Chloride in Kansas: Plant, Soil, and Fertilizer Considerations

Department of Agronomy | MF2570 | Soil Fertility

Chloride (Cl) is one of 16 elements essential for crop growth. Because it is needed in small quantities, chloride is considered a micronutrient. Chloride deficiencies in crops in Kansas and the Great Plains have been identified and confirmed. This publication discusses chloride in terms of plant, soil, and fertilizer considerations.

Plant Considerations

Chloride is taken up by plants as the Cl^- ion. A major function of chloride in plants is as a counter ion for cation (Ca^{+2}, K^+, Mg^{+2}, N_4H^+) transport and as an osmotic solute. As a counter ion, chloride maintains electrical charge balance for the uptake of essential cations. In addition, chloride serves an essential role in maintaining cell hydration and turgor. A critical role of chloride is as a cofactor in the oxidation of water in photosynthesis and as an activator of several enzymes.

Although research in 1954 identified chloride as an essential plant nutrient, little concern existed about supplying this element as part of a complete fertilization program. By the early 1980s, however, research conducted in several states indicated responses to chloride fertilization when soil chloride levels were low. In addition, chloride application has been shown to suppress or reduce the effects of numerous diseases on a variety of crops. The exact mechanism of this effect is not well defined, but it may be related to the role of chloride in osmotic regulation. In wheat, chloride has been shown to suppress take-all root rot, tan spot, stripe rust, leaf rust, and Septoria, while in corn and grain sorghum it suppresses stalk rot.

Physical symptoms of chloride deficiency in plants vary and are not always consistent. In wheat, some varieties show a characteristic leaf spotting, best described as random chlorotic spots on the leaves (Figure 1). The spots resemble tan spot lesions, but are smaller and do not have the characteristic "halo" at the edge of the spot. On low-chloride soils in Kansas, some varieties consistently show the leaf spotting, while other varieties never spot. Other research indicates no obvious visual deficiency symptoms occurred on corn or grain sorghum, even where chloride fertilization increased yields.

Figure 1. *Chloride deficiency symptoms in wheat resemble tan spot lesions; some varieties might not show a visual deficiency symptom.*

Excessive levels of chloride in the soil can result in chloride sensitive crops accumulating excessive amounts of Cl^-, which can be toxic. For example, in the southeastern United States where large amounts of potassium chloride have been applied to supply needed potassium, high soil chloride levels exist. Chloride sensitive soybean varieties show toxicity on these soils. In Kansas, the only situation where chloride toxicity may be a factor is on saline soils. In this case, the major detrimental effect of chloride results from its contribution to osmotic stress caused by excessive salts in the root zone.

Soil Considerations

Chloride is normally present in the soil in sizeable quantities, particularly in U.S. coastal areas where chloride deposition is high. Estimates of chloride levels in soils range from near zero to more than 1,000 pounds per acre. Limited evaluation in Kansas indicates fairly low soil chloride levels. This could be due to low chloride atmospheric deposition due to the distance from oceans and the relatively high indigenous potassium levels of the majority of Kansas soils, which means little potassium chloride (KCl) fertilizer has been applied. Summaries of soil test data in Kansas show a majority of the samples had chloride levels below 40 pounds per acre, with a significant number of samples less than 10 pounds per acre (on 0- to 24-inch samples).

As an anion, a negatively charged ion, chloride is not readily adsorbed on the soils exchange complex and is subsequently not attached. Because of this, chloride moves readily with soil water. Chloride is quite leachable, even more so than nitrate. In fact, leaching of chloride is often used as a tracer for movement of other soluble anions such as nitrate or sulfate. Soil microorganisms do not change the oxidation state of chloride in the soil.

The Kansas State University Soil Testing Laboratory and most commercial labs offer a chloride soil test. Because of the leaching potential of chloride, we recommend sampling to a depth of 24 inches to best assess soil chloride status (just like nitrogen and sulfur). When testing for pH, phosphorus, potassium, organic matter, and zinc, a 0- to 6-inch sample is recommended. When testing for the mobile nutrients (nitrogen, sulphur, or chloride) a 0- to 24- inch sample is recommended.

Fertilizer Considerations

Several potential sources of chloride exist, including commercial fertilizers, atmospheric deposition, and naturally occurring chloride in the soil. The atmospheric deposition of chloride in Kansas and most of the Great Plains region is quite low, and many Kansas soils are low in naturally occurring chloride. Thus, fertilizers become an important chloride source.

Potassium chloride (KCl) is the most common and readily available chloride-containing fertilizer in Kansas. On an elemental basis, potassium chloride fertilizer is 53 percent potassium and 47 percent chloride. For ease of calculating, assume a ratio of roughly 50 to 50 potassium to chloride. For example, if 50 pounds of potassium chloride fertilizer is applied, about 25 pounds of chloride would be furnished. Since phosphorus and potassium in fertilizer are reported on an oxide basis (P_2O_5 and K_2O), it can be confusing because many fertilizer dealers know potassium chloride as 0-0-60 or 0-0-62. For ease of calculating chloride application, just remember the product is about 50 percent chloride.

