Localized dry spots caused by hydrophobic soils: What have we learned?

Research at the University of Georgia examines many factors that can influence the development and management of this widespread and challenging problem.

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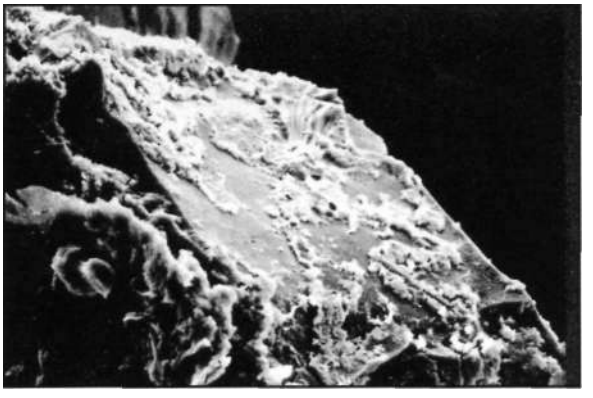
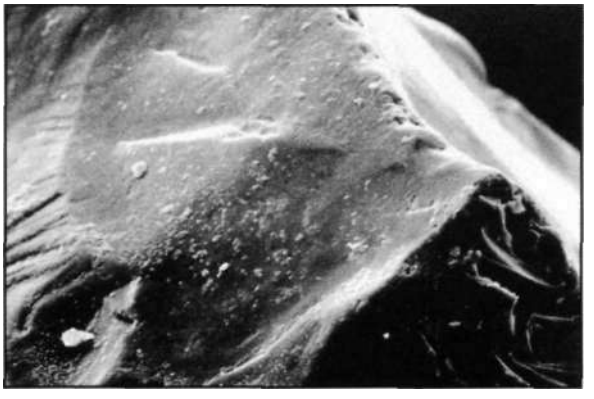
In golf course management, particularly in the care of greens, hydrophobic soil is a condition that occurs throughout the United States. Localized dry spots (LDSs) caused by hydrophobic soils occur primarily when turfgrass is grown on coarse-textured (sandy) soils.

However, water-repellent soils don't occur only in association with turfgrasses. Many reports describe this condition occurring in citrus groves, forests and grasslands. In all these cases, however, the soils tended to have high sand contents. In fact, hydrophobicity is reported to be a worldwide problem wherever cool-season turfgrasses are grown on sandy-type soils.

Since 1989, when *GCM* presented an article on the subject by University of Georgia researchers, the university has continued to support studies on the cause and control of LDSs caused by hydrophobic soils. A brief review of our findings will help golf course superintendents better understand this puzzling phenomenon, and we hope it also will provide some guidance in terms of managing turf that is suffering from hydrophobic soil conditions.



This scanning electron microscope photograph shows a sand particle (x655) at a depth of 0 to 1 inch from a localized dry spot.



In contrast, here is the same type of photograph of a sand particle (x655) at the same depth from a healthy area of a golf course green.

Cause

The hydrophobicity associated with LDS on golf greens is believed to be caused by an organic coating of the soil or sand particles. The organic coating results from the natural breakdown of organic substances such as roots, shoots, peat moss or other organic soil amendments that may be part of the root zone mix. This is a normal microbiological process that occurs in all soils. The coating, when very dry, is of a chemical nature that repels water, which, along with the inherent poor moisture-holding capacity of a sandy soil, predisposes the turf to extreme soil-moisture deficits. This condition can become so severe that normal irrigation practices are often ineffective in restoring adequate soil moisture.

DRY SPOTS

Hydrophobicity on greens

As a hydrophobic condition develops on a green, the degree of water repellency may vary across the area. In other words, certain spots may show the hydrophobic condition sooner and more severely than others — even within a few centimeters. However, over time, the entire green will be affected, but to varying degrees, which may range from mild to very severe. In terms of depth, soil hydrophobicity tends to be a surface phenomenon. In most cases, the greatest water repellency is found in the top 2 inches of soil. As depth increases, water repellency decreases, and we have rarely seen any significant degree of hydrophobicity more than 3 inches deep.

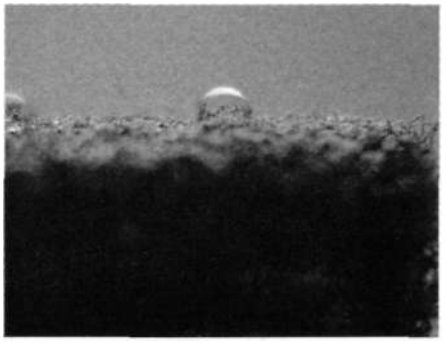
Development of water repellency

Soil water repellency can develop any time from six months to 18 months after initial green construction. Its occurrence on golf greens does not appear to be the result of any specific management practice or use of certain chemicals. In fact, water repellency appears to develop regardless of the type, frequency or rate of application of fertilizers and pesticides. For example, our research has found that a nonhydrophobic greens mix or a 100 percent sand root zone established to turfgrass will develop water repellency even though little or no fertilizers or pesticides were used over a period of several months.

However, it is believed that the use of certain pesticides and fertilizers may influence the rate of formation of hydrophobicity, but this relationship is still unclear. On the other hand, we do know that certain irrigation practices, soil pH, sand particle size and species of turfgrass can affect the rate of development and the severity of the hydrophobic soil condition. It should be remembered that regardless of the rate of formation, it appears that greens constructed primarily with sand will eventually develop the condition to some extent.

