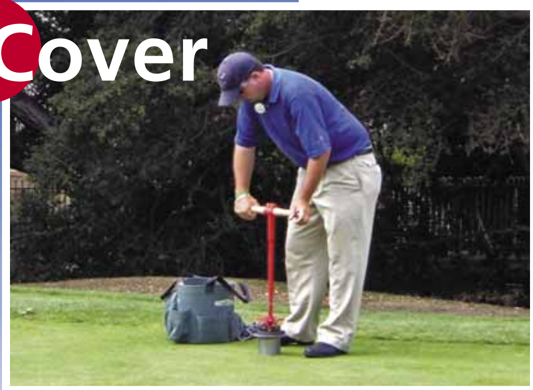

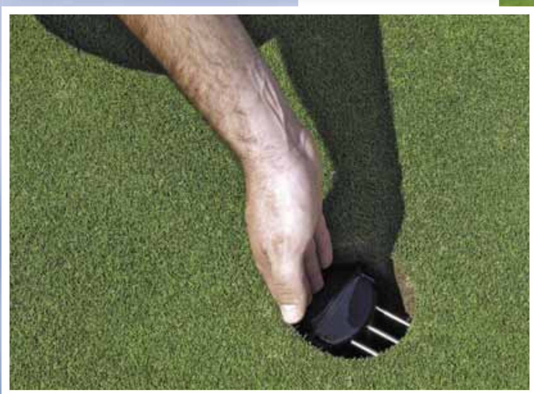

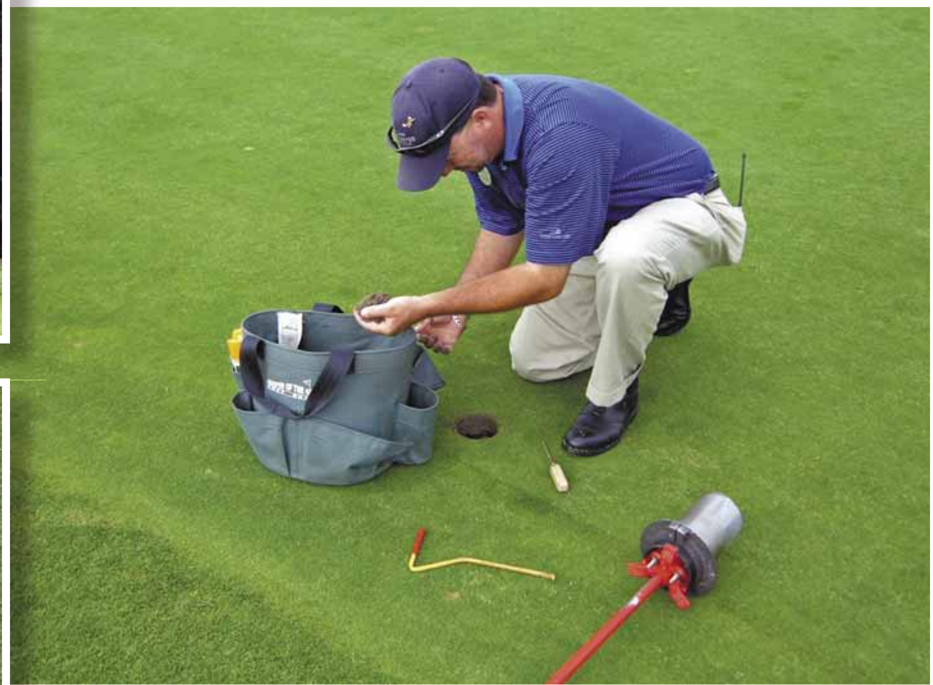

PHOTOS COURTESY OF THE TORO COMPANY.

A cup cutter is used to create the hole for the Toro Turf Guard wireless sensor. Once the sensor is properly placed in the hole, it is filled in with soil and then the topped off with the turf plug.

Water Management

Utilize technology to monitor soil moisture

by Aaron Johnsen

Soil moisture sensing technology can detect small changes in soil moisture. The benefits of using soil moisture data include improved turf quality, consistency between locations, improved hand watering and overhead irrigation, disease prevention, optimized water usage and increased time between irrigation cycles.

