Sulfur, The Fourth Major Plant Nutrient

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WE NORMALLY CONSIDER nitrogen, phosphorus, and potassium as the three major plant nutrients, and they are always listed in that order on the fertilizer bag. Recent research indicates that sulfur should be given a priority rating equal to or greater than phosphorus. Many areas of North America are deficient in sulfur, while some areas have adequate amounts supplied through water or from atmospheric fallout as air pollutants.

The amounts of indirect sources of sulfur available to turfgrasses have declined. Restrictions on the burning of high-sulfur coals and other fossil fuels and the high degree of refinement of fertilizers have practically eliminated sulfur as a contaminant and, thereby, reduced its availability to plants. Without the addition of adequate levels, the plant must take its sulfur from residual levels in the soil, which is mineralized for the most part from organic materials. A constant lowering of the level of sulfur through removing clippings can cause stress in plants, particularly if growth is stimulated with moderate to high levels of nitrogen.

Sulfur is required in plant tissue for the formation of the vitamins thiamine and biotin and the essential amino acid cystine, which is a component of plant proteins. Sulfur deficiency in plants quite often resembles nitrogen deficiency. Amino acids and other nitrogen compounds may accumulate in tissue of sulfur-deficient plants, probably because protein synthesis is not maintained at a rate comparable to that in plants receiving adequate sulfur.

Turfgrasses may not exhibit recognizable sulfur deficiency until tissue levels fall below 0.2 percent. Turfgrasses receiving an adequate level of all nutrients may show wide ranges of tissue levels of the individual nutrients, depending upon genus, species, and possibly grass variety being grown. Reports concerning adequacy of tissue sulfur range from 0.2 percent to over 0.5 percent. There is documentation that shows adequacy for phosphorus ranging from 0.13 percent to as high as 0.55 percent in tissue. This would lead us to believe then that sulfur is as much a major plant nutrient as phosphorus. This has been verified through several years of research at Washington State University's Western Washington Research and Extension Center, at Puyallup, Washington, where tissue sulfur levels ranged from a low of 0.23 percent (average of 0.28 percent) with no sulfur fertilization, and a high of 0.5 percent (average of 0.44 percent) with high sulfur fertilization. We have concluded that minimal sulfur tissue levels for Astoria colonial bentgrass maintained as putting green turf should not fall below 0.3 percent. These highest sulfur levels were obtained in the tissue from applications of 3.5 pounds per 1,000 square feet of elemental wettable sulfur per year.

BENTGRASS fertilized with 6, 12, and 20 pounds of nitrogen and 1.15 pounds of sulfur per 1,000 square feet per year showed significantly better color than plots receiving no sulfur. It is important to point out that no significant improvement of color occurred at the low nitrogen level with any rate of sulfur, indicating the plants were under no stress for nitrogen or sulfur. Yield of clippings was significantly less at the low nitrogen level. Plots receiving 12 pounds of nitrogen per 1,000 square feet per year exhibited no color difference between the low and high rates of sulfur, but they had significantly better color than those receiving no sulfur. Plots receiving 20 pounds of nitrogen per 1,000 square feet had significantly better color at the highest sulfur level than low or no sulfur.

As much as 30 percent of the plot area was infected by Fusarium patch disease at the higher nitrogen levels where no sulfur was applied. Disease was reduced to an average of 15 percent with applications of 1.15 pounds of sulfur per 1,000 square feet. Disease was further reduced to less than 5 percent with applications of 2.3 pounds of sulfur per 1,000 square feet per year, and no disease occurred in any plot when sulfur was applied at 4.6 pounds per 1,000 square feet per year. Phosphorus and potassium applications reduced disease slightly, but not to a significant degree.

Annual bluegrass was reduced from 60 percent to less than 5 percent with applications of 3.5 pounds of sulfur per 1,000 square feet per year over a seven-year period. Annual bluegrass decline was noted at the end of the third year of sulfur application, and it continued to decline until the test ended.

Phosphorus applications significantly increased annual bluegrass populations at all levels of nitrogen. The highest sulfur levels reduced *Poa annua* populations to less than 20 percent with all nitrogen levels when phosphorus was high. This conclusively proves that higher soil levels of available phosphorus will stimulate annual bluegrass encroachment unless it is suppressed in some other manner.

These tests were conducted on a fine sandy loam with an original pH of 5.7 containing moderately high calcium levels. No lime was applied throughout the test period and pH values dropped as low as 4.0 with a combination of the highest levels of nitrogen and sulfur. It was interesting to note that all high nitrogen plots without sulfur had the same pH with or without applied sulfur.

