OKLAHOMA

Sulfur and Chloride Response in Oklahoma Winter Wheat

By J.M. LaRuffa, G.V. Johnson, S.B. Phillips, and W.R. Raun

In the fall of 1995, three locations were identified in Oklahoma for annual evaluation of wheat response to S and Cl. The Carrier location is a silt loam and the Hennessey location is a sandy loam, both typical of the environment for wheat production in the large north central Oklahoma region. The Perkins location is on a deep, sandy, low organic matter soil, subject to leaching of mobile nutrients such as Cl and S.

At each location 0, 50, 100, and 200 lb S/A were applied preplant as gypsum ($CaSO_4 \cdot 2H_2O$, 17 percent S). The Cl trials were similar except 0, 30, and 60 lb Cl/A were applied preplant as calcium chloride ($CaCl_2$, 60.7 percent Cl) and only grain was harvested. Nitrogen (N), phosphorus (P), and potassium (K) were adequate, or supplied, except at the Perkins location where N inadvertantly was not applied and, thus, became yield-limiting.

Plot size for all trials was 16 by 20 ft. In 1995-96 only grain was harvested because extremely dry weather did not support significant fall and winter forage. Both grain and forage were harvested in 1996-97 from the S experiment. Grain production for 1996-97 was hurt by late freezing (April 13-15), but helped by excellent grain filling conditions.

Sulfur (S) and chloride (Cl) are two essential plant nutrients, occasionally found to be deficient in winter wheat. These nutrients have received considerable attention in various parts of the U.S. in the past 20 to 30 years. Sulfur functions in plants as an important element in three amino acids and is thus critical to the normal development of proteins in plants. Chloride is believed to be essential in plant regulation of water. Both are absorbed in chemical forms that are mobile in soils; that is, they move with water. Consequently, deficiencies of S and Cl should be expected when high yields are produced in deep, sandy soils that are low in soil organic matter.

In the fall of 1995, surface soil samples, 0 to 6 inch depth, were taken at each location. Soil Cl in the upper 6 inches ranged from about 25 to 40 lb/A, and S ranged from 23 to 37 lb/A. Subsurface soil samples, 6 to 24 inch depth, were not taken in 1995. Therefore, the initial amounts of S and Cl present in the upper 2 ft. of the soil profile cannot be accurately determined. Soil samples to 2 ft. were taken after harvest in 1997 for S and Cl at all three locations. Although the soil test data may not reflect a response to S or Cl since the samples are taken post-harvest, the data are indicative of the range of nutrient levels found and present for the next production year. Values for these samples ranged from 46 to 219 lb S/A and 70 to 102 lb Cl/A in the upper 2 ft. of soil.

1995-96 Yields

Grain yields were exceptionally good at Carrier and Hennessey, in spite of the relatively dry year. Nevertheless, there was no significant response to Cl at these two locations (**Table 1**). The yield response to Cl at Perkins was statistically significant and was likely a result of the sandy location that allowed Cl to be leached out the previous year (above average rainfall) and drought stress in the 1995-96 season. There were no significant responses to S applications at any of the three locations in 1995-96 (**Table 1**).

1996-97 Yields

Wheat grain response to Cl in 1996-97 (**Table 2**) was similar to that for 1995-96. Yields were relatively high at Carrier and Hennessey, and there was no significant response to Cl, although the Hennessey location showed an 8.8 bu/A response to 60 lb Cl/A. At Perkins, yields were extremely poor, but there was a small and significant response to the 60 lb Cl/A rate.

Wheat grain yields responded significantly to the addition of 200 lb S/A applied as $CaSO_4{\bullet}2H_2O$ at Hennessey where the yield was 8.2 bu above the no-S control (**Table 2**). At Carrier, where yields averaged 60 bu/A, there was no response to S. Similarly, there was no grain response to S at Perkins, although yields were much lower.

TABLE 1. Wheat response to Cl and S at three locations in 1995-96.

Cl rate, lb/A	Carrier	Hennessey	Perkins
	....	yield, bu/A	....
0	42.1	42.9	19.0
30	41.5	41.6	20.7
60	43.5	41.9	25.0*
S rate, lb/A	**Carrier**	**Hennessey**	**Perkins**
	....	yield, bu/A	....
0	44.8	41.0	23.2
50	44.7	41.0	22.9
100	41.7	40.7	25.8
200	43.6	41.0	21.3

*Significant at the 0.05 probability level.

TABLE 2. Wheat response to Cl and S at three locations in 1996-97.

