Understanding Turf Management

The fourth in a series by
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SOIL AIR AND WATER

In previous articles we have talked about soil porosity and the relation between water and air in the soil pores. As the soil dries, more and more of the soil porosity becomes filled with air, whereas when the soil is wetted by rain or irrigation the air is forced out of the pores as they refill with water.

SOIL AIR

During the process of wetting and drying there is an exchange of the air between the soil and the atmosphere. In addition there is a continued exchange of air due to a second process called diffusion; a much slower but continuous process. Furthermore the air may move in and out of the soil due to expansion from the heating of the soil during the day.

In an inactive soil without plants the concentration of gases in the soil is the same as that in the atmosphere we breath; 21.0% oxygen, 0.03% carbon dioxide, 78.9% nitrogen and the remainder a mixture of other gases. When grass roots grow in the soil or the microbial population is active, a process takes place within all living cells, called respiration. During respiration oxygen is consumed and carbon dioxide is produced. Without continued exchange of gasses between the soil pores and the atmosphere, a level of oxygen will be reached, generally less than 10%, where respiration will cease and the roots will die.

When a soil is close to saturation with water the time required for the soil to become depleted in oxygen is reduced to a few days. The soil is now know as 'anaerobic' (lacks oxygen) in contrast to an 'aerobic' (normal) soil. Thus good drainage is essential to maintain an 'aerobic' soil. Compaction, which tends to destroy macro pores, also results in low oxygen levels in the soil.

When the oxygen in the soil is depleted by respiration the carbon dioxide level is increased. When the carbon dioxide level approaches 3 to 5% it becomes toxic to the root system of grasses. To further intensify the harmful effects of low oxygen on grass roots in an anaerobic soil, microbes which do not require oxygen multiply and in their respiration process produce gasses such as ethylene which are toxic to plant growth at very low levels, levels measured in parts per million.

An additional adverse effect of decreasing oxygen supply in the soil is a change in the oxidation state or physical chemistry of the soil. Anaerobic soils develop what is called 'reducing' conditions which increases the iron and manganese concentration in the soil solution to a level which may be toxic to root development. Furthermore, nitrogen may be lost as a gas to the atmosphere by a process called denitrification.

SOIL WATER

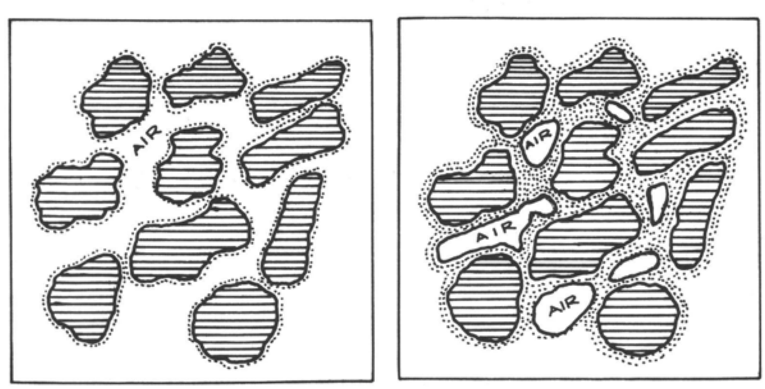
While excessive water in the soil may be harmful, an adequate supply of water in the soil pores is essential at all times for grass growth. There are three basic functions of the water in the soil;

(1) to replace the water lost through evapotranspiration from soil and leaf surfaces,

(2) to act as a solvent in which all plant nutrients must dissolve before they are absorbed by the grass roots, and

(3) to act as a moderator of soil and leaf temperatures. The moderating effect is because it takes at least five times more energy to raise the temperature of water one degree Celsius than soil or leaf tissue.

Figure 1: A schematic representation of soil water, air and particles. On the left is a dry soil at the permanent wilt point. On the right is a wet soil where air only remains as small pockets between the particles. Some of this water may drain out of the soil, drawing fresh air into the pores.



Water, even in the driest soil, exists as a layer over the surface of all soil particles. This layer increases in thickness as the soil becomes more moist. Eventually, as the water content increases further, the smallest pores become filled with water first, followed by larger and larger pores (Fig. 1).

