Green drainage — another look

Good drainage is vital to the health of a green.

She-Kong Chong, Ph.D.; Richard Boniak; Chang-Ho Ok; Sam Indorante, Ph.D.; and Dan Dinelli, CGCS

According to O.J. Noer (9), the two most important ingredients for building and maintaining a good golf course are common sense and drainage. Turf research pioneers such as Piper and Oakley (7) and W.P. Miller (5) also recognized that good drainage is essential to successful green construction (2,8).

Poor soil drainage results in anaerobic conditions, and a poorly drained green is more susceptible to disease, can increase carbon dioxide levels and induces black layer formation in the root zone. It also affects the playability of a golf course.

Good drainage promotes favorable conditions for turf and soil organisms and enhances soil tilth. Good drainage also promotes the ready diffusion of oxygen,makes nutrients readily available for plant growth and reduces the risk of accumulation of toxic gases such as methane and ethylene in the soil profile.

Excess water may occur on the green surface or within the root zone when water movement is impeded. Surface drainage is primarily designed to remove water before it infiltrates the soil.

It is often assumed that subsurface drainage naturally occurs by deep percolation. On the contrary, only a minimal amount of water is able to penetrate through the subgrade. Subsurface drainage in a green serves to remove excess water from all layers between and including the root-zone sand mix and the drainage tile system installed beneath the gravel.

Intermediate and gravel layers

Intermediate sand and gravel layers are omitted in the California method of green construction. A USGA-recommended putting green profile requires a 4-inch layer of gravel uniformly spread under the root-zone sand mix. The size of the gravel is defined in the recommendations. If gravel of the proper size cannot be found, an intermediate sand layer must be used. The gravel should be spread on a smooth and compacted subgrade with enough drop to allow water flow. The gravel must be clean and washed, so that all the fine material is removed, as suggested in the USGA recommendations.

Clogging seldom occurs in the intermediate and gravel layers if the correct gravel size is used. However, most drainage problems in the intermediate and gravel layers can be attributed to apathy and ignorance. Clogging is commonly caused by erosion outside the green, when fine materials are carried in by rainwater and are mixed in with the gravel. It is therefore important to cover the edge and surrounding areas of the green to prevent erosion if drainage installation has not been completed.

More Info: www.gcsaa.org

Key points

- Drainage is one of the most important components of putting green construction because it promotes healthy greens.
- USGA recommendations for putting green construction provide for adequate green drainage.
- Our research showed that hydraulic conductivity was the key factor in influencing bentgrass root development in root-zone mixes.
- We believe the gridiron design is preferable to the herringbone design in green drainage construction.

Hydraulic conductivity is the key to controlling water movement in the sand root-zone mix. Low hydraulic conductivity of a sand root-zone mix results in poor drainage, which leads to a waterlogged green profile.

Poor drainage can be attributed to any one or a combination of the following factors:

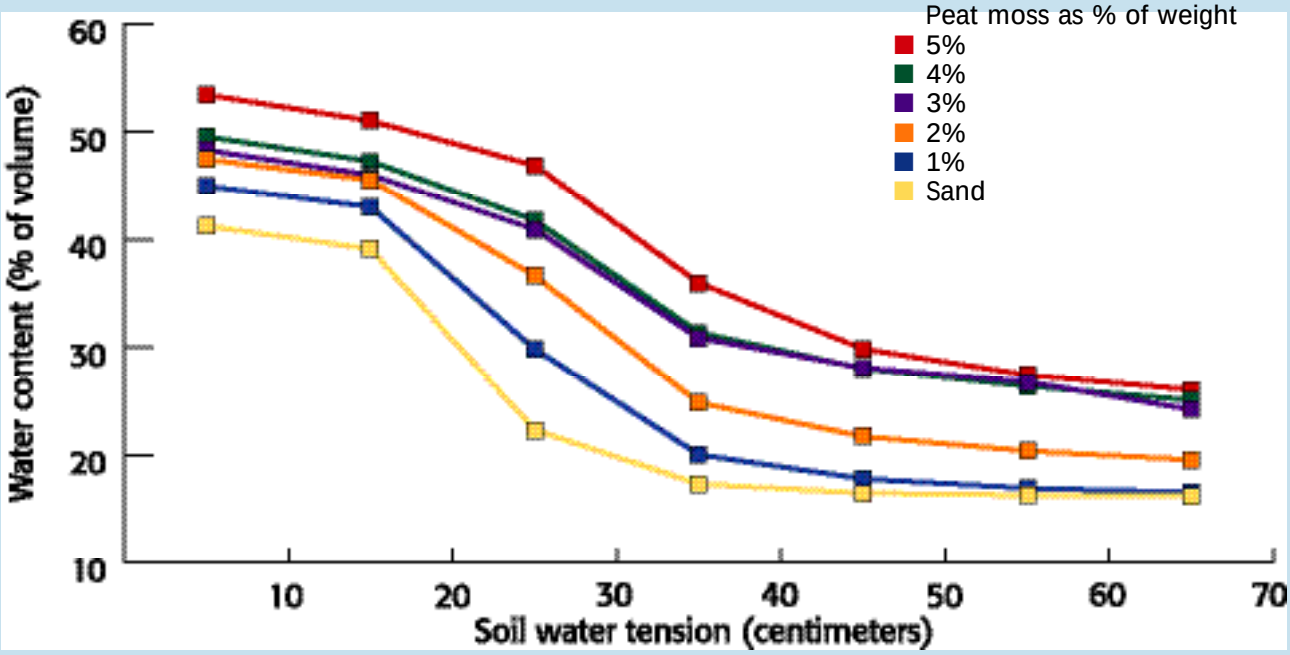
- incorrect sand selection
- soil compaction during installation
- accumulation of organic materials in the profile
- clogging of soil pores by microorganisms and fine particles

