Peat in Greens: Knowns, Unknowns and Speculations

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USGA SPECIFICATIONS define acceptable limits in the screen analysis of sand used in golf green construction and topdressing mixtures, and in key physical properties of sand-peat mixtures. Appropriate peat characteristics are not defined. In the material that follows, we will examine peat, not only from its physical side, but from the perspective of its chemical and biological properties as well.

Physical Properties of Peat

Peat is blended with sand primarily to reduce the bulk density of the sand and to add water-holding capacity. Thus, physical properties head the list of desirable peat characteristics.

The bulk densities of peats commonly range from 3 to 30 percent of those of sands (Table 1). Consequently, 8:2 volume blends of the two materials generally provide bulk densities in the range of 1.17 to 1.42 g/cc. These extremes are very near or outside the limits of 1.25 to 1.45 g/cc set by the USGA. Laboratory testing can readily define a blend that will provide the proper bulk density for any particular combination of sand and peat, but often testing is not performed. In this case, we need to be sure to select a peat with a bulk density in the range of 0.10 to 0.25 g/cc.

Everyone is aware of the high water-holding capacities of peats. By using the data in Table 1 and assuming use of the popular 8:2 blend, we can calculate that the moisture-holding capacity of sand-peat mixtures may range anywhere from 15 to 26 percent. That is, providing the peat is not allowed to air-dry before it is used. Air-drying reduces peat's moisture-holding capacities some 30 to 80 percent and can result in a blend that holds no more moisture than pure sand.

Moisture-holding capacity *per se* is not critical for USGA greens. The real concern is the contribution of peat to the plant-available water content of the greens mix. A large portion of the water in peat is bound so tightly that plants cannot use it. By definition, plant-avail-

Figure 1: Demonstration of the mobility of potassium in sand, an 8:2 sand-peat mix and an 8:1:1 sand-peat-silt loam mix.

Table 1.

Common Ranges in the Physical Properties of Peats[1]
(Sand properties shown for comparison)

Property	Peats	Sands
Bulk density, g/cc	0.05-0.50	1.45-1.65
Water-holding capacity[2]		
Continuously moist, %	28-66	12-16
Air-dried, %	6-46	12-16
Available water, %[3]	18-42	6-8
1/3 Available water, %	6-14	2-3

[1]Adapted from Boelter (1974), Dyal (1960), Puustjarvi and Robertson (1975), and Taylor and Blake (1984).

[2]Volume basis at 0.2 bar pressure.

[3]Difference in volumes of water retained at 0.2 bar and 15 bar pressures.

able water is that water held by soil at tensions (also known as suctions or pressures) between 1/3 and 15 atmospheres. In applying this concept of available water, we need to recognize that on a warm, sunny day, plants typically begin to show signs of wilt when they have used up only one quarter to one third of the available water in the soil. By this standard, the contribution of peat to the plant-available water supply in six inches of an 8:2 sand-peat blend with a bulk density of 1.3 g/cc ranges from approximately 0.2 to 0.5 inches of water. Even at a moderate to high transpiration rate of 0.3 inches of water per day, this is a significant contribution, because it represents 0.7 to 1.7 days of additional readily available water.

Chemical Properties of Peat

Laboratory testing of sands and peats for green construction focuses entirely on physical properties and conveys the idea that peat is chemically inert. Peat, in fact, imparts certain chemical properties that have a strong bearing on the performance and management of USGA greens. Peat has very high pH buffering action, retains calcium, magnesium, and potassium in exchangeable forms, and has the capacity to form chemical complexes with certain micronutrients. Because of the very high pH buffering capacity of peat, the pH of the peat determines the initial pH of sand-peat mixtures. As shown in Table 2, this means that such mixtures may initially have pH values anywhere from 3.1 to about 7.6. To put this in perspective, a pH range of 6 to 7 is generally considered optimum for most grass species.

Sands are noted for having very low cation exchange capacities. Thus, they contain relatively small amounts of calcium, magnesium, and potassium ions, and allow for rather high leaching rates of these nutrients. Peat is very effective in increasing soil retention of calcium and magnesium, but considerably less so for potassium.