Water is held in the soil by physical forces of adhesion and cohesion. These forces create a tension or 'pull' on the water so that energy is required to remove the water or counteract the tension. The thinner the layer of water on the soil particles the greater the energy that must be exerted to remove the water. Hence a point is reached where the grass root cannot exert enough energy to extract water and the plant wilts. Conversely, as the soil becomes more moist the energy the root needs to exert to obtain its water requirement decreases.

Soil scientists have developed a system of defining the energy required to remove the water from the soil. They have established reproducible laboratory procedures which relate the moisture content of the soil to the energy or tension by which the soil retains water. The procedure generates what is called a moisture retention curve (Fig. 2). These curves illustrate two things. First a sandy soil contains less water at any given energy level than a clay and secondly the amount of water held between two energy levels is less in the sand than in the clay. The difference between sands and clays is due to the finer particles in clay soils and the greater surface area associated with the finer particles.

Certain points on the curve are related to plant growth and realistic field conditions and are used to describe the moisture content of the soil. There are three points which are of significance in plant growth. They are the maximum water retention capacity, field capacity and the permanent wilt point.

The maximum water retention capacity is the moisture level at which all soil pores are filled with water. Essentially the soil is saturated and contains little air. Some of the water is held with so little energy that it will flow out of the soil due to the pull of gravity. It is often referred to as gravitational water or drainage water and will flow out of a well drained soil in 48 hours or less. This water is of only temporary value to the grass; in fact it may be argued it is harmful water as it is excluding air from the pores.

Field capacity is the moisture content of the soil when all downward movement of water

Figure 2: The relationship between the tension exerted on soil water by the soil particles and the moisture content of a sand and a clay soil.