Sulfur tests conducted on washed sand-based putting green turf did not prevent annual bluegrass from spreading, although plots with highest sulfur levels had significantly less annual bluegrass. This would tend to indicate some other factors are involved. Further investigations are being conducted.

WITH LOWER nitrogen applications the objective of most golf superintendents today, sulfur applications at any level probably will not enhance color unless sulfur is very deficient. In general, one pound of sulfur per 1,000 square feet per year is adequate for nutrition. The advantage of higher levels of sulfur appears to be in its effects on reducing certain turfgrass diseases and suppressing annual bluegrass. Elimination of algae and suppressed earthworm activity were also noted.

On this yellow Astoria colonial bentgrass plot, nitrogen levels were "high" but sulfur levels were at "0."

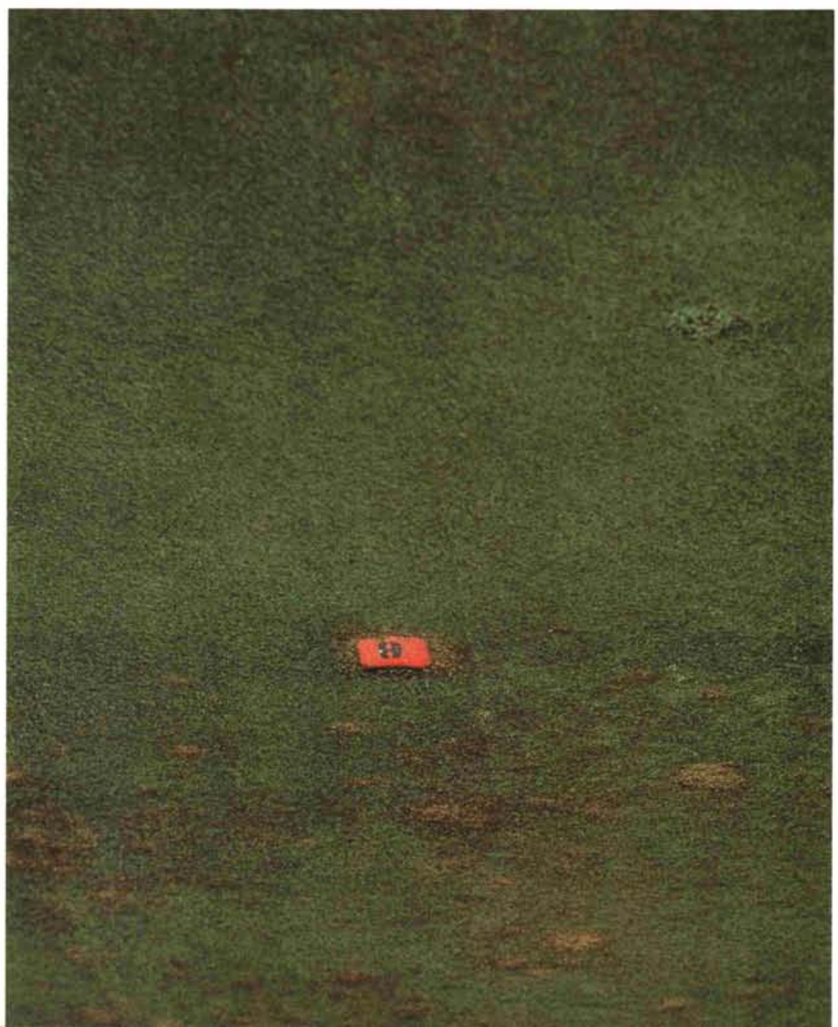
Reduced annual bluegrass seed heads on the "high" sulfur plot but excessive on the "low" plot.

It is advisable that sulfur applications to putting greens be made in one-half pound per 1,000 square feet increments or less, and these applications should be confined to the cooler periods of the growing season when there is soil bacterial activity. Sulfur applications during midsummer should be reduced to avoid the possibility of adverse effects.

Continuous applications of ammonium sulfate will produce essentially the same effects, provided that nitrogen applications are six pounds per 1,000 square feet or higher. It is doubtful that these effects can be achieved from this source of nitrogen at lighter rates.

Golf course superintendents dealing with soil pH values of 7.0 or more may apply higher levels of sulfur, but they should seek advice from turfgrass specialists in their areas or accredited soil testing laboratories.

Several golf course superintendents in the Pacific Northwest who have diligently applied sulfur for several years report significantly less Fusarium patch disease and large savings in fungicide treatments.



(Top, right) Minimal Fusarium Patch appears on the ammonium sulfate plot while excessive on the urea plot.

(Right) No disease on the "high" sulfur plot while there is much disease on the "low" sulfur plot.