Research

Amendments can play a very important role in the hydraulic conductivity of a sand root-zone mix. An experiment conducted at Southern Illinois University in Carbondale examined hydraulic conductivity of sand root-zone mixes amended with various organic materials. In the study, six different amendments were tested. Each amendment was separately mixed with a sand meeting USGA putting green recommendations. The amount of each amendment added to the sand mix ranged from 0 to 5 percent (by weight in 1 percent increments).

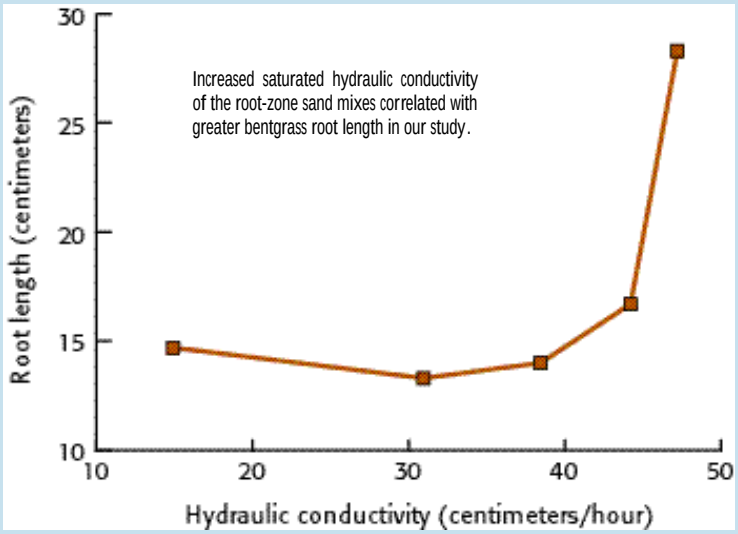
Soil columns (3.1 inches in diameter and 4 inches long) were constructed following USGA recommendations (11). Each treatment was replicated three times. The hydraulic conductivity of each soil column was measured using the unit gradient approach (3). Water-retention characteristics of each core were obtained by the hanging-water-column technique (4). Saturated and unsaturated hydraulic conductivities were calculated based on Darcy's law (3) and Campbell's approach (1), respectively. Results indicated that soil mix

Water content vs. soil water tension



Water retention capacity of sand mixes amended with different amounts of peat moss.

Root length vs. hydraulic conductivity



amended with material with a higher organic content (for example, peat moss) had higher water-retention capacity but lower hydraulic conductivity. Hydraulic conductivity remained almost unchanged when the amendment in the soil mix was increased to a certain level (for example, 3 percent by weight for peat moss).

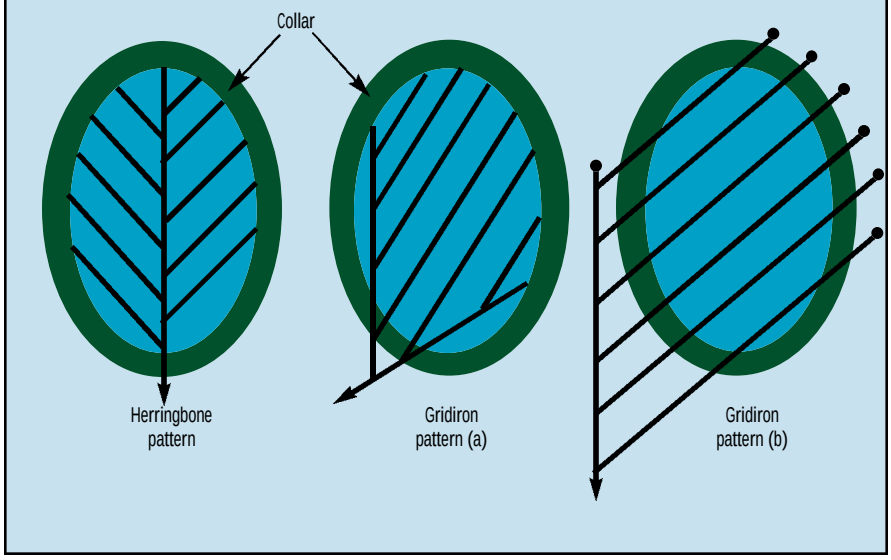
The sand mixes were also tested and seeded with bentgrass in the greenhouse. Root-mass and root-length data were collected at the fourth month after seeding. Statistical results indicate that hydraulic conductivity was the key factor influencing bentgrass root development in the mixes. Both rooting system and turf quality scored higher (on a scale of 1-9, with 9 being the best) in well-drained soils. Root-zone sand mix with high water retention and low hydraulic conductivity generally had a shallow rooting system. Therefore, it is very important to check both water retention and hydraulic conductivity when selecting a rooting-zone sand mix for green installation.

