More Conference Highlights

♦ Turf Drainage: Theory and Practice by Dr. R. Sheard and Geoff Corlett (Part 1 of 2 lectures)

♦ The Do's & Don'ts of Renovation, Seeding, and Drainage by Gord Dol

Turf Drainage: Theory

Dr. R. Sheard

Soil texture should not to be confused with soil structure. Soil texture is simply a percentage of sand, silt, and clay in any sample of soil. Clay soil particles are .002 mm in diameter, so small you need an electron microscope to see them. Silt particles are .002 m to .005 mm, and they can be seen under a light microscope. Sand particles are .005 mm to 4 mm. Particles larger than this are considered gravel. These particles can be seen by the naked eye. Very fine particles can be viewed with a hand lens.

These size groupings have been established by soil scientists. In any handful of soil, you have a continuum of particles from the very finest clay right through to dust. Soil scientists decided because there exists an infinite number of combinations of percentages of sand, silt, and clay, that they would divide them into groupings. These are sandy loam, loamy sand, loam, clay loam, and silt loam. The groupings really reflect how a certain percentage of sand, silt, or clay will react.

We now understand that anything called a sandy loam or loamy sand is going to act like sand. You can feel it with your fingers; it will be gritty—this is easy to identify. Another class is the loams. Loams are easy to till and easy to work. When a farmer talks about how he has a loamy soil, he is talking about a soil that is easy to till. On average, the loams class have an equal balance of sand, silt, and clay.

Then you have the clay types, the clay loams, the clay, and the silty clay loams. To the layman, clays are difficult to work with because they have many fine particles. By and large, if a person is working a subsoil he will say it's a clay because subsoil has no organic matter in it, no structure, it is difficult to till, to make a seed bed, or do anything in terms of growing plants. There are misconceptions as to the ability of the individual to manipulate soil.

Structure

Aggregates are the cementing together of sand, silt, and clay into larger units. These in turn are cemented together with organic matter or humus. This is a very weak cementing nature, very fragile—you can destroy soil structure. You cannot destroy soil texture unless you add sand to make a sand rootzone, for example.

Soil structure is fragile and breakable. Every time you put a machine over a golf green or a sports field; every time a player walks over it or a soccer teams' cleats press into the surface, the structure of the soil is shifted around, and it can be destroyed. Soils tend to destroy quickly when the water content is high, because the water content is the lubricant that allows the particles of sand, silt, and clay to slide over one another into closer configuration and thence into compaction.

You cannot destroy the structure of an all sand green because sand does not have any structure. It is only when you have silt and clay introduced into the system, the binding effect of organic matter, and the introduction of these larger units called aggregates, that you run into some problems. This is the decided advantage of all sand rootzones. If you have a natural soil system with organic matter, you have aggregation, you have structure, and you have a potential to destroy it—particularly under wet conditions.

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Porosity

Pore space is the area or void between soil particles and the space between and within soil aggregates. Ideal surface soil that you can walk on or drive a 150 HP tractor on, will be composed of 50% pore space. Volume will be 50% solids (sand, silt, and clay) and the other 50% will be pore space. It is this pore space that is so crucial to the management of air. Air has to move into and out of the soil because roots require oxygen for respiration. Air has to go out of the soil to remove the by-products of respiration (carbon dioxide) and to remove toxic gases such as methane, which will build up in the soil under poorly drained conditions.

Pore space may be divided into two major groups, macropores and micropores. Macropores are those large enough to allow the free movement of air and water due to the forces of gravity downward through the soil. The micropores are pore spaces in the soil which retain water. In soils that have aggregation, porosity tends to be between the aggregates. If you push the aggregates tighter together through compaction, you decrease the macroporosity far more than the microporosity and hence you influence the drainage characteristics of the soil more than the water retention characteristics of the soil. Macropores are often termed aeration porosity—porosity through which air is transferred in and out of the soil. Micropores are also called capillary pores.

Water content of soil

Maximum water holding content of the soil is when all pores are filled with water (macro and micropores), and there is no air in the soil. It is saturated. It is what microbiologists call anaerobic, because it has no oxygen. Anaerobic respiration takes place, and roots cannot grow because they have no oxygen. Microbes can still grow because there are microbes which can function without oxygen, but these often generate things that are toxic to roots such as ethylene, carbon dioxide, etc. This is what happens to a soil if you get a batch, pulverize it, and then pack it together—you destroy the structure.

Field capacity

Used to describe moisture content or the amount of water retained, field capacity is when all of the macropores have drained out and only the micropores retain water. This depends on a number of conditions such as compaction, granulation, texture, etc.

Permanent wilt point

The water content of a soil when a plant is considered irreversibly moisture stressed. The plant will not recover at this state.

Drainage water

Water in the soil between the maximum water holding capacity and field capacity is drainage water or gravitational water. This is the water that flows out of the soil after it is saturated due to the force of gravity pulling it downward (the forces of gravity pull everything toward the centre of the earth). It is this force which drains the macropores. Therefore, it is the drainage of that water which indicates field capacity. This allows the air to flow back into the soil.

Plant available water

This is the water held in the soil that is available to plants between field capacity and permanent wilt point. Capillary water is another term (water held in the micropores). Drainage does not remove plant available water, it only removes water in the macropores. It does not remove any of the microporosity or capillary water. If you drain your golf course or athletic field, you are not going to decrease the amount of water you use for plant growth. There may still be an occasion 24 hours after a heavy rain when the gravitational water has drained through the system. You may have used some of that water. So, plant available water is that between field capacity and permanent wilt point. Thus, when you are scheduling your irrigation, you should organize it to occur when you have used up roughly 50% of the plant available water. The reason for this is that as the water content of the soil decreases, the energy which the plant roots have to expend in order to extract water from the soil increases quite markedly as you pass the 50% reduction stage. So the drier it is, the tougher it is for the roots to get that water; therefore, never let the plants get anywhere near the wilt point.

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Gravitational flow of water

As already mentioned, gravitational flow of water is only directed down. It is defined as the water between maximum water holding capacity and field capacity, and it flows out through the macropores.

Capillary flow

This is the other type of flow that occurs through the soil. It is the flow through capillaries or micropores. Capillary flow is multi-directional, sideways, upwards, and downwards due to the forces of adhesion and cohesion between the water surface and any other surface. If you have a very fine diameter pore, water will move upward in that pore. That is the whole basis for the physics of water movement by capillary flow.

In the sand rootzone, water is supposed to move upward from the water table to the interface between the sand and the gravel bed and move upward through the plant roots through capillary flow. Water in the soil flows from moist areas to dry areas through capillary flow. It tends to be higher in fine textured materials and most rapid in coarse textured materials. It does not rise to the top in either. When selecting sand for an all sand rootzone, the particle size becomes critical due to the fact it has an influence on how far and how fast the water moves by capillary flow. Usually, failure of sand root systems is due to distribution of the particle size.

To end, there are a couple of other terms that relate to the movement of water in the soil. Infiltration: this is the rate of movement of water into the soil surface. Saturated Hydraulic conductivity: this is the rate of water movement through the macropores. It determines how quickly the soil will drain. Unsaturated hydraulic conductivity: this refers to the movement of water through the macropores. When the soil is saturated, all pores are filled with water. When the water drains, soil pores fill with air which is good for root growth. ♦

Editor's Note

Dr. Sheard's lecture was covered in greater detail in a series titled "Understanding Turf Management." This series was published in the Sports Turf Manager *newsletter starting in June 1991. Some copies are still available in the STA office. This series and others will eventually be available in book form (to be published at a future date).*