To illustrate this point, we leached fertilizer potassium from three columns, one containing pure sand, one with an 8:2 sand-peat mix, and the third with an 8:1:1 sand-peat-silt loam mix. We first leached with the equivalent of four inches of distilled water and then with four inches of tap water containing substantial amounts of calcium and magnesium. The results are shown in Figure 1.

Potassium readily leached from pure sand, regardless of the type of water applied. Tap water removed more than one-half the potassium from the sand-peat column, but only about one-third of the potassium from the sand-peat-silt loam column.

These observations reflect that ion exchange sites on soil minerals show less preference for calcium and magnesium than do the sites on organic matter. Thus, from the perspective of potassium leaching, peat alone is not an ideal amendment for sand-based greens.

Peat further affects turfgrass nutrition through formation of chemical complexes with copper, iron, manganese, and zinc. Complexation of these nutrients generally reduces their plant availability, and becomes more extensive as soil pH rises to 7.0 or above.

Peat may be up to 99 percent organic matter, but it generally contains variable amounts of mineral matter in the form of sand, silt, and clay (Table 2). Ash content of peat indicates mineral content, but the two are not the same. Ash contains substantial amounts of carbonates formed with metallic ions in the peat during combustion. Our experience is that about 20 percent of ash consists of carbonates and the remainder is sand, silt, or clay particles. The significance of a high mineral content in peat is tied to its biological properties.

Biological Properties of Peat

In terms of the numbers and kinds of microorganisms present, peat is biologically as active as many mineral soils. The biological stability of the peat itself is of much greater concern. Like any other organic material, peat is a food and energy source for microorganisms, and it decomposes, but we don't know how fast in USGA greens. Under laboratory conditions it takes anywhere from one to five years for one-half of the peat to decompose. Assuming similar biological half-lives of peat in USGA greens, the consequences are illustrated in Figure 2. For peat with a half-life of one year, only about 4 percent of the peat added remains five years after green construction. With a five-year half-life, one-half the peat remains after five years.

Figure 2.