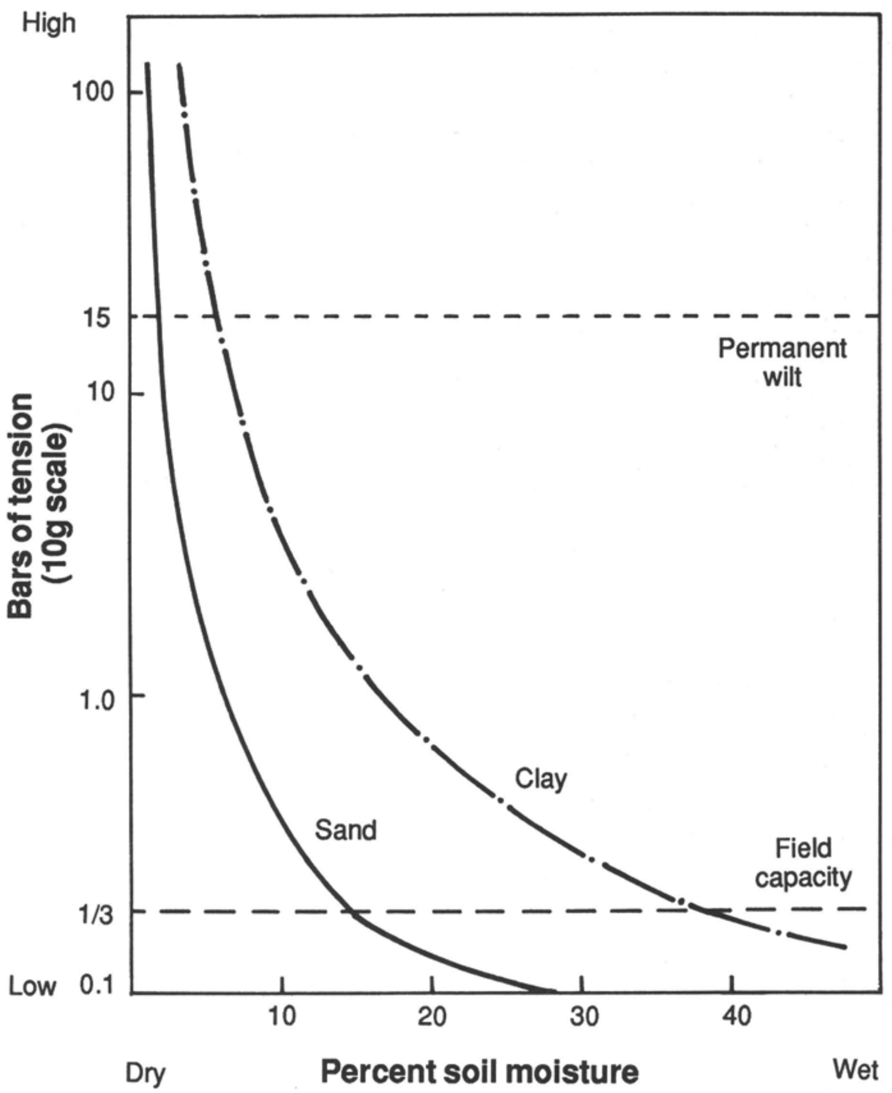


Table 1: Some values for the moisture content of soils of different textures, at three moisture constants and the amount of plant available water.

	Water content at the Moisture Constants of:			
Texture	**Retention Capacity**	**Field Capacity**	**Permanent Wilt**	**Plant Available**
		(% by Weight)		
Dune Sand	32.4	6.2	2.2	4.0
Loam	46.8	28.0	14.6	13.4
Silt	47.2	30.8	9.7	21.1
Clay	58.4	40.2	29.2	11.0

due to the pull of gravity has ceased. It is often called capillary water. At this moisture content only the micro pores are filled with water and the macro pores are filled with air. It is the ideal moisture content of the soil and the grass must exert a minimum amount of energy to absorb water. This moisture content will exist in a sports field during the first 24 hours after a rain or irrigation which thoroughly wets the top six inches. Evapotranspiration, however, causes the moisture content to continually decrease.

The permanent wilt point, as the name suggests, is the moisture content at which the grass permanently wilts and will not recover if the soil is rewetted. Actually this moisture level was initially established before modern techniques of soil physics, using sunflower seedlings which do not have the recuperative ability of turf grasses. At this point all but the very finest pores are filled with air. The grass can no longer exert sufficient energy to withdraw water from the soil; so it wilts.

These three special points on the moisture retention curve are called soil moisture constants because they are reproducible values which can be determined in the lab for any soil sample. Each soil sample, however, will have a its own specific curve so the value for the three constants will differ between samples. They are often referred to by other terms related to the energy required to extract the water. The common term in use today is bars of tension on the water. The higher the bar reading the drier the soil. Thus the maximum water retention capacity , having no tension, has a bar reading of zero. Field capacity has a bar reading of one/third and the permanent wilt point has a bar reading of fifteen.

The difference in moisture content between field capacity and the permanent wilt point is know as the plant available water. Water remaining in the soil at the permanent wilt point obviously is unavailable to the grass. Water in excess of field capacity is removed rapidly under good drainage so is of little value. As the soil becomes drier the energy required to extract water by the grass increases so it is a good practice to irrigate when the soil moisture is 1/3 or more of field capacity.

Generally it is desirable to have a soil with a high percentage of plant available water (Table 1). Sands always contain less plant available water than clays. It is interesting to note that silts contain more plant available or capillary water than loams although the water retained at field capacity is not greatly different. The spherical nature of silt particles, however, create a lower water content at 15 bar tension making the difference between the values for the two moisture constants greater. The combination of spherical shape and greater amount of easily held water contribute to the engineering problems with silt soils.

However, there are other factors which may require a sacrifice of some of the plant available water that a silt or clay will retain when choosing a soil for sports field construction. Among these is aeration. A sand will rapidly lose gravitational water and will seldom become anaerobic. □

BASEBALL DIAMOND CLINIC

Chingacousy Park, Central Parkway and Queen Street, E., Brampton, will be the venue for a baseball diamond clinic on Wednesday, April 29th, from 10 a.m. to 3 p.m. The event is being sponsored by Plant Products Co. Ltd. The clinic will consist of a discussion of diamond maintenance and the installation of Turface on a baseball diamond under the supervision of Ed Miller, retired Yankee Stadium groundskeeper.
Lunch will be served at no charge, ensuring that all attendees will be as rich in nutrients as they will be in baseball diamond maintenance knowledge.

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[This announcement does not constitute endorsement of the products by the Sports Turf Association.]