How Water Behaves in the Soil

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IN ORDER TO understand properly how water behaves in the soil, we must understand what water is and what soil is. Water is certainly easy to describe: as every high school student learns, it is a liquid composed of molecules made of two atoms of hydrogen and one of oxygen. What is not usually learned is the special properties of these molecules.

Water molecules are polar, with a strongly positive hydrogen end and an equally negative oxygen end. Water exhibits strong hydrogen bonding to other molecules, primarily other water molecules. This gives water a very high boiling point for such a small molecule, and at the same time it gives it a relatively high freezing point. Water molecules are also strongly attracted to other polar molecules, so much so that plants are unable to extract all the water from the soil.

Water retention in the soil is directly related to the amount of surface area on the soil particles. Therefore, the more soil particles in a given volume of soil, the more water the soil can hold. Particles having the most surface area per volume are clay and organic matter. Soils heavy in these two materials, therefore, have very high water-holding capacities, but they are not necessarily good mediums for the roots of turf under golf course traffic.

Soil is not as easy to describe as water. A simplistic all-inclusive definition is a loose naturally occurring material on the earth's surface in which plants grow. This definition allows for inclusion of a wide range of material, from relatively infertile sands to black gumbo prairie soils.

Soil is always considered to have some organic matter in it. A microflora of fungi, bacteria and algae plus enough nutrients to support some type of plant life.

Because soil is so variable in nature, the understanding of how water behaves in soil is very difficult. Water molecules tend to form a film of moisture around particles. The more plentiful the water, the thicker the film held there by the collective forces of adhesion and cohesion. If all the pores of soil are small, then this water film excludes air from the soil. If the soil's pores are large, then once the film reaches a certain thickness, the force of gravity is stronger than the weak forces of adhesion and cohesion on the outer layers of the film and the water is removed, leaving air pockets.

Plant roots do not simply absorb this water like a sponge. They must expend energy to absorb water and must expend energy to grow out into moist areas after they absorb the water immediately next to themselves. Oxygen from soil air is needed for both processes. Water will move back into areas where the roots have absorbed the moisture by capillary movement but not rapidly enough to satisfy plant need under conditions of high water use. Capillary action is almost nonexistent in coarse sands and very slow in fine-textured soil of poor structure. To add to this problem, cool season grass roots tend to have slow growth rates under warm summer soil conditions. In fact, root systems of *Poa* species and creeping bentgrass may be more dead than alive when soil temperatures exceed 70 degrees Fahrenheit for long periods in July and August.

Nature appears to have designed grass plants which survive the hot, dry stresses of summer best by going into a dormant stage when their root systems are needed least. By not allowing the grass plant to become dormant, we spend the summer fighting nature.

Plant roots need an ideal medium to absorb water if an ideal plant is to be grown above ground. An ideal medium becomes even more important if the plant above ground is to be put under a tremendous amount of stress by being mowed abnormally close to the ground.

Close mowing results in a minimum of leaf surface to produce stored energy, and, therefore, there is little energy to keep the root system functioning.

The ideal medium for plant roots will vary some with the type of plant one is trying to grow. Grass is most difficult to grow where traffic is reasonably intense. Intense traffic compacts the soil and reduces pore space. Most importantly, the larger pores in which air movement in the soil takes place are lost. The ideal medium for grass roots is one that will have, after compaction, at least 50 percent pore space. Ideally, about half of this will be water-holding pore space and half larger pores which will hold air.

The USGA Green Section specifications for putting green construction arrive at a satisfactory method of handling water in putting greens under intense traffic. The desired porosity is built into the specifications so that the compacted mixtures have a total pore space volume between 40 and 55 percent. The volume of non-capillary pores (those in which air moves) are insured to be not less than 15 percent.

(Above) A fairway turf grown on ledge — green color evident mainly over cracks in ledge providing more air (oxygen) to grass roots.

(Below) Traffic on wet soil destroys structure and causes serious problems of soil compaction.

Water retention capacity is also handled by the USGA specifications in that the mixture should have a laboratory capacity between 12 and 25 percent by weight on an oven-dried soil basis.

USGA specifications call for a minimum laboratory infiltration and transmission rate for water of two inches per hour for greens planted to bermudagrass and three inches per hour for greens planted to bentgrass. A maximum infiltration and transmission rate in the laboratory should not exceed 10 inches per hour with normal materials. Rates of four to six inches per hour are ideal. These rates are determined on a topsoil mix which has been compacted at a moisture content equal to field capacity and maintained under a constant head flow of water for 24 hours at a temperature of 20 degrees centigrade.

The USGA specifications for putting green construction have evolved because water management is so critical to growing desirable grass on putting greens. It is much easier to maintain putting greens if we have an artificial soil mix, because soils differ so widely from place to place. The definite characteristic thus obtained from an artificial mix comes as close as possible to providing optimum conditions for plant roots without demanding the tender loving care and cooperating weather necessary with most native soils.