Irrigation and rainfall

Irrigation practices that encourage severe wetting/drying cycles of the soil tend to enhance the rate of development and the degree of severity of hydrophobicity. Although the continual maintenance of a wet root zone will prevent the symptoms (LDSs) of hydrophobic soil, this practice will not remove or discourage the formation of the organic coating over the sand/soil particles. Obviously, excessive water application may cause other problems such as algae formation and/or nutrient and pesticide leaching. There have been many observations suggesting that a heavy or torrential rainfall (1 or more inches in an hour) will temporarily alleviate soil hydrophobicity for as little as a few days or up to several weeks. An equivalent amount of irrigation water does not appear to have the same effect. The reason for this difference is not clear at this time.



Water droplets on the surface of a hydrophobic soil core.

Vegetation and turf species

As mentioned above, a 100 percent sand root zone will become hydrophobic. However, water repellency only develops if the soil is established to plant material. Sand not established with vegetation and without organic material will not become hydrophobic.

The type of vegetation affects the rate of development of water repellency. For example, in a recent study, we found creeping bentgrass (Penncross) resulted in the most rapid development of soil hydrophobicity. The creeping bentgrass was followed by bermudagrass (Tifgreen), tall fescue and zoysiagrass (Emerald). There is no information pertaining to the effects of cultivars of a given turfgrass species on the formation of hydrophobic soil. Currently, we are in the process of monitoring the effects of 33 creeping bentgrass cultivars on the development of hydrophobic soil.

Soil amendments

The occurrence and the rate of development of hydrophobicity appears to be affected by the type and/or amount of soil amendment used in the root zone mix. In our studies, a sand-peat (85-15) mix resulted in a more rapid development of hydrophobicity than other soil amendments. However, in every case, regardless of the amendment used, all root zone treatments, including a 100 percent sand medium, eventually developed water repellency. Since we have only been able to evaluate a limited number of soil amendments to date, we hope to expand this area of research during the next several months.

Sand particle size

Our studies have shown that coarse sand (particle sizes 0.5 to 2.0 mm) is more prone to the rapid development and increased severity of hydrophobicity than fine-textured sand (0.106 to 0.5 mm). This probably has to do with the greater likelihood of the coarse sand undergoing increased extreme wetting-drying cycles, which seem to hasten the development and increase the severity of soil water repellency in greens.

Fine-textured soils

Our research, as well as observations made by others, has shown that the presence or the incorporation of fine-textured soil (clay or clay-loam) into the root zone will significantly reduce or eliminate the occurrence of soil hydrophobicity. The increased water-holding capacity of the soil apparently overshadows the water-repelling tendency of the organically coated soil particles. The amount of fine-textured soil used depends on the material itself, as well as the characteristics of the sand-based root zone mix into which it is being incorporated. In our studies, relief from hydrophobicity has been achieved when the root zone mix contained 15 percent of a clay-loam soil. Of course, one should be aware of the potential

consequences when incorporating fine-textured materials into a sand root zone, such as compaction, layering and a decreased percolation rate. It is possible that other materials that enhance the water-holding capacity of the soil may also help reduce the occurrence or the severity of soil hydrophobicity.

Soil pH

The university's studies have shown that the organic coating can be solubilized by raising the soil pH to a range between 8.5 and 10. Repeat applications of sodium hydroxide followed by a water drench significantly removed the coating and reduced hydrophobicity for up to six months. Depending on the treatment used, soil pH returned to normal within a two- to three-week period following the last application of sodium hydroxide. Although little or no phytotoxicity was observed with a single application followed by a water flush, this strategy can result in significant discoloration of the turf if certain precautions are not followed. More research must be conducted before this practice can be used by superintendents.

Wetting agents

In terms of more conventional treatments, we have worked with wetting forks and topdressings, and injection of water-absorbing polymers. However, wetting agents remain the primary management tool available to superintendents for the treatment of localized dry spots caused by hydrophobic soil. A wetting agent study conducted at the University of Georgia showed all materials tested significantly reduced soil hydrophobicity at least temporarily. No single wetting agent material appeared to be superior to any other in terms of reducing the acute characteristics of soil water repellency when used at the manufacturer's recommended rate. Although the wetting agents' performances under the conditions of this study were similar, there were differences among products in terms of the amount of material and number of applications required to alleviate water repellency. In this regard, we recently tested a wetting agent product from overseas. This material, applied as a single application, significantly reduced soil hydrophobicity for several months. The potential for this product or other wetting agents to exhibit this type of efficacy is tremendous.

Here, a hydrophobic experimental Penncross green was used as the test area for a coring/soil amendment study.

Use of biostimulants or certain organic fertilizers

There has been some concern expressed regarding the use of biostimulants or certain organic-based fertilizers that appear to contain the same or similar ingredients (i.e., humic and fulvic acids) that have been found in, or make up, the coating of the hydrophobic soil particles. Our research has found no relationship between the use of these materials and increased development or severity of hydrophobic soil. There are many different chemical forms of humic acid, and those forms responsible for soil water repellency are different from those used in commercially available products.

Acknowledgments

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