Unit 3: Understanding Secondary Nutrients in Soils

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Objectives

- Understand the need for secondary nutrients for crop production in southwestern Minnesota.
- Understand the importance and use of soil tests for predicting secondary nutrient needs in southwestern Minnesota.

SECONDARY NUTRIENTS AND THEIR IMPORTANCE

Calcium (Ca), magnesium (Mg), and sulfur (S) historically have been classified as secondary nutrients. They are just as important as all other nutrients needed for plant growth; however, plant requirements for these nutrients are lower than those for nitrogen (N) and potassium (K) (Table 1). This lower requirement has resulted in the use of the word "secondary."

Table 1. Nutrients removed by several crops.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Per-Acre Yield</th>
<th>Nutrient</th>
<th>Nutrient</th>
<th>Nutrient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>phosphate</td>
<td>potash</td>
</tr>
<tr>
<td>corn</td>
<td>150 lb/A</td>
<td>235</td>
<td>90</td>
<td>185</td>
</tr>
<tr>
<td>corn</td>
<td>grain only</td>
<td>135</td>
<td>53</td>
<td>40</td>
</tr>
<tr>
<td>soybeans</td>
<td>40 lb/A</td>
<td>150*</td>
<td>35</td>
<td>55</td>
</tr>
<tr>
<td>wheat</td>
<td>60 lb/A</td>
<td>105</td>
<td>44</td>
<td>74</td>
</tr>
<tr>
<td>alfalfa</td>
<td>6 ton</td>
<td>270*</td>
<td>60</td>
<td>270</td>
</tr>
</tbody>
</table>

*Nitrogen used by these crops is supplied from both soil and air.

Calcium helps maintain the structure of cell walls. Without adequate Ca, plants would not remain rigid and would lodge easily.

Magnesium, an important component of chlorophyll, is actively involved in the food manufacturing process that occurs in all plants. In most crops, if Mg is deficient the lower leaves start to turn yellow while new leaves remain green. With corn, there is a striping for the entire length of the leaf. Mg deficiency is rare in southwestern Minnesota.

Sulfur, like N, is an important component of some amino acids, the building blocks of the proteins needed in plant growth. In contrast to N, relatively small amounts of S are needed for crop production.

THE SECONDARY NUTRIENTS IN THE SOIL

Calcium

Calcium is found in the film of water that surrounds soil particles and is associated with the negative charges on the surface of clay particles and soil organic matter. The amount of Ca in soils increases as the pH increases. Since relatively little Ca is used by growing crops, most agricultural soils are well-supplied with this nutrient even if they are very acid. Large quantities of Ca are naturally present in soils in southwestern Minnesota, so no Ca will be needed in a fertilizer program.

Magnesium

Magnesium, like Ca, is found in the water film and is associated with clay particles and soil organic matter. Magnesium is used in relatively small amounts for crop production. In general, soils in southwestern Minnesota have naturally high levels of Mg. These high Mg levels are the result of the soil-forming processes that have taken place for many years in this region. If agricultural limestone is needed and used, adequate amounts of Mg are supplied.

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in the dolomitic lime. Therefore, there should be no need to add Mg to a fertilizer program in southwestern Minnesota.

**Ca/Mg and Mg/K Ratios**

Some agricultural advisers believe there are "ideal" ratios of Ca/Mg, Mg/K, and Ca/K in soils and that these ratios provide an indication of the balance of nutrients in soils. For example, there are some who attempt to convince farmers that the amount of Mg applied in dolomitic limestone can be harmful for crop production. Research, however, has shown that use of relatively high rates of Mg as in a dolomitic limestone program has no harmful effect on crop yield.

The Ca/Mg, Mg/K, and Ca/K ratios are simply statements of the relative proportions of Ca, Mg, and K. Ratios do not give any information about the actual levels of these nutrients in soils. For example, the Ca/Mg ratio may be ideal for some very sandy soils, yet the actual amount of Mg may be too low for good crop growth. In this case, the Ca/Mg ratio concept would give the wrong information.

The idea that soils had an ideal Ca/Mg ratio originated from studies conducted in New Jersey in the 1940s that suggested an ideal ratio of 6.5 to 1.0. The ideal Mg/K ratio was thought to be 2.0 to 1.0. Recent research in several states, however, has shown that these ratios can be altered over a wide range without harming yield. This research has clearly shown that fertilizer recommendations should be based on the absolute amount of these nutrients in the soil rather than on the ratio of one nutrient to another. Thus, growers should ignore any suggestions that their soil has a less-than-ideal Ca/Mg, Mg/K, or Ca/K ratio or that nutrients are out of balance.

**Sulfur**

Sulfur, like N, exists in the soil in several forms and is easily transformed from one form to another. Approximately 90 to 95 percent of soil S is in the organic matter.

Plants absorb S in the sulfate (SO₄) form. There are several sources of sulfate sulfur (SO₄-S) for crop production. The soil organic matter is the primary source. Before the S in the organic matter can be used by crops, it must be converted to SO₄-S by a process called mineralization. The amount of SO₄-S that becomes available through mineralization varies with soil texture, the percentage of organic matter, soil temperature, and soil aeration. In general, more SO₄-S becomes available from mineralization in fine-textured soils than in sandy soils. Research trials in southwestern Minnesota have demonstrated that non-sandy soils in the region produce enough SO₄-S each year by mineralization to meet the crop requirements for S. Consequently, no S is needed in a fertilizer program.

Rainfall also contributes small amounts of S to the soil system. Relatively small amounts of S, however, are supplied by this source unless there is a lot of industry in the immediate area. Consequently, only small amounts of S will be supplied by rainfall in southwestern Minnesota.

Small amounts of S also can be supplied to the soil by some herbicides and rootworm insecticides. The amount of S supplied by these sources, however, is usually very small.

In the past, certain fertilizers such as concentrated superphosphate (0-20-0) that were used to supply other nutrients contained substantial amounts of S. As these fertilizers have been replaced by higher analysis materials, the amount of S supplied by this means has dropped substantially.

Because the S content of modern fertilizers is very low, the amount of S coming from rainfall is substantially less than in the past, and crop yields continue to rise, there are some who believe that the need for S in a fertilizer program will extend to more geographical areas in future years. Current recommendations in Minnesota are to include S in a fertilizer program where crops are grown on sandy soils that have a low organic matter content. Very few areas of these sandy soils are found in southwestern Minnesota.

Studies are now underway to evaluate the effect of S in a fertilizer program on the yield and quality of corn and alfalfa grown in southeastern Minnesota. To date alfalfa, which uses the most S, has not responded to the fertilizer S and the quality of the alfalfa hay has not been affected.

Fertilizer S did increase the yield of corn at one location. A broadcast rate for S of 10 lb/acre was satisfactory for maximum production. Three conditions probably contributed to the response to S at the site. The soil had a low organic matter content (less than 2 percent), the yield was high (about 190 bushels per acre), and rainfall was above normal. The results from this one site do not mean that S is needed for corn production on all of the soils in southeastern or southwestern Minnesota. On the contrary, fertilizer S is probably needed on very few.

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