Silica Sand: The Ultimate Inorganic Soil Amendment?

by Larry Stowell, Ph.D. and Wendy Gelernter, Ph.D.

The use of soil amendments in topdressing mixtures on greens continues to be an area of interest, primarily because the selection of the right topdressing material has such a significant impact on the overall performance of golf course greens. However, the use of soil amendments, and particularly the use of sand substitutes, is also an area of great controversy, primarily because the product claims are so broad and so diverse. According to the product literature, products such as Axis, Profile, PSA, Greenschoice or rhyolite can do everything from improving water holding capacity, to preventing localized dry spots, to increasing air space, to enhancing nutrient holding ability. Are these claims too good to be true? Is there data to substantiate the claims? Are these sand substitute amendments worth their weight, or they just an old fad revisited? In this issue of PACE Insights, we will briefly review the types of inorganic soil amendments that are available on the market, and describe their key features. But we'll tell you up front that we believe that it is difficult to improve on the track record, the data base and the performance of the most widely used of all inorganic soil amendments -- silica sand.

Potential benefits of sand substitutes

Water holding capacity: Reduced water costs, improved turf health and alleviation of localized dry spot are three desirable benefits of improved water holding capacity. In theory, sand substitutes improve moisture retention because the small holes, or pores in each particle create a more porous surface for absorption of water. In contrast, sand particles do not have internal pores. In reality, there are some watch-outs. Most importantly, increases in water holding capacity may not always result in increased availability of water to the plant. This is because water can become locked inside the pores, making it impossible for the plant to access it. While there is laboratory data to support the moisture retention claims of some products, only a limited number of field tests show that the turf actually benefits from this.

Increased air space: Increased air space sounds great. All of the amendments have the ability to improve air filled porosity if the original soil has a large proportion of fine particles or organic matter. Unfortunately, none of the amendments, regardless of apparent increases in pore spaces, will be able to overcome the biological barrier of the thatch layer. This is because the volume of soil gasses produced by soil microbes and the roots of turf plants will rapidly overwhelm the volume of air held in the pore spaces, **unless** the turf is properly aerified; aerification creates a passageway through the barrier of the thatch for exchange of gasses. For this reason, the use of aeration techniques has a much greater effect on air movement into the soil profile than soil amendments do.

Nutrient storage: Compared to topdressing sands, some sand substitutes have the ability to retain more positively charged cations (nutrients such as calcium [Ca], magnesium [Mg], potassium [K], and ammonium [NH3], as well as the detrimental cation sodium [Na]). This is because the negative charge of a soil particle acts as the glue or magnet that attracts these positively charged nutrient cations. Ideally, the soil will have a sufficient negative charge to allow the particles to hold onto nutrient cations with sufficient strength that rainfall and irrigation do not wash them away, but not so strongly that the plant is unable to extract them for growth and development.

The number of negative charges that a soil contains per unit of weight is a physical characteristic of that soil and is quantified in terms of the soil's Cation Exchange Capacity (CEC) or Total Exchange Capacity (TEC), typically measured in milliequivalents per 100 grams of soil (meq/100 g). The higher the CEC or TEC value, the more nutrient cations held on each soil particle. When a soil has a CEC of less than 2 meq/100g, it is considered to have poor nutrient holding capacity. The typical topdressing sand in California has a CEC that ranges between 2 and 5 meq/100g, and the average California golf course green, with a root zone composed of sand, peat and organic matter has a CEC of about 10 meq/100g. In general, therefore, our topdressing sands and greens have sufficient cation holding capacity to meet the needs of turf, and the use of sand substitutes provides little benefit. In addition, we should be aware that in areas of the country such as California, where frequent irrigation with high sodium or high bicarbonate water is typical, retention of sodium as a result of irrigation may negate any advantages provided by these amendments.

In heavy rainfall areas of the country, however, soils with low CEC values are unable to retain sufficient levels of cations for turfgrass growth. In these areas, it is important to maintain a sufficiently high CEC, and the use of sand substitutes can provide a valuable benefit by preventing the leaching of the major nutrients. Some sand substitute amendments can have CEC values exceeding 30 meq/100g - three times the average cation exchange capacity of the average California green sand.

Nutrient storage, continued: can we retain too many cations? In California and other arid environments where irrigation with high sodium or high bicarbonate water is typical, soils with elevated CECs can actually cause a significant problem in management of soil sodium levels.

When a soil has a low CEC, it is relatively easy to manipulate the composition of the of the major nutrients. For example, the typical California green has a CEC of 10 meq/100 g soil. When sodium is at its maximum desirable (6% of the total cations), the soil will contain 1.5 lbs of sodium/1000 sq ft of green in the top six inches. If sodium accumulates to 10% of the soil cations as a result of irrigation, the soil will contain 2.5 lbs of sodium/1000 sq ft of green. In order to bring the sodium level back to the desired 6% of cations, about one pound of calcium (4.3 lbs of gypsum @ 23% calcium) will be needed. Alternatively, a soil that has a high CEC of 150 meq/100 g (for example, and 80:20 sand/zeolite mixture) will contain 3.0 lbs of sodium/1000 sq ft of green (Andrews, 1997) . When sodium levels increase to 10% of the total cations, 38 pounds of calcium (165 lbs of gypsum/1000 sq ft) will be needed to reduce the sodium content of the soil. Thus, in heavily irrigated areas of the country, increased soil CECs will probably result in increased management costs as a result of increased requirements for calcium based amendments (such as gypsum) to offset the accumulation of sodium. This is an extreme example but claims of increased nutrient holding capacity should be viewed with caution depending upon the quality of your water source.