Other chloride-containing fertilizers include: ammonium chloride (NH_4Cl), calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), and sodium chloride (NaCl). These fertilizers contain 66 percent, 65 percent, 74 percent, and 60 percent chloride, respectively. Calcium chloride, ammonium chloride, and magnesium chloride are sometimes available as liquid fertilizer. Research in Kansas has evaluated all of these sources of chloride. Results show each of these fertilizers to be equally effective in supplying chloride.

Chloride Research in Kansas

Considerable research with chloride fertilization has been conducted in Kansas on wheat, corn, and grain sorghum. Positive yield responses have been noted on these crops. To date, response to chloride fertilization on other crops such as soybean has been limited.

Wheat

Early work clearly showed that chloride fertilization not only increased wheat yields on low-chloride soils, but also suppressed the progression of leaf rust. Research has also clearly shown differences exist among wheat varieties in terms of responsiveness to chloride fertilization. For example, field trials conducted at multiple locations showed that, when applying 20 pounds of chloride to some varieties, yields increased more than 10 bushels (Figure 2). However, some varieties in the same field can show limited response to chloride fertilization. These results suggest that wheat yield response to chloride is influenced not only by soil chloride availability, but also by possible environmental conditions and disease pressure affecting wheat varieties. Multiple years of chloride research on wheat in Kansas showed proximately 7 to 10 percent yield increase on low chloride soils (Figure 3). Also, the relationship between yield response and the available chloride level suggest that yield response is typically expected with values below 45 pounds chloride per acre (Figure 3).

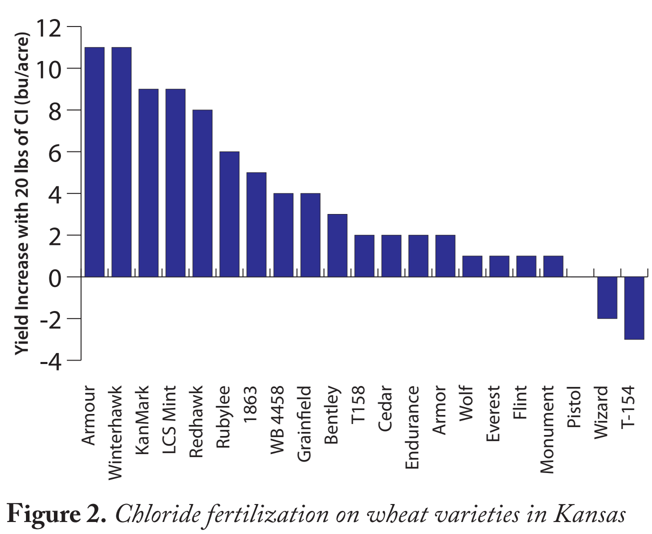

Figure 2. *Chloride fertilization on wheat varieties in Kansas (2015-2017).*

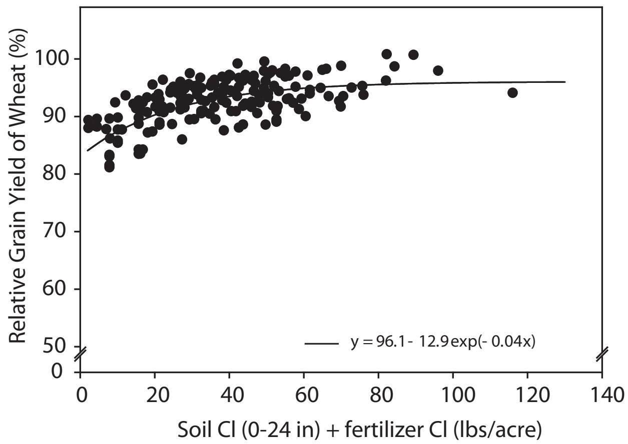

Figure 3. *Wheat response to soil and fertilizer chloride in Kansas.*

Corn and Grain Sorghum

Figures 4 and 5 provide summaries of several site-years of chloride research on corn and grain sorghum. Overall, results are similar to wheat results. All sites with low soil chloride levels (less than 25 to 30 pounds chloride per acre) responded to chloride application. As with wheat, leaf tissue chloride concentrations of the check (no chloride added) treatments at responsive sites were generally 0.15 percent or lower. Chloride fertilization significantly increased leaf tissue chloride concentrations.

Over many years of work on chloride fertilization, several chloride rates and sources were evaluated. In most cases, application of 10 to 20 pounds chloride per acre was sufficient to achieve optimum response. Ammonium chloride, magnesium chloride, calcium chloride, potassium chloride, and even sodium chloride as sources were evaluated. All chloride sources performed equally. Potassium chloride is the most readily available source. When potassium chloride is used as a chloride source, there is the possibility that the potassium could be the cause of any response. This research was conducted on sites with high soil potassium levels and potassium concentrations in leaf tissue samples were measured.

