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soil easily stores 500 or more lbs/A of plant available potassium and allows for little or no leaching loss. Under this circumstance, once soil test K is built to 300+ lbs/A, annual application of 0.8 lbs K_2O/M for every pound of N applied will put your turfgrass on a high K diet. Assuming the K goes on only once a year (preferably in early fall), the annual N rate is 3 lbs and the K is going on with 0.5 lbN, then we are, in fact, talking about a fertilizer whose N:K_2O ratio is nearly 1:5 in order to have 0.8 lbK_2O per pound of annual N.

Because of K leaching loss from USGA greens mixes and a K storage capacity of only about 250 lbs/A, the fertilizer N:K_2O ratio required is generally in the range of 1:1.0 to 1.2. In this case, it is impractical to even think of getting by with only one or two K applications per season. If all the N is going on as a dry material, the appropriate N:K_2O fertilizer ratio is 1:1 to 1:1.2. However, the most common situation is one in which N is being applied at frequent low rates for much of the season, often as a urea solution. Then there is no alternative but to apply K alone (preferably as K_2SO_4) three or four times each year. The appropriate rate for each application is the annual N rate multiplied by 1 to 1.2 and divided by the number of applications.

Owing to the fact that we can't expect to build K levels much above 250 lb/A in USGA greens without getting excessive leaching, this is a reasonable soil test to shoot for. However, we need to realize that this is not enough K to keep turfgrass on a high K diet for an entire season.

5. My soil test results are starting to scare me. Soil pH values have slowly been rising in green, tees and fairway results. Many are now in the 7.6-7.8 range. Am I risking real problems of nutrient availability yet? Should I be on an elemental sulfur program? How many lbs/A can I safely use? When's the best time to apply?

ROCK COUNTY

ANSWER: Your pH values have risen to 7.6 to 7.8 because you, like many others in the state, are irrigating with hard water. Every time you irrigate you're applying calcium and magnesium that act as liming material. Your pH values should not increase much above where they are at the present time.

We normally think of high soil pH as a common cause of micronutrient deficiencies in Wisconsin turf. The most likely candidate is iron, but we haven't seen any Fe deficiency.

The pH rise you've experienced is common, cannot be avoided and, at least so far, has not seemed to create nutrient deficiencies. For this reason alone, I'm not a proponent of elemental sulfur programs. Even if widespread micronutrient deficiencies did begin to show up in turfgrass growing on high pH soils, elemental sulfur would not be the total answer to the problem. There are several reasons for this. Sulfur neutralizes soil alkalinity only as a result of microbial oxidation to sulfuric acid. Theoretically, (i.e., when 100 percent of the sulfur is oxidized), slightly more than the equivalent of three pounds of calcium carbonate is neutralized per pound of sulfur applied. Even then, the amount of sulfur required is impressive. For example, decreasing the pH of a sandy soil from 7.5 to 6.5 requires approximately 500 lb/A or 12 lbs/M of sulfur. Contrast this with the fact that turfgrass injury is likely if more than 2 lbs/M of sulfur are applied at any one time and if more than four lbs. are applied in a single season. Clearly, soil pH control with sulfur has to be approached as an annual affair extending over several seasons.

Another problem with pH control through sulfur application is incomplete sulfur oxidation and, therefore, less than 100% effectiveness. How much sulfur will be oxidized varies greatly from one soil to another and is unpredictable. In the years to come we're going to hear a lot of heated discussion about the effectiveness of sulfur applications, simply because oxidation rates vary widely from one location to another.

Finally, in turf, sulfur must be surface applied. Soil pH at the surface will eventually drop very low, perhaps as low as 3.0. It is only over time that the acidifying action of the sulfur will work its way downward in soil. I am not aware of any studies that show how surface applications of sulfur affect soil pH in both the short and long run.

6. We're rebuilding some putting greens on our golf course next summer. The question I'm confronted with is one that has received a lot of discussion lately. Opinions seem to vary. Do you recommend the very coarse sand layer in the USGA specifications?

MANITOWOC COUNTY

ANSWER: The very coarse sand layer was originally incorporated into USGA greens solely to provide a barrier to prevent fine soil particles from migrating into the pea gravel bed, clogging pores and impeding drainage. The idea that the very coarse sand layer may not be necessary arose from studies conducted by researchers at Texas A&M University and reported in the November/December 1980 issue of the USGA Green Section Record. They concluded from studies with eight-year-old greens and simulated greens subjected to prolonged saturated water flow in the laboratory that "no significant effect of the two-inch sand layer was evident when proper size gravel was used." In other words, they found no evidence for downward migration of fine soil particles into the pea gravel when the very coarse sand layer was left out.

The USGA Green Section does not refute this conclusion, but emphatically points out that the Texas A&M observations apply only when the 12-inch sand-peat mix adheres rigorously to USGA specifications and the pea gravel falls almost exclusively in the 1/4 to 3/8 inch size range. It is out of concern that these specifications are often not strictly adhered to that the Green Section staff continues to recommend installation of the 1½ inch coarse sand layer over the pea gravel bed.

My recommendation is to continue to install the very coarse sand layer unless your construction materials have been subjected to rigorous laboratory testing, have been shown to meet USGA specs, and mixing of the sand and peat will be as prescribed by the USGA. Most people that I've talked to point out that the cost of installing the very coarse sand layer is not a major component of total green construction cost and is worth the insurance it provides against drainage system failure.

7. We did some remodeling last year and built a new green. I was under a lot of pressure from the course architect to use straight sand in the rootzone mix. I resisted but still wonder if it would have been okay to use sand alone. He lobbied heavily with my committee and I would like some assurance it was worth the battle. What do you think?

PORTAGE COUNTY

ANSWER: Consider yourself lucky that you won the battle. Unfortunately, your club membership will probably never fully appreciate what you've done for them. Peat is mixed with sand to provide a lower soil bulk density that facilitates root penetration, to increase pore space by 30 to 40 percent so as to ensure adequate aeration and to increase water holding capacity by 60 percent or more. Without this added water holding capacity, it is very difficult to get completely through a single sunny, summer day without turfgrass wilting. Peat also contributes a substantial amount of cation exchange and pH buffering capacity. These mean better nutrient retention against leaching and a more stable soil pH. I know of a pure sand green in Wisconsin that requires 20 lbs N/M/season just to maintain satisfactory bentgrass color!

In summary, mixing peat with sand provides a more favorable physical environment for turfgrass and a chemical environment that makes soil fertility easier to control. The net results in the long run are

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