USE IT OR LOSE IT: BMPs FOR WATER MANAGEMENT

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U*se it wisely or lose it* should be the real slogan here. The goal is to provide turf with the right amount of water when it is needed and at the lowest cost and the least impact on the environment. There are negative consequences when turf receives too little or too much water. Not enough water can result in drought stress, thinning, localized dry spots and dormancy. Too much water, on the other hand, can result in shallow root growth, increased soil compaction, susceptibility to disease, leaching of nutrients, wet wilt and a waste of water due to runoff or drainage.

Turf & Water Interactions

A turfgrass plant is composed of 90% water. Water is also needed in every stage of plant growth. If water levels within a plant get below a critical level the plant will die. As little as a 10% reduction in turf water content may be sufficient to cause death. Water is needed for photosynthesis, cell division, temperature control and nutrient movement. The equation for photosynthesis showing the role of water (H_20) is below:

$$6CO_2 + 6H_20 \xrightarrow{\text{light}} C_6H_{12}O_6 + 60_2$$

Photosynthesis and cell division account for 1% of a plant's water needs. The majority of a plant's water needs are for temperature control and nutrient movement and these account for 99% of a plant's water need. All nutrients are moved into plants through the soil solution. This nutrient rich solution is taken up by the roots and transported via the xylem in solution. This movement occurs from the roots to all parts of the plant.

IMPORTANT
TABLES/FIGURES AVAILABLE
★ as an insert ★

Cooling of turfgrass plants is made possible because of water loss from the plant through transpiration (as a vapour). Ninety percent of the water loss is through the stomates. In a turf system, water is also lost from the soil through evaporation. There is a combined loss of water from the soil by evaporation and by the plant through transpiration and this is called evapotranspiration (ET). ET is difficult to measure, but it can be estimated. It is influenced by sunlight, soil and air temperature, relative humidity, wind speed, turfgrass species, height of cut of turf and rainfall. It is measured in inches/day, inches/week or mm/day. Evapotranspiration is used to calculate plant water requirements. It is estimated with a device called an evaporation pan. This gives the amount of water that evaporates from a flat shiny surface. It must then be adjusted for each crop and for each microclimate. One equation that is used to estimate plant water requirements is below:

$PRW = ET \times K_c \times K_{mc}$

PRW = plant water requirement
ET = evapotranspiration
K_c = crop coefficient
K_{mc} is the microclimate factor

Crop coefficients vary with each type of grass species and the height at which they are maintained. Most crop coefficients are based on seasonal averages. Some cool season turfgrass crop coefficients are listed in Table 1 (see insert).

Microclimates may also vary from area to area and for the purpose of this article, from sports field to sports field. The microclimate factor is a correction factor that relates to things such as proximity to buildings, paved surfaces, slope, shade and wind. A microclimate factor in a full sun sports field with heat reflecting and heat generating buildings nearby that is exposed to the prevailing winds would have a high K_{mc} and a microclimate with shade and no wind would have a low K_{mc}. In general there are three K_{mc} microclimate correction factors: high = 1.4, medium = 1 and low = 0.5.

An Alternative Method of Estimating Evapotranspiration

Some work done at the Cambridge Research Station by Dr. Robert Sheard came up with a way to estimate pan evapotranspiration based on observed weather conditions. This is an alternative method to having your own evaporation pan, which is easier, but may be a bit less accurate. Table 2 gives the estimated pan ET in millimeters based on weather observations at 1:00 pm.

A combination of the visual estimates of humidity and wind in addition to an observed temperature gives the estimate of pan evaporation. This then needs to be corrected for grass with the season correction factors found in Table 3.

ET calculation example:
Date – July
Sun – Sunny
Temperature – 27ºC
Humidity – low
Wind – low
Estimated pan evaporation from Table 2 (7.5) x seasonal correction factor from Table 3 (.75) = estimate of grass ET (5.5 mm) for that day.

Soil and Water Interactions

The amount of water a plant needs is influenced by soil particle size, soil particle size distribution (soil classification) and root zone depth. Soils can be classified according to their particle size into sand, silt and clay. Sands can be further divided into five categories: very fine sand, fine sand, medium sand, coarse sand and very coarse sand. Table 4 shows the particle size diameter of coarse sand down to silt and clay.

For every field that you are responsible for irrigating within your municipality, it is very important to know the soil classification or particle size distribution of that field. Without this information, it is almost impossible to accurately deliver the right amount of irrigation. One way of obtaining this information is to have a soil laboratory run a soil texture analysis of every field. This is a useful exercise and only needs to be done once in the life of a sports field. A cheaper and quicker method is to simply use the mason jar test and a soil texture triangle. Just follow the steps below. Figure 1 shows a mason jar with roughly 80% sand and 20% silt.