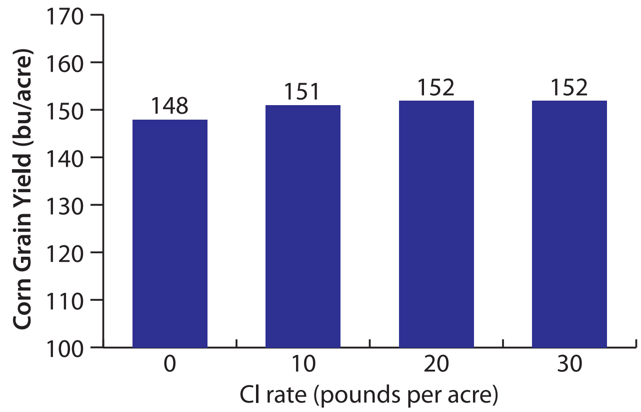

Figure 4. *Chloride fertilization on corn in Kansas.*

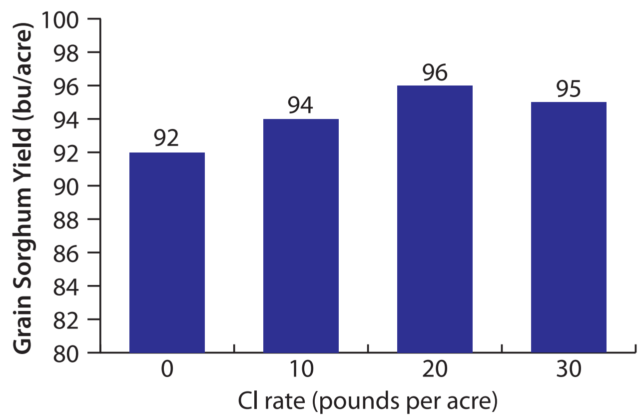

Figure 5. *Chloride fertilization on grain sorghum in Kansas.*

Chloride Soil Test Interpretation and Fertilizer Recommendations

Research indicates the likelihood of a response to chloride fertilizer is directly related to soil chloride levels. Chloride levels in Kansas soils vary, but levels below 25 pounds per acre are not uncommon, particularly where potassium chloride fertilizer is not normally used. Since most central and western Kansas soils are high in potassium, use of potassium chloride fertilizer has been limited, and low soil-chloride levels are often found. In eastern Kansas, however, where potassium chloride is routinely applied, low soil-chloride levels are not widespread. On soils low in chloride, optimum yields of crops may require addition of chloride

Table 1. *Soil test chloride interpretation and fertilizer recommendation.*

	Soil Chloride*		Chloride Recommended
Category	**pounds per acre**	**ppm**	**pounds per acre**
Low	< 30	< 4	20
Medium	30-45	4-6	10
High	> 45	> 6	0

**Interpretations valid for 0–24 inch samples on wheat, corn, and grain sorghum.*

fertilizer. The information in Table 1 summarizes our interpretation of soil test chloride information.

Plant tissue analysis also has proven valuable in assessing a potential need for chloride. Research shows that whenever leaf chloride concentrations are in the 0.10 to 0.12 percent range or less, this is a good indicator of low soil chloride levels. Again, research has been limited to wheat, corn, and grain sorghum. Research with wheat used leaf samples taken at boot stage, while corn and grain sorghum leaf samples were taken at the 6- to 8-leaf stage.

When soil tests indicate a need for chloride, the recommendation is to apply 10 to 20 pounds of actual chloride per acre, depending on soil test chloride level. For example, if potassium chloride is being used, application of 30 pounds per acre of potassium chloride would supply about 15 pounds per acre of actual chloride. Research shows equal performance of chloride applied either preplant or topdress (November through early March) for wheat. On corn and grain sorghum, preplant or planting time applications are preferred. With the good solubility of all chloride fertilizers, surface broadcast applications work well with sufficient rainfall or irrigation after application.

Remember, response at any given soil chloride level in a specific year may vary with several factors, including variety, disease pressure, timing of moisture or temperature stress relative to the effect of chloride on plant development, and soil chloride distribution relative to crop root distribution.

Summary

Chloride, an often-overlooked nutrient, is essential for plant growth. Deficiencies of this nutrient have been verified in Kansas. Chloride is essential for photosynthesis and serves other critical roles in plants. Plants take up chloride as the Cl^- ion. This ion is very mobile in the soil and is subject to leaching.

Soil testing and plant analyses have proven useful in identifying potential deficiencies of chloride. Recent Kansas research has verified a need for chloride fertilization on some soils. Chloride recommendations are based on soil test chloride levels. If supplemental chloride is needed, several sources of soluble chloride fertilizers are available and agronomically effective.

Dorivar A. Ruiz Diaz

Soil Fertility and Nutrient Management Specialist

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