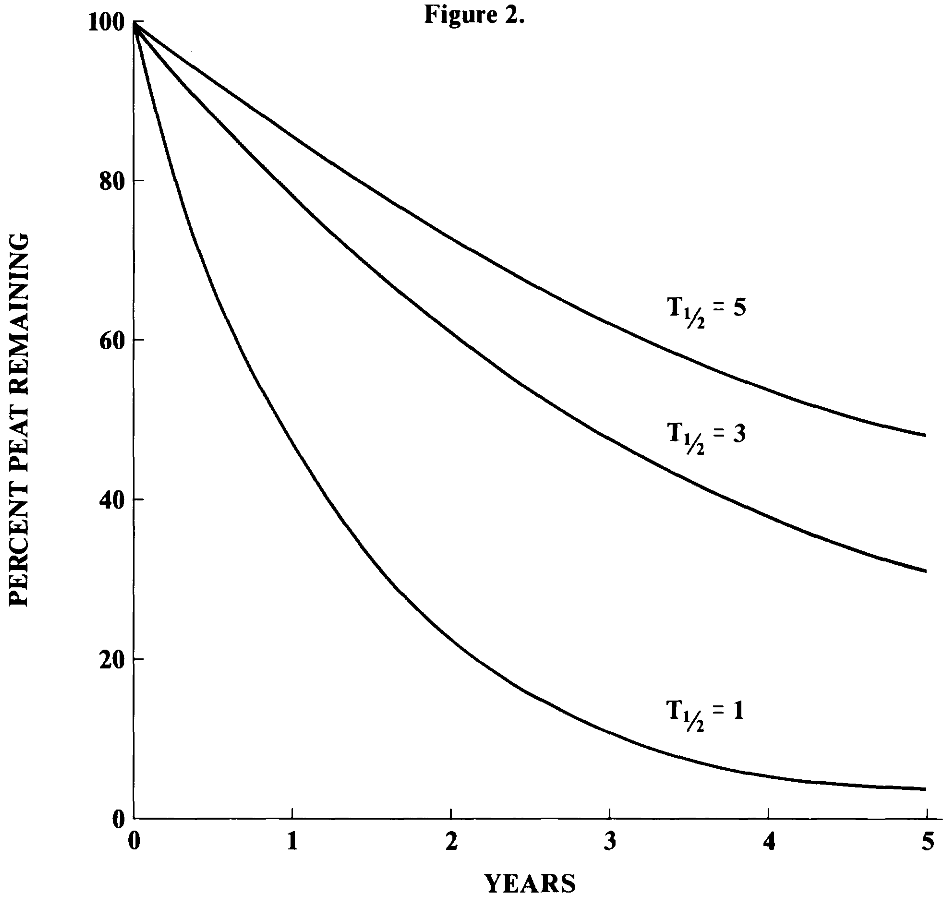

Figure 2: Laboratory incubation decomposition curves for peats with half-lives ($T_{1/2}$) of 1, 3, or 5 years.

Table 2.

Common Ranges in Selected Chemical Properties of Peats[1]

Property	Range
pH	3.1 - 7.6
Cation exchange capacity, me/100g	40 - 240
Organic matter content, %	40 - 99
Ash content, %	2 - 70

[1]Adapted from Dyal (1960) and Lucas (1982).

Table 3.

General Effects of the Degree of Decomposition on the Properties of Peat

	Degree of Peat Decomposition		
Property	**Low**	**Medium**	**High**
Bulk density	Low	Medium	High
Available water	Low	High	High
Cation exchange capacity	Low	Medium	High
Ash content	Low	Medium	High
Biological stability	Low	Medium	High
pH		Variable	

The question often arises concerning what dead turfgrass roots and stems contribute to the organic content of greens. Root tissues initially decompose very rapidly in soil, but some 20 percent of the carbon originally present remains after five years. In the case of stems with their higher lignin contents, perhaps as much as 30 or 35 percent of the original carbon remains after five years. Hence, plant tissues likely do contribute substantial amounts of organic matter to greens. This contribution, however, is principally in the top five inches or so of the green.

The impact of peat decomposition on the long-term performance of USGA greens is very speculative. We can anticipate progressive increases in bulk density and reductions in readily available water content and cation exchange capacities. Perhaps we should be more concerned about what might happen if we start out with a peat with a high silt and clay content. We know from studying mineral soils that silt and clay particles migrate downward for some depth, and then begin to accumulate. The silt and clay particles fill the spaces between sand grains in the zone of accumulation, and eventually form a barrier to water movement. Is this one of several processes that can lead to black layer formation? Who knows?

Selecting a Peat for USGA Greens

We can see many ways that the peat we select influences both the short-term and long-term performances of our greens. Making a good selection begins with understanding that the physical, chemical, and biological properties of peat relate more to its degree of decomposition than to its origin.

Table 3 shows the general relationship of various peat properties to its degree of decomposition. For example, a peat with very low bulk density typically has low mineral content, but it also has relatively low retention capacity for readily available water and low biological stability. Similarly, peats with high biological stability are highly decomposed to begin with, and have high bulk densities and mineral content.

Degree of peat decomposition is judged by its so-called rubbed fiber content. Highly decomposed peat contains virtually no discernible plant fibers, just black amorphous organic matter. Peat with little or no decomposition is generally brown to tan in color and consists primarily of plant fibers matted together. We need to be looking for peats that are intermediate to these extremes, and contain 50 to 75 percent rubbed fiber content.

Non-quantitative assessments of the rubbed fiber content of peats are quite simple to perform. A ball of moist peat approximately one inch in diameter is formed and held under flowing tap water above a fine mesh metal or plastic screen. The ball of peat slowly disintegrates in the stream of water by rubbing it gently between the thumb and forefinger. The amount of fibrous material that remains on the screen after disintegration allows us to judge the rubbed fiber content of the peat.

Obviously, selection of a peat for USGA greens involves compromises. Until matters of peat biological stability and mineral content are related to the long-term performance of USGA greens, emphasis should be placed primarily on peat bulk density and available water retention capacity. Taken together, these criteria preclude a material such as undecomposed peat moss, and favor a peat with an intermediate degree of decomposition.