Sulfur for Montana Forage Crops

Summary: Sulfur deficiency may be limiting Montana forage crop yields and protein.

09/30/2011 Contact: Clain Jones (406) 994-6076 or clainj@montana.edu

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BOZEMAN – Until recently, sulfur did not often limit crop growth in most Montana soils. However, modern NPK fertilizers contain less sulfur as a manufacturing by-product. Also, higher yielding varieties and more intense cropping are leading to removal of more sulfur from fields, increasing the chance for sulfur deficiencies.

Sulfur deficiency may be confused with nitrogen deficiency. Sulfur deficient plants are often stunted with yellowing upper leaves, in contrast to yellowing lower leaves, which are an indication of nitrogen deficiency.

"Unfortunately, soil tests for sulfate-sulfur are not a reliable indicator of plant available sulfur," said Clain Jones, Extension Soil Fertility specialist in the Department of Land Resources and Environmental Sciences at Montana State University. He suggests instead that plant sulfur status be determined through tissue sampling. The uppermost leaves of grasses before heading should contain 0.20 to 0.25 percent sulfur, while the top 6 inches of growth in alfalfa during early bud stage should contain 0.22 to 0.25 percent sulfur. Since adequate sulfur and nitrogen are both needed to make protein, the nitrogen to sulfur ratio is also a potential indicator of plant sulfur status. Grasses may be sulfur deficient at a nitrogen to sulfur ratio greater than about 15:1, while alfalfa is sulfur deficient at a nitrogen to sulfur ratio above 17:1. However, a good nitrogen to sulfur ratio can be misleading if both are deficient.

Sulfur is released from soil organic matter or gypsum (calcium sulfate) at a rate of 4 to 13 pounds of soluble sulfur per acre per year.

"Deficiency is found more on soils with low organic matter, on side-slope positions, and in coarse textured and eroded soils," said Jones. He added that sulfur deficiency tends to occur in cool, dry environments, and is more common on irrigated coarse soils because of sulfate leaching. Practices that maintain or increase soil organic matter, such as reduced tillage, or the addition of manure, can help supply a relatively constant amount of available sulfur.

If producers suspect sulfur deficiency, they may do a strip trial with readily available sulfur such as ammonium sulfate early next year. If they observe a color or height difference compared to an equal strip that only differs by lacking the sulfur addition, a rescue treatment can be applied to the whole field.

Jones suggested that if field response trials or plant tissue analysis indicate deficiency, 20 to 30 pounds sulfur per acre can be applied to increase alfalfa and grass yields. Studies in Iowa found alfalfa yield increases in response to gypsum applied after the first cutting varied by site. The harvest increase ranged from 0.3 ton per acre with 12 pounds sulfur per acre to 2 tons per acre with 29 pounds sulfur per acre. Studies by Dave Wichman, superintendent and agronomist at the Central Agricultural Research Center at Moccasin, found 25 pounds sulfur per acre increased forage yield of dryland alfalfa and alfalfa/grass by 30 percent at one site, but there was no yield increase at two other sites.

Sulfur may not only increase yields but also influences forage protein.

"Because efficient nitrogen conversion into protein requires sufficient sulfur, increased sulfur can lead to increased forage protein content and digestibility and reduced forage nitrate concentrations," said Jones. Wichman's studies in central Montana found 25 pounds of sulfur per acre on dryland alfalfa and alfalfa/grass mix increased forage protein an average of 0.8 percentage points. Haybet barley grown in western Montana showed no forage yield increase with sulfur, but a decrease in forage nitrate at high N levels. Haybet fertilized with 120 pounds nitrogen per acre contained 0.52 percent nitrate. The addition of 20 pounds sulfur per acre lowered the nitrate levels to 0.41 percent. This is within the range of 0.15 to 0.50 percent nitrate considered generally acceptable for non-pregnant livestock or fed 50/50 diluted with low nitrate hay to pregnant livestock. Producers are encouraged to keep records of tissue analysis and protein and/or yield response to strips of sulfur applied to develop their own sulfur management program.

In-season applications of readily available sulfur, such as ammonium thiosulfate and ammonium sulfate, can rapidly correct sulfur deficiency. Sulfate fertilizers are not suggested for fall application because they can be lost to overwinter leaching. Elemental sulfur has the highest sulfur content of sulfur fertilizers (90 to 100 percent); however, it is slow to supply plant available sulfur. Therefore Jones suggests it be applied in the fall or before seeding to give time for some of the sulfur to become available before peak demands. Because of the slow release, elemental sulfur will supply crop needs for over 2 to 3 years.

Annual tissue samples can help track the sulfur status of the field. Or, Wichman encourages producers to place a tarp over a patch of perennial forage before spreading fertilizer to create a check patch without fertilizer. Remove the tarp, along with any fertilizer collected on top after fertilization. This check patch allows the producer to see the effect of the fertilizer, and when the check spot is no longer visible it is time to apply more fertilizer.

"If there is adequate sulfur in the soil, levels can be maintained with applications every few years to replace that removed by the harvest," said Jones. Alfalfa and grass hay remove 5 and 2 pounds sulfur per ton respectively. If the forage is grazed, rather than removed as hay, then less sulfur is removed from the field because livestock release most of the ingested sulfur back to the soil. The slow release of elemental sulfur may be desirable on forage crops to reduce the risk of excess sulfur in the forage. While forage plants are sulfur deficient at tissue levels below 0.20 to 0.22 percent, it is possible to cause feeding problems (mineral interactions of sulfate with copper and zinc in the animal) with forage sulfur levels greater than 0.30 percent, cautioned Dennis Cash, Extension forage specialist in the Department of Animal and Range Sciences at Montana State University. If readily available sulfur is used, then Cash suggests the application be split.

Sulfur can be lost to leaching and volatilization. Generally these are small losses, however, irrigated systems or years of heavy rains can cause sulfur leaching beyond the depth of early root growth. Yet, “as roots grow deeper they may access this sulfur or sulfur from dissolved gypsum found in many Montana subsoils,” noted Jones. Careful water management under irrigation can help minimize sulfur loss to leaching or toxic sulfur accumulation on the surface. Burning dry grass can cause a 75 percent loss of total vegetative sulfur to the atmosphere and make sulfur more susceptible to leaching. The bottom line is that sulfur should not be ignored and including sulfur in your soil fertility program can benefit yield, quality, and economics.

For more information on forage response to sulfur see Fertilizer Fact 27 (http://landresources.montana.edu/FertilizerFacts/) or call (406) 994-6033 for a printed copy. For more information on sulfur cycling and management see the publication "Nutrient Management Module No. 6" (http://landresources.montana.edu/nm/) or contact Extension Publications at (406) 994-3273 or http://www.msuextension.org/store/ to order a printed copy. Contact your local MSU Extension agent (http://www.msuextension.org/localoffices.cfm) or crop adviser for help with specific fertilizer decisions.