Sulfur May Not Reduce pH on Some Greens

By Jack Fry, Steve Keeley and Joon Lee

Some golf course putting greens in the United States are constructed using calcareous sands, which by definition are inherently high in calcitic limestone.

Many of these sands arose from coral or are composed of quartz sand in which seashell fragments have been mixed (Carrow et al., 2001). It is not unusual for the pH to be greater than 8 in these growing media.

Sulfur is an essential plant nutrient, with tissue levels of approximately .2 percent thought to be reflective of adequate sulfur nutrition (Goss, 1974). However, superintendents are more likely to apply sulfur in an attempt to reduce soil pH.

We applied 40 pounds sulfur per 1,000 square feet over two years and observed no significant decrease in pH.

As sulfur is oxidized, hydrogen ions are released that can acidify the soil (Carrow et al., 2001). This pH reduction then makes other nutrients, such as iron, more available. On calcareous sands, reducing pH can be an arduous, if not impossible, task because the high lime content acts to buffer any pH effect that sulfur may have (Christians, 1998).

Standard recommendations for reducing sandy soil pH from 8 to 6.5 suggest that up to 25 pounds of sulfur may be required per 1,000 square feet, depending upon calcitic limestone content (Carrow et al., 2001).

To avoid injury on established creeping bentgrass putting greens, however, some experts recommend that no more than 2.5 pounds per 1,000 square feet of elemental sulfur be applied (Turgeon, 1999). Following these guidelines, 10 years would pass before the required amount of sulfur could be applied.

Theoretically, it's possible that a slight change in pH near the soil surface could help to make some micronutrients more available. However, no research has specifically investigated soil and plant responses to sulfur application on a calcareous-sand putting green.

We wanted to evaluate the influence of sulfur rate and timing on soil pH and creeping bentgrass injury, and the potential for using ammonium sulfate as a nitrogen source to reduce pH.

Our approach

This two-year study was initiated in September 1998 on a sand-based golf green at the Rocky Ford Turfgrass Research Center at Manhattan, Kan.

Established Penncross creeping bentgrass was growing on a root-zone mix comprised of 84 percent sand, 14 percent silt and 2 percent clay. Soil pH was 7.7, and the calcitic limestone content was approximately 1.5 percent. Irrigation water was delivered from a well, and had a pH of 7.1. Turf was mowed six days weekly at 5/32 inch with a riding triplex mower and was irrigated on rain-free days to provide about .2 inches of water.

Elemental sulfur from a 90-percent source was applied at 2.5, 5, 10 or 20 pounds per 1,000 square feet once annually (October), split equally into two (April and October) or five (April, May, September, October and November) applications through the year.

An ammonium sulfate treatment was also included and was applied in April, May, September and October at 1 pound per 1,000 square feet; and in June and July at .5 pound per 1,000 square feet.

A control plot was also included that received methylene urea at the same rates as described for ammonium sulfate. All plots except ammonium sulfate-treated

TABLE 1

Creeping bentgrass injury in 1999 and 2000 as affected by sulphur applied at 20 lbs./1,000 ft^2/yr split into 1, 2, or 5 applications.

	INJURY*			
Applications	1999	2000		
per year**	July 15	May 10	June 7	July 5
1	4.3c***	7.0 b	5.0 b	5.0 c
2	7.7 b	9.0 a	8.3 a	7.3 a
3	8.7 ab	9.0 a	9.0 a	9.0 a

*Bentgrass injury was rated visually on a 0 to 9 scale where 9 = no injury and 0 = dead turf.

**The total annual sulphur level was applied once (September), split equally in two (April, October) or five (April, May, September, October and November) applications.

***Means followed by the same letter in a column are not significantly different ($P<0.05$).

turf also received the same application of methylene urea.

Data were collected to evaluate soil pH and creeping bentgrass injury. Three or four 1-inch diameter by 2.75 inch-deep cores per plot were sampled in July 1999 and July 2000 to determine sulfur application effects on soil pH.

In 2000, additional sampling-depth intervals were included to evaluate potential vertical differences in pH within the profile. Sampling depths were 0 to .5 inch, .5 to 1.6 inches and 1.6 to 2.75 inches.