1) Fill a mason jar 1/3 full of a random sample of soil from one field.
2) Pack it down and mark the level with a permanent marker.
3) Add water to fill the jar 3/4 full.
4) Shake vigorously.
5) Let sit for 5 minutes.
6) Measure the sand layer (the one on the bottom of the jar) as a percent of the depth of the original soil.
7) Measure the silt layer (the one above the sand layer) as a percent of the depth of the original soil.
8) Add the percent sand and percent silt together and subtract that from 100 to get percent clay (the clay is still suspended in the water).

Figure 1: Mason Jar Test

Now that you know that you have an 80% sand and 20% silt soil you can go to the soil texture triangle (Figure 2) to determine the soil classification. Follow the percent sand arrow over to 80 and follow the % silt down to 20 and follow each of those lines to the point where they intersect. In our example, we end up in the loamy sand area of the triangle. Soil texture affects plant available water and water infiltration rates. Both of these are important factors in determining efficient irrigation scheduling.

Infiltration rate is a measure of how quickly water enters soil. It is greatest at the beginning of an irrigation event or rainfall event and again it is influenced by soil texture. Infiltration rates of each soil or each field can be measured in one of two ways. A double ring infiltrometer is the most accurate way of measuring infiltration rates. Another way is to simply put on the irrigation system and measure the time until runoff. Infiltration rates can also be estimated if you know the soil texture. Table 5 gives a list of the basic infiltration rates of six different soil classifications.

Another important aspect of a soil is its available water. This is the amount of water stored in a soil between field capacity and permanent wilt. Another way to think of it is the amount of water that the plant can extract from the soil. In fine textured soils such as a clay loam, some of the water is held so tightly onto the soil particles that it is not available to the plant. In a coarse textured soil, some of the water applied to a soil is not available to a plant because it is lost through drainage. Table 6 gives the available water in mm based on soil texture. If you are using the calculation based on soil texture, the plant available water is the available water multiplied by the active root zone depth. There are two instruments that can be used in the field to measure plant available water: a time domain reflectometry probe (TDR probe) and a frequency domain reflectometry probe (Theta probe). Both of these methods measure volumetric water content.

Plant available water is the available water which can be measured in the field or it can be calculated based on soil texture. To calculate plant available water:

Plant available water = available water (from Table 6) x root zone depth

Example:
Sandy loam soil with a 300 mm root zone
Plant Available Water (PAW) = (available water from Table 6) 0.12 mm water/mm soil x (soil root zone depth) 300 mm soil
PAW = 36 mm water

Another important concept in the field of irrigation is how much water can be depleted from a soil before there are adverse affects to the plant. This is called the maximum allowable depletion. In general, it is agreed upon that if plant available water is allowed to deplete to 50% before re-applying water that there will be no harmful effects on the turfgrass plant.

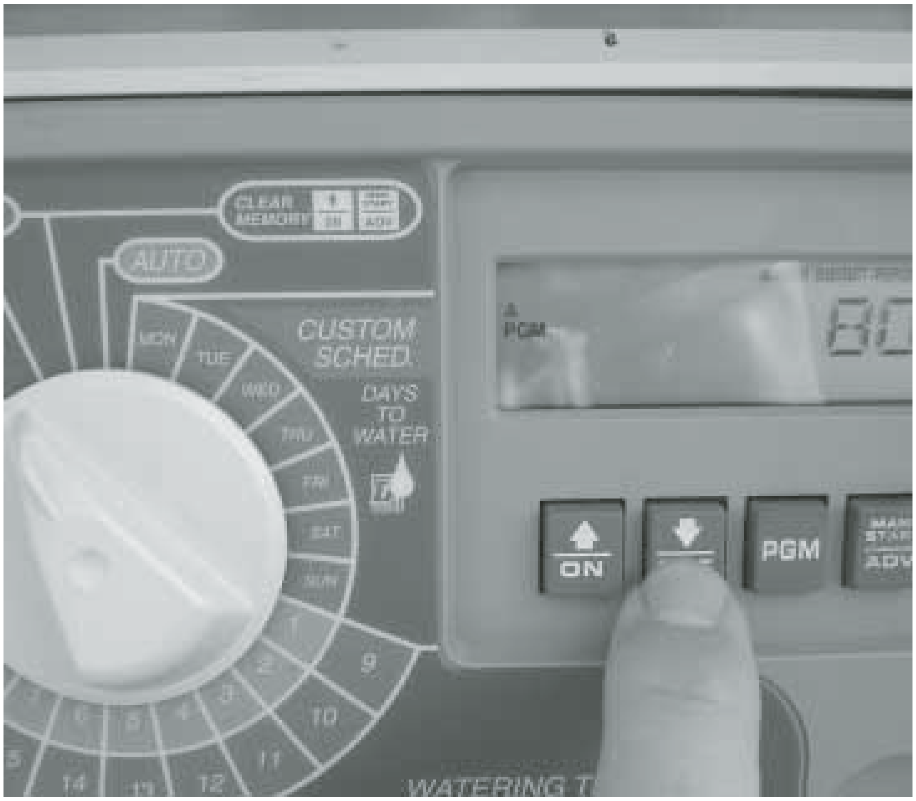
Below is an example to help put all of the pieces together. Table 7 shows an example of a water budget. The assumptions in the example are:

- A sandy loam root zone
- Rooting depth 300 m
- Plant available water is 300 mm x 0.12 mm/mm = 36 mm
- Want to irrigate when 50% of available moisture is depleted (ie. at 18 mm)
- Assume field capacity on day 1 = 36 mm plant available water

This example shows that this particular field, when ET rates are high, the field needs only to be irrigated every second or third day.

