 6 ppm or less, Cl fertilization significantly increased yields of these crops. These results mirror the results of our Cl work on wheat. With soil Cl at 6 ppm or less, corn yields were increased 7 bu/a, averaged over all sites (Fig. 1) and grain sorghum yields increased 14 bu/a (Fig. 2). Again, all Cl sources performed similarly. When soil Cl levels were greater than 6 ppm, yields were unaffected by Cl fertilization.

Crop growing conditions over the course of this work were generally good to excellent, resulting in very little disease pressure. As a result, we were unable to evaluate Cl fertilization/disease relationships. Yield responses observed were likely a nutrient response to Cl.

SUMMARY

Chloride fertilization increased grain yields of corn and sorghum at all sites where soil Cl levels were 6 ppm or less, corroborating earlier work on wheat in Kansas. As a result of our Cl work, our fertilizer recommendations now suggest Cl fertilization for wheat, corn, and grain sorghum if soil Cl levels are 6 ppm or less. Chloride fertilization significantly increased leaf Cl concentrations of both crops regardless of soil Cl levels, though increases were more dramatic at

lower soil Cl levels. Results of this work suggest all Cl sources evaluated were effective in providing Cl.

More work is needed on these crops over a wider range of soils and environments to further evaluate potential need for Cl and to explore Cl nutrition/plant disease relationships. Research is also needed on other crops including legumes and forage grasses.

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Table 1. Chloride fertilization on corn in Kansas.

Cl Rate	Cl Source	98 A Yield	98 A Leaf Cl	98 B Yield	98 B Leaf Cl	99 A Yield	99 A Leaf Cl	99 B Yield	99 B Leaf Cl	00 A Yield	00 A Leaf Cl	00 B Yield	00 B Leaf Cl	01 A Yield	01 A Leaf Cl
lb/a		bu/a	%	bu/a	%	bu/a	%	bu/a	%	bu/a	%	bu/a	%	bu/a	%
0	--	107	.12	133	.29	123	.16	94	.15	87	.19	38	.10	79	.26
20	KCl	108	.28	133	.36	124	.29	106	.18	92	.26	42	.27	82	.40
40	KCl	116	.37	133	.36	129	.40	107	.55	94	.28	47	32	79	.46
20	NaCl	114	.30	133	.37	119	.29	104	.42	95	.29	43	.30	--	--
40	NaCl	112	.39	137	.38	134	.46	108	.59	94	.33	46	.37	--	--
20	$CaCl_2$	--	--	--	--	120	.21	101	.23	90	.27	44	.27	82	.40
40	$CaCl_2$	--	--	--	--	127	.32	96	.32	91	.31	43	.33	81	.45
LSD (0.10)		NS	.06	NS	NS	10	.11	7	.13	6	.03	5	.04	NS	.04
Mean Values:															
Cl	20	111	.29	133	.37	121	.26	104	.27	93	.27	43	.28	81	.40
Rate	40	114	.38	135	.37	130	.39	103	.49	93	.31	45	.34	81	.45
LSD (0.10)		NS	.04	NS	NS	6	.05	NS	.06	NS	.02	NS	.03	NS	.03
Cl	KCl	112	.32	133	.36	127	.34	107	.36	93	.27	45	.30	81	.43
Sources	NaCl	113	.34	135	.38	127	.38	106	.50	95	.31	45	.34	--	--
	$CaCl_2$	--	--	--	--	124	.27	99	.28	91	.29	43	.30	81	.42
LSD (0.10)		NS	NS	NS	NS	NS	.06	5	.07	NS	.02	NS	.03	NS	NS
Soil Test Cl, ppm, (0-24")		7		11		3		2		4		2		17	

Table 2. Chloride fertilization on grain sorghum in Kansas.

Cl Rate	Cl Source	98 A Yield	98 A Leaf Cl	98 B Yield	98 B Leaf Cl	98 C Yield	98 C Leaf Cl	99 A Yield	99 A Leaf Cl	900 A Yield	900 A Leaf Cl	01 A Yield	01 A Leaf Cl	01 B Yield	01 B Leaf Cl
lb/a		bu/a	%	bu/a	%	bu/a	%	bu/a	%	bu/a	%	bu/a	%	bu/a	%
0	--	63	.06	87	.09	125	.17	98	.13	87	.07	92	.15	88	.09
20	KCl	69	.26	107	.21	129	.23	109	.36	100	.19	119	.43	89	.38
40	KCl	72	.38	103	.26	122	.29	111	.51	100	.25	133	.49	96	.50
20	NaCl	74	.30	112	.25	121	.25	106	.36	93	.19	--	--	--	--
40	NaCl	69	.47	109	.33	130	.29	107	.47	91	.27	--	--	--	--
20	$CaCl_2$	--	--	--	--	--	--	109	.38	93	.15	107	.49	95	.45
40	$CaCl_2$	--	--	--	--	--	--	105	.49	98	.22	121	.53	94	.46
LSD (0.10)		7	.06	15	.07	NS	.07	7	.06	11	.02	21	.06	6	.06
Mean Values:															
Cl Rate	20	72	.28	110	.23	125	.24	108	.37	95	.17	113	.46	92	.41
	40	71	.43	106	.30	126	.29	108	.49	96	.25	126	.51	95	.48
LSD (0.10)		NS	.04	NS	.05	NS	.04	NS	.03	NS	.01	NS	.04	NS	.04
Cl Sources	KCl	71	.32	105	.24	126	.26	110	.43	100	.22	125	.46	92	.44
	NaCl	72	.38	110	.29	126	.27	107	.42	93	.23	--	--	--	--
	$CaCl_2$	--	--	--	--	--	--	107	.44	96	.19	114	.51	94	.45
LSD (0.10)		NS	.04	NS	.05	NS	NS	NS	NS	NS	.01	NS	.04	NS	NS
Soil Test Cl, ppm, (0-24”)		2		3		13		2		2		6		4	