Samples from each treatment were submitted to the Kansas State University soil-testing laboratory for analysis. Bentgrass injury was rated monthly from May through July each year using a 0 to 9 scale, where 9 = no signs of sulfur burn; and 0 = dead turf.

Sulfur effects on pH

Neither sulfur level nor application timing had any effect on reducing soil pH in 1999. Separating the soil profile vertically to determine pH in 2000 again revealed no effect of sulfur on reducing pH regardless of rate, timing or soil depth.

Furthermore, ammonium sulfate was no more effective in reducing soil pH than sulfur. Mean soil pH values in both years ranged from 7.8 to 8.1.

Isolated sampling in 2000 of plots treated with sulfur at 20 pounds per 1,000 square feet per year showed localized are where the pH was approximately 4.5. These plots had previously exhibited symptoms of injury

Sulfur has been shown to effectively reduce soil pH on noncalcareous soils (Bell et al., 2001). In that study, the pH of sand under creeping bentgrass was reduced from 7.1 to 6.5 when sulfur was applied at 1.5 pounds per 1,000 square feet monthly between July and November.

The authors observed no effect of sulfur on turf quality.

Theoretical calculations suggest that neutralizing the surface 3 inches of sand containing 1 percent calcitic limestone would require that sulfur be applied at approximately 74 pounds per 1,000 square feet (Carrow et al., 2001).

Using these figures, nearly four years would be required to neutralize pH if sulfur were applied at 20 pounds per 1,000 square feet per year. Indeed, we applied 40 pounds of sulfur per 1,000 square feet over two years and observed no significant decrease in pH.

Furthermore, the risk of bentgrass injury is too great when this level of sulfur is applied over such a short period of time.

Superintendents may apply sulfur when soil pH exceeds 7.5 simply because they are frequently reminded that the optimum pH for turf performance is between 6 and 7. This may be, in part, because they are concerned that a hidden micronutrient deficiency may occur when soil pH is relatively high.

In fact, visible iron deficiencies, exhibited as leaf chlorosis, are common when soil pH approaches 8 (Christians, 1998), but were not observed in our test. Attempts to reduce the pH of calcareous sand under a bentgrass with sulfur or ammonium sulfate, under conditions similar to those evaluated in this test, would be a waste of time and money.

Superintendents should be aware of the calcite content of their root-zone sand before attempting to alter its pH with sulfur or ammonium sulfate.

Alternatively, a better approach would be to use fertilizer applications to address potential nutrient deficiencies.

Creeping bentgrass injury

Only sulfur applied at 20 pounds per 1,000 square feet per year caused bentgrass injury, and phytotoxicity was greater when this rate was delivered in one application instead of two or five (Table 1). During 1999, treatment differences were not observed until July 5, which was 10 months after the initial application.

The oxidation of sulfur, and subsequent release of hydrogen, are dependent upon the bacterium *Thiobacillus* (Carrow et al., 2001). As such, the rate of this reaction increases with temperature. Because complete reaction of elemental sulfur can take months, superintendents often misdiagnose sulfur injury as some other problem. In fact, initial symptoms of sulfur injury resemble dollar spot and then become progressively worse.

We were surprised by the lack of bentgrass injury observed across sulfur levels from 2.5 to 10 pounds per 1,000 square feet per year.

We have received reports of bentgrass injury from superintendents following single application levels as low as 2 pounds per 1,000 square feet. Injury may be less likely on a calcareous sand that buffers the acidifying effects of sulfur.

Furthermore, application overlaps and miscalculations are more likely on the golf course than on research plots. Other factors employed under actual golf green conditions may also increase the likelihood of sulfur injury, including ultralow mowing heights and greater soil compaction and turf wear resulting from foot traffic.

Conclusions

Superintendents should be aware of the calcite content of their root zone sand before attempting to alter pH with sulfur or ammonium sulfate. Calcitic lime content can be easily determined by any soil-testing laboratory.

When a calcareous sand is present, attempts to adjust pH with sulfur should be avoided. Potential nutrient deficiencies that appear on sand-based calcareous greens should be addressed with fertilizer applications.

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