Drainage tile

The main objective of laying tile under the green is to remove excess water more rapidly from the system. Of the four tile systems most commonly used in golf course design (6,10), interception and random systems are commonly found in the fairway and rough areas, and herringbone and gridiron tile systems are most often used for greens.

Both the surface and the subsurface

Drainage tile patterns



drainage of a green are man-made, and the area involved is relatively small and therefore can be easily controlled. The most common problems with a tile drainage system in a green, clogging and the collapse of the drainage tile,can be attributed to any one of the following circumstances.

- The subgrade of the green was not sufficiently compacted to prevent subsidence.
- The tile line did not provide sufficient drop to permit water flow.
- The tile line was not laid deep enough and was damaged by equipment operation during the installation.
- The tile line was not installed straight enough or had an abrupt change in direction, thereby slowing water flow and increasing fine particle deposits in the tile.
- Tile joints and connections were not fit tight enough to prevent infiltration of fine materials.
- The upper openings of the tile were left open.

We believe the herringbone system should be avoided in green installation because it usually results in a longer main tile and more joints and connections, which can increase the risk of poor fitting and changes in direction of the drainage system. Another disadvantage is that the main line is often located near the center line of a green. If repair work is needed, digging and trenching might have to take place at the center of the green. In periodic maintenance, it will be more difficult to remove clogs in tile from the herringbone system. The gridiron drainage system permits maintenance without unnecessarily disturbing the green.

If conditions permit, all the joints and connections of a drainage tile should be outside the green, and all the upper openings should be extended at least 3 to 6 feet outside the apron. Keeping outlets and openings away from the green and apron provides easy access and prevents unwarranted disturbance on the green during repair and maintenance, although the initial construction expense may be higher (2). To prevent loose material and small animals from getting into the tile, the upper opening of each tile line should be capped. The layout of the tile system should also be mapped for future maintenance.

Good drainage is important to maintain the health of the greens, which leads to high-quality playing conditions, happy golfers and a happy superintendent. It should always be a high priority in golf course construction and is a very worthwhile investment. ■

Acknowledgments

We appreciate the generous contribution from the Illinois Turf Foundation, which partly funded this research.

Literature cited

1. Campbell, G.S. 1985. Soil physics with basic. Elsevier Science, Amsterdam.
2. Engel, R.E. 1959. Good drainage for greens. *USGA Journal and Turf Management*, April, p. 27-28.
3. Hillel, D. 1982. Introduction to soil physics. Academic Press, New York.
4. Klute, A. 1986. Water retention: Laboratory methods. p. 635-662. *In:* A. Klute (ed.), Methods of soil analysis, Part 1. Physical and mineralogical methods. Agronomy Monograph 9,2nd ed.ASA, Madison, Wis.
5. Miller, W.P. 1924. Tile-drainage for golf course. *Bulletin of Green Section of the USGA* 4(3):66-74.
6. Musser, H.B. 1962. Turf management. McGraw-Hill, New York.
7. Piper, C.V., and R.A. Oakley. 1917. Turf for golf courses. Macmillan, New York.
8. Schwartzkopf, C. 1975. Drainage: Why and how. *USGA Green Section Record* 13(3):1-3.
9. Tadge, C.H. 1980. Drainage is important to turfgrass management. *USGA Green Section Record* 18(2):17-19.
10. USGA Green Section Staff.1973. Refining the Green Section specifications for putting green construction. *USGA Green Section Record* 11(3):1-8.
11. USGA Green Section Staff. 1993. USGA Recommendations for a method of putting green construction. *USGA Green Section Record* 31(2):1-3.

She-Kong Chong, Ph.D., is a professor in plant soil and general agriculture and Richard Boniak is a turfgrass student at Southern Illinois University in Carbondale. Chang-Ho Ok is a research assistant and a Ph.D. student at the University of Missouri, Columbia.Sam Indorante, Ph.D.,is an adjunct professor in plant soil and general agriculture at Southern Illinois University in Carbondale. Dan Dinelli is CGCS at North Shore Country Club in Glenview, Ill.