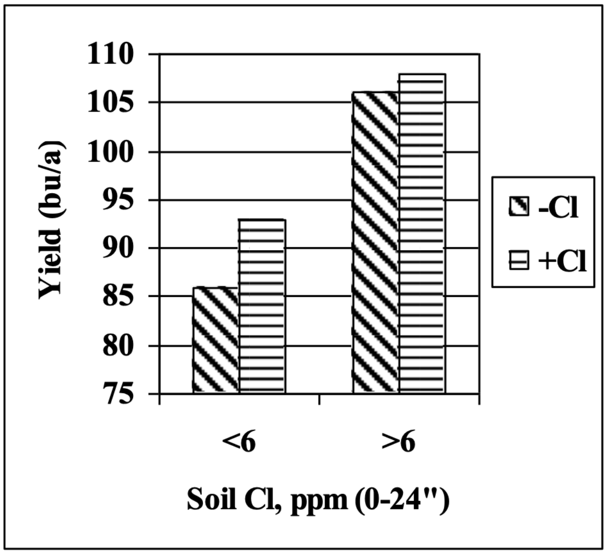

Figure 1. Effects of soil Cl levels and Cl fertilization on corn yield.

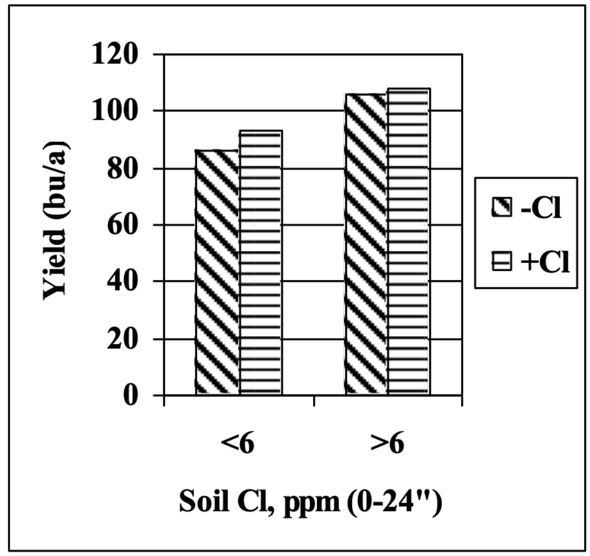

Figure 2. Effects of soil Cl levels and Cl fertilization on grain sorghum yield.

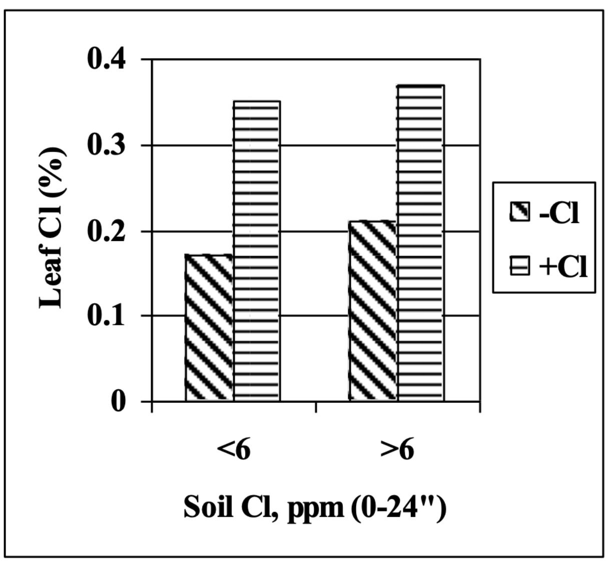

Figure 3. Effects of soil Cl levels and Cl fertilization on corn Cl concentrations.

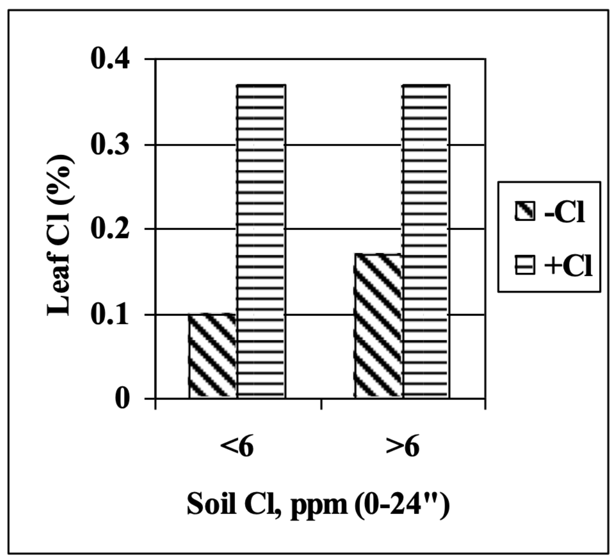

Figure 4. Effects of soil Cl levels and Cl fertilization on grain sorghum Cl concentrations.