Maintaining Adequate Phosphorus Levels in Sand Greens

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MOST putting greens built today are constructed with high sand content mixes because of the need for good soil drainage and compaction resistance. The large pore spaces, low surface area, and low cation exchange capacity that are characteristics of sandy mixes, however, result in soils that are quite susceptible to leaching of nutrients, particularly nitrogen and potassium. The addition of soil to the mix, as suggested in USGA specifications, is helpful, but such a mix is still predominantly sand and requires careful management (fertilizer selection and timing, irrigation programming) to protect against leaching. Sand/peat mixes are somewhat more susceptible to leaching than the soil-based mixes.

With ever-increasing concerns for protection of water quality, more and more emphasis will be placed on careful management of nutrients on golf courses in the future. There have been several instances recently in which golf course developments have been significantly delayed or restricted because of the concern for pollution of ground and surface waters with nitrates and phosphates. While some of this concern is based on a lack of understanding of turf and soil conditions, managers must be aware of the potential for nutrient pollution of surface and ground waters. Appropriate fertilization and irrigation programs can then be implemented to prevent a pollution problem from developing.

While the potential for leaching of nitrates and potassium are generally understood by most golf course superintendents, the fate of phosphorus in soils is not as well understood.

The chemistry of phosphorus in soils is very complex. Phosphorus has a much lower solubility in the soil than nitrates or potassium, but it is, nevertheless, somewhat soluble in water. While there are several reasons for the relatively low solubility of phosphorus, one is related to surface area of the soil. Soils with greater amounts of silt and clay have very high surface areas, and phosphates are sorbed on these surfaces by way of a mechanism that has little to do with cation exchange capacity. Conversely, sands have a much lower capacity to sorb phosphorus because of their low surface areas. Despite what you might think, the addition of peat to sands for green construction adds very little phosphorus sorption capacity.

Most soils on greens which have been in use for years test very high for available phosphorus. Consequently, most fertilizer programs for greens have incorporated very low levels of P_2O_5 annually. On new greens established on sandy mixes, though, these low-phosphorus programs have often not been adequate. How much phosphorus is needed to establish and maintain healthy putting green turf while protecting against the leaching of phosphorus? There is some evidence from

Phosphorus deficiency (on the right) is characterized by very slow growth, low turf density and a purplish green turf color. Deficiencies of phosphorus have been most common on new greens built of sandy root zone mixes that have not been properly fertilized.

the literature, but more research is needed to answer this question.

Textbooks point out the need for phosphorus in both establishment and maintenance of turf, but of particular note is the need for phosphorus during the establishment period. Since phosphorus has a relatively low solubility, the roots of young turf seedlings must grow to where the nutrient is. The application of extra phosphorus to the seedbed, then, is essential for best establishment success. A recent article reported the response of creeping bentgrass to light, frequent applications of phosphorus to a sand green. Turf response to the first increment of phosphorus was dramatic, but a good-quality turf was subsequently maintained at very low available soil phosphorus levels.

Studies at Michigan State University on the response of Penncross creeping bentgrass putting green turf to phosphorus applications were initiated on three types of soils in 1983. The soils were dune sand, coarse sand mixed with 20% peat by volume, and fine sandy loam. Annual applications of P_2O_5 were made with finely ground 0-46-0 at the rates shown in the tables. Clippings were routinely removed from the site, and irrigation was applied to prevent wilt. Three applications of each treatment were made. Soil samples were taken in the fall of 1983 and the fall of 1988 before applications of P_2O_5 were made.

TABLE 1
Phosphorus treatment effects on Bray P1 soil tests of a putting green growing on dune sand

Treatment	Bray P1 soil tests, lbs./acre		
P_2O_5 lbs./1,000 sq. ft.	1984	1988	
	0-3 inches	0-2 inches	2-4 inches
0	11 c*	7 c	8 c
1	14 c	11 c	9 c
2	21 b	29 b	28 b
4	34 a	63 a	43 a

*Means in columns followed by the same letter are not significantly different from each other at the 5% level of significance using Duncan's Multiple Range Test.

TABLE 2
Phosphorus treatment effects on Bray P1 soil tests of a putting green growing on a mixture of sand and peat

Treatment	Bray P1 soil tests, lbs./acre		
P_2O_5 lbs./1,000 sq. ft.	1984	1988	
	0-3 inches	0-2 inches	2-4 inches
0	47 d*	11 d	5 d
0.5	94 c	50 c	16 c
1.0	161 b	97 b	31 b
2.0	247 a	215 a	82 a

*Means in columns followed by the same letter are not significantly different from each other at the 5% level of significance using Duncan's Multiple Range Test.

TABLE 3
Phosphorus treatment effects on Bray P1 soil tests of a putting green growing on a fine sandy loam soil

Treatment	Bray P1 soil tests, lbs./acre		
P_2O_5 lbs./1,000 sq. ft.	1984	1988	
	0-3 inches	0-2 inches	2-4 inches
0	126 b*	141 b	157 b
0.5	132 b	159 b	153 b
1.0	189 ab	213 b	163 b
2.0	275 a	375 a	149 a

*Means in columns followed by the same letter are not significantly different from each other at the 5% level of significance using Duncan's Multiple Range Test.

It is clear that the dune sand holds very little phosphorus (Table 1). When high rates were applied, there was movement noted into the 2- to 4-inch depth in the 1988 tests. Within about one year, traditional phosphorus deficiency symptoms began to appear, characterized by lack of growth, loss of turf density, and the typical dark, purplish green color. Even weeds did not grow in such a phosphorus-deficient growing medium. With the first application of phosphorus, the deficiency symptoms disappeared. Turf quality remained very good even with extremely low soil phosphorus tests (11 pounds per acre in 1988).

When the plots were first established, in 1981, some phosphorus had apparently been applied. This was evident from the soil test results in the sand/peat mix in 1984 (Table 2), where the check plot had a test result of 47 pounds per acre. However, with continued clipping removal, phosphorus deficiency developed in 1988 and became very evident in 1989.

The fine sandy loam soil had a very high phosphorus level at the time of establishment and, while phosphorus levels had increased somewhat, at higher rates it is clear that essentially none had moved into the 2- to 4-inch depth by 1988. Obviously, fine-textured soils have a high-phosphorus sorption capacity.

Managing phosphorus fertilization on sandy greens requires a different approach than on soil-based greens, and golf course superintendents should use soil tests regularly to determine phosphorus needs. If the turf is healthy, dense, and vigorous, application of P_2O_5 may not be necessary even if soil tests suggest it should be applied. The turf should be watched carefully, though, to be sure deficiency does not occur. The approach is particularly appropriate in areas where there are lakes or streams nearby or where a shallow water table exists.

All turf managers should use every tool available to protect the environment while providing a good-quality, stress-tolerant turf. Careful planning of the fertilization program is one important aspect of accomplishing these goals.