Selected classes of inorganic soil amendments (summarized from Waddington, 1992 and Carrow, 1997)

Silica sand: Composed primarily of quartz, silica sands are harvested from deposits or are produced by crushing rocks. They are effective in increasing air porosity and improving water movement but do nothing to increase water retention. The distribution of sand particle sizes will greatly influence the performance of the sand in improving soil conditions. The cation exchange capacity of sands is low, sometimes less than 1 meq/100 g. Sand is the most heavily researched and predictable of the inorganic soil amendments currently available and has been shown to have a positive influence in root zone and topdressing mixtures.

Calcined clay: Calcining occurs when clay particles are heated to temperatures near their melting point to remove water and to stabilize the clay particles. Examples of calcined clay include products such as Profile, Greenschoice, Turface and Terragreen. Isolite is a combination of diatomaceous earth and clay that is calcined. These products are effective in increasing air porosity and permeability when combined with some sands, but the opposite may occur with other sand types. Calcine clay products also hold large quantities of water, at least some of which is available to the plant. The CEC of calcined clays generally ranges from 2 to 30 meq/100 g.

Diatomaceous earth: Based on the remains of diatoms, which are small microorganisms that produce porous silica shells, diatomite proudcts are stable and lightweight materials that are either calcined (Axis) or kiln fired (PSA). They increase air porosity and permeability of soils. Although these materials have high water holding capacity, much of the water is unavailable to the plant. The CEC of diatomaceous earth ranges from 1 to 30 meq/100 g.

Pumice: Rhyolite is derived from pumice, a porous volcanic rock with high silica content. Pumice-based products increase soil water retention, air porosity and permeability. Little published information is available on the field performance of these materials.

Zeolite: These naturally occurring silicate materials have a porous crystalline structure. When properly sized, zeolite can improve drainage and provide increased water and nutreint retention. The CEC of zeolites can be as high as 230 meq/100 g, with a particular affinity for potassium and ammonium ions.

If you are considering using sand substitute products, keep these things in mind.

USGA Specifications: One of the most important factors to consider when selecting a root zone material or amendment is how predictable the performance of the material will be under field conditions. The current USGA specification (USGA Green Section Record, March/April, 1993) continues to provide a reliable guide for selection of root zone materials. To determine whether an amendment will provide a benefit or detriment to established turf, obtain a physical analysis of the amendment alone and in combination with the root zone sand. If the analysis does not meet or surpass USGA physical specifications, do not use the amendment.

Field performance: A laboratory physical analysis alone may not provide sufficient information to determine how an amendment will perform in the field. For this reason, always request independent field testing results of product performance before using a new amendment. When tested in combination with the sand that it is to be mixed with, use of the amendment should improve the soil, water, air and nutrient holding capacity without restricting percolation. If no field testing has been conducted, use the products with caution and test the amendments for several years on a restricted area prior to widespread use (Carrow, 1993). If you cannot predict the results of using a new product or practice, you have to ask yourself, "why make the change?"

Uniformity: The uniformity, or same-ness of the product will also greatly effect field performance. To be sure that you are receiving uniform materials from the supplier, have physical analyses conducted on several samples of the material and compare the results to insure that the different samples have similar physical parameters.

Summary

Based upon our current understanding of inorganic amendments, only silica sands can be recommended with the assurance that we can predict their performance. While sand substitute products are not likely to damage your system, there is currently insufficient data to support the additional cost of including them in your topdressing mixtures. Until more data is available, your money might be better spent purchasing and using aeration equipment and high quality silica sand in a frequent topdressing program for greens.

References

Andrews, R. 1997. Space age soil mix uses centuries-old zeolites. Golf Course Management, 65:61-66.

Baker, S.W., and Richards, C.W. 1997. Soil physical properties of golf greens: Relationships between laboratory and field measurements. International Turfgrass Society Research Journal, 8:47-58.

Carrow, R.N. 1993. Evaluating soil and turf conditioners. Golf Course Management, 61:56-70

Carrow, R.N. 1997. Personal communication.

Waddington, D.V. 1992. Soils, soil mixtures, and soil amendments. In Turfgrass (Waddington, D.V., Carrow, R.N., and Shearman, R.C. eds.) pages 331-383. Agronomy Monograph #32. American Society of Agronomy, Madison.

1997 PTRI Publications: We continue to strive to distribute research results to as wide an audience as possible. Listed below are some of the publications that appeared through PTRI this year. As is usual, the names of the PTRI Advisory Board appear at the end of each Golf Course Management and California Fairways article that we've published.

Gelernter, W.D. and R. Hickling, 1997. Keep your ear to the ground. Golf Course Management. March, 1997. pp. 49-52.

Gelernter, W.D. 1997. Resistance to microbial insecticides: the scale of the problem and how to manage it. In Microbial Insecticides: Novelty or Necessity?, HF Evans, ed. 302 pp.

Stowell, LJ and W. Gelernter. 1997. How to test products and practices: Part 1, getting started. California Fairways. November/December, 1997. pp. 20-22.

Yenny, R., LJ Stowell and S. Davis. 1997. Poa annua invasion of 14 bentgrass varieties: Southern California results.

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PACE Consulting
1267 Diamond Street
San Diego, CA 92109