Cl rate, lb/A	Carrier	Hennessey	Perkins
	....	yield, bu/A	....
0	54.0	30.7	9.4
30	55.0	32.2	9.8
60	55.3	39.5	12.4*
S rate, lb/A	**Carrier**	**Hennessey**	**Perkins**
	....	yield, bu/A	....
0	60.4	37.5	15.8
50	60.2	38.6	16.0
100	57.0	35.4	19.2
200	61.4	45.7*	16.3

*Significant at the 0.05 probability level.

Total forage production from fall (Feekes 4) and winter (Feekes 10) harvests showed no response to S at either Carrier or Hennessey. At Perkins there was a significant response to 100 lb S/A, but not to 50 lb or 200 lb S/A. This is unusual, since $CaSO_4{\bullet}2H_2O$ is non-toxic, and one would expect that if the 100 lb rate caused a positive response, so would the 200 lb rate.

Twelve site-years of examining wheat grain response to Cl and S have resulted in three significant positive responses. Two have been to the application of Cl at the Perkins site, where no N was applied and yield levels were relatively poor (11 to 22 bu/A). A significant grain response to S was found at the Hennessey site, but only at the 200 lb S/A rate in 1996-97. In the same production year, forage yields were abnormally high, but there were no significant responses to applied S at this site. The only significant forage response to S came at the Perkins site at the 100 lb S/A rate.

Sulfur deficiencies in Oklahoma are rare since rainfall annually adds approximately 6 lb S/A to the soil. Further, if there is an N requirement of 80 lb/A, the S requirement is only 4 lb/A. Considering the post-harvest soil samples had from 46 to 219 lb S/A (0 to 24 inch depth) at the various locations, it is not surprising that there were few yield responses to the addition of $CaSO_4{\bullet}2H_2O$ since a significant amount of S has accumulated in the upper 2 ft. of the soil profile.

Research in South Dakota led to the designation of 60 lb Cl/A as the amount necessary in the surface 2 ft. of the soil profile for optimum yields in spring wheat. In addition, Kansas research has shown that winter wheat response to Cl is very likely when soil Cl is less than 20 lb/A in the surface 2 feet. The initial soil test data indicated Cl contents of 21 to 51 lb Cl/A in the surface 6 inches alone. Analysis of the soil samples taken post-harvest indicated 70 to 102 lb Cl/A in the surface 2 ft. at the various locations.

Small grain responses to fertilizers containing Cl have been found in the Great Plains. This is often the result of disease suppression rather than correction of an actual nutrient deficiency in the plant. Inconsistencies in the response of wheat grain and forage to the application of Cl and S fertilizers point to the need for additional research. Of particular interest in this study was the recurring response to Cl in an environment deficient in N at the Perkins location. BC

The authors are researchers at Oklahoma State University, Stillwater.

Good Sources of Potassium Abound in Foods

Looking for healthy sources of potassium (K) in your diet? Check out foods such as bananas, orange juice, and potatoes.

According to the U.S. Department of Agriculture's Nutrient Database, one medium-sized banana contains 467 milligrams (mg) of K. One cup of orange juice (frozen concentrate, diluted) has 473 mg. Either will help you toward the recommended minimum of 2,000 mg of K a day.

By the way, that 2,000 figure really is a "minimum." Some guidelines recommend as much as 3,500 mg a day – that's what's used as the "Daily Value" reference when K content is listed on food labels.

Either way, most people get plenty of K because it's in such a variety of foods: a cup of baked acorn squash contains 895 mg of K; a 7-ounce baked potato contains 844 mg; a cup of baked beans, 752 mg; a cup of boiled zucchini, 455 mg; a 6-ounce can of tuna, 407 mg; a large fast-food hamburger, 394 mg; a 1.5-ounce box of raisins, 323 mg; a medium-sized tomato, 273 mg. Even an 8-ounce cup of coffee isn't a bad source of K, with 128 mg.

It's good that K is so prevalent in the diet. It works within cells to help muscles contract, help nerves send messages, and generally help cells do what they're supposed to do. It also works with other minerals – sodium (Na), calcium (Ca), and magnesium (Mg) – to help the body maintain a proper balance of fluid, which promotes normal blood pressure and heartbeat. It does that in a variety of ways. If your body gets bloated, K is the hero that sends excess fluid to the bladder. Reducing the body's fluid levels leads to a reduction in actual blood volume. That, in turn, decreases blood pressure. With the fluid goes excess Na, which, in some people, is linked with high blood pressure.

Also, some high blood pressure medications may cause K levels to dip, so people taking them are also given a K supplement and encouraged to eat K-rich foods. Luckily, those foods aren't hard to find. BC

Source: Ohio State University and USDA.