Sprinkler Performance

Now that the plant side is taken care of, let us look at irrigation system performance. In order to irrigate efficiently, you must have an irrigation system that is performing properly. Irrigation system performance can be determined by an irrigation audit. This can be done in-house or you can hire an irrigation auditor to perform it. An irrigation audit will ensure that all sprinkler heads are level and that the pressure is relatively uniform. It will also determine the distribution uniformity (DU) of the irrigation system and this is calculated by measuring catch device volumes in the field. An irrigation audit will also determine the precipitation rate (PR). This is the rate at which water is applied per unit time (in/hour or mm/hour) and it is often referred to as the application rate. With this information you can determine your run time multiplier and finally your maximum run time cycle.



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Irrigation Scheduling

The next question should be "How long do I have to run my irrigation system to deliver 14 mm or 24 mm of irrigation?". If you have performed an irrigation audit, you can easily determine your run time. To determine this you need to know the following:

- run time multiplier (RTM)
- distribution uniformity of the lower quarter (DU) (from irrigation audit)
- precipitation rate (PR) (from irrigation audit)
- base run time(RT_b) RT_b = plant water requirement/precipitation rate x 60.

With the above information you can then:
- calculate the adjusted run time (RT_{adj}). $RT_{adj} = RT_b$ x RTM
- calculate the maximum run time/cycle = infiltration rate/precipitation rate x 60

The run time multiplier is a correction factor that is used to compensate for non-uniformity of distribution of an irrigation system. Run time multipliers can be found in the Certified Golf Irrigation Auditor workbook put out by the Irrigation Association and they can also be found on the internet. The infiltration rate can either be estimated based on soil texture or you can determine it with a double ring infiltrometer as discussed earlier in the article.

Example run time calculations based on the water budget example above:
- Base run time RT_b = PWR/PR (24 mm/ 15 mm (from irrigation audit) x 60) = 96 minutes
- Adjusted run time RT_b x RTM (96 x 1.22 = 117 minutes)
- Infiltration rate – 14 mm (from Table 5)
- Maximum run time/cycle
- Infiltration rate/precipitation rate x 60 = 14 mm per hr/15 mm x 60 = 56 minutes
- The maximum time this zone should be run to avoid runoff is 56 minutes. Basically, two run cycles of roughly 56 minutes will deliver the required amount of water to recharge the root zone in this water budget example.

Irrigation Checklist

This checklist below gives a quick overview of the information and/or equipment needed to be able to apply the right amount of water to turf.

1) Determine soil texture of each irrigated field (mason jar or lab).
2) Make note of the infiltration rate (based on soil texture, double ring infiltrometer or observation of time to runoff) and available water (based on soil texture) and root zone depth for each field.
3) Calculate plant available water = available water x root zone depth.
4) Perform an irrigation audit to determine precipitation rate and distribution uniformity.
5) Keep track of ET rates based on temperature, humidity and wind.
6) Have a method for measuring rainfall and a rain shut off feature.
7) Use the water budget to schedule irrigation.
8) Use run time calculations to determine how long to water.
9) Schedule to water only in early morning (low wind and less evaporation).
10) Ground truth by inspecting fields to make sure the turf is getting adequate water and that there are no over-watered, under-watered areas or localized dry spots.
11) Have a dedicated knowledgeable staff person in charge of irrigation.
12) Don't forget other cultural practices for maintaining healthy turf:
- Mow as high as possible and frequently enough to maintain a stress-free plant.
- Alleviate compaction (core aeration, etc.) which helps maximize infiltration rate.
- Control thatch.
- Fertilize according to the plant's needs.

Abbreviations

DU =	disribution uniformity
ET =	evapotranspiration
K_c =	crop coefficient
K_{mc} =	microclimate factor
PAW =	plant available water
PR =	precipitation rate
PWR =	plant water requirements
RTM =	run time multiplier
RT_{adj} =	adjusted run time
RT_b =	base run time

References

1) Carey, K. C., 2001. Irrigation Scheduling Principles: Tools for Dry Times. *Sports Turf Newsletter*, Vol. 14, pp. 6-7.
2) Irrigation Association, 2004. *Certified Golf Irrigation Auditor*, pp. 65-82.
3) Sheard, R.W., 1992. A Water Budget for Irrigation Scheduling. *Sports Turf Newsletter*, Vol. 5, pp. 5-7. ♦