Soil water basics

Water exists in the soil in three general categories: gravitational, capillary and hygroscopic. Gravitational water is present in the large pores of a soil, and it freely moves through the soil due to gravity. Gravitational water is not available to the plant. Capillary water is held close enough to the soil particles where gravity does not move the water. Capillary water is available to the plant. Hygroscopic water is held so close to the soil particles that gravity and plants cannot move the water. The intersection between gravitational and capillary water is considered field capacity. The intersection between capillary and hygroscopic water is considered the wilting point.

Soil moisture measurement

Soil moisture can be measured as soil matric potential or water content. Soil matric potential is the measurement of the suction force required to move water from the soil into the plant roots. Tensiometers and electrical resistance blocks are the most popular tools for measuring soil matric potential. These sensors can be used to measure a wide range of soil depths and typically cost less than $100. Tensiometers require a user to read the sensor in the field. Electrical resistance blocks require no maintenance, but are not as accurate when the soil is very wet.

Water content can be measured volumetrically or gravimetrically and is reported as a percentage. Volumetric water content is a measure of the volume of water in the soil. Gravimetric water content is a measure of the weight of water present in the soil. Gravimetric water content is not measured with sensors, but with manual methods. Volumetric water content can be measured with manual methods or sensors and is the most common measurement form used by soil moisture sensors that superintendents might use.

Continued on page 12

Water Management

Continued from page 10

The field capacity and wilting point on a volumetric water content scale differ for each soil type. For example, pure sand has a wilting point near 5 percent and field capacity near 15 percent, while clay soils have a wilting point near 22 percent and field capacity near 45 percent. Most soils meeting USGA specifications have a wilting point near 8 percent and field capacity near 25 percent.

Since soils vary, superintendents should calibrate their sensor to the soils they want to measure. This can be done simply by recording soil moisture measurements in an area where the turfgrass is wilting and where the soil is very wet. Both measurements must be collected in the same soil texture. These two measurements will give a good idea of the wilting point and field capacity of the soil. To get a better idea of the soil moisture parameters, excess water should be applied and allowed to drain for two hours. Measurements should then be collected periodically over time until the turfgrass wilts. As with all research, the more data points collected, the better. It is reasonable to collect four measurements a day. The upper value will be near the field capacity, while the lowest number will be the wilting point of the soil.

Selecting a sensor

Selecting a soil moisture sensor can be a difficult process. Understanding your needs goes a long way toward narrowing the choices. Do you want data available whenever and wherever you are? Do you want to collect measurements in several areas or just a couple? At what depths do you want to collect soil moisture? There are three categories of soil moisture sensors: inground wired to a data logger, inground wireless and portable.

PHOTO COURTESY OF SPECTRUM TECHNOLOGIES, INC.

An example of an inground sensor wired to a data logger.

Inground sensors wired to a data logger, such as Irrometer's Watermark, provide accurate soil moisture measurements at the lowest cost. Soil moisture sensor packages start at $200, and each additional sensor costs $75 and up. These sensors have wires running underground, which must be removed for certain maintenance practices, such as aerating, and with basic models, data can only be retrieved by going into the field. If you want to get data via the Internet, a wired or wireless connection from the data logger to a computer is needed. This adds $1,000 or more to the cost. Inground sensors wired to a data logger are best used when measurements are desired at depths greater than 12 inches.

PHOTO COURTESY OF IRROMETER CO., INC.

Watermark soil moisture sensors are placed in the active portion of the rootzone.

Inground wireless sensors, such as the Toro TurfGuard or Advanced Sensor Technology's UGMO system, have the same capabilities as inground sensors wired to a data logger, but they cannot be placed as deep. Inground wireless sensors eliminate the issue of wires in the ground, but they still must be removed for certain maintenance practices. With these sensors data is sent wirelessly to a computer. Soil moisture sensor packages start at $4,000 for one sensor, and each additional sensor costs approximately $1,000. An added benefit of inground wireless sensors is they often measure temperature and salinity.

Portable soil moisture sensors, such as Spectrum Technologies' TDR 300 and the Dynamax TH$_2$O start at around $750. Portable sensors are configured to be inserted into the ground for a measurement and then removed. This eliminates maintenance issues that occur with field-installed sensors and allows soil moisture measurements to be collected at any location and time. On a negative side, this flexibility requires a user to collect the data. Data collected with portable soil moisture sensors is immediately displayed for the user. High-end models store the measurements in a data logger, so they can later be downloaded to a computer.

Using soil moisture data

The first step to using soil moisture data is to set the optimum soil moisture. For example, if the wilting point of a soil was 10 percent and the field capacity point was 25 percent, I recommend that you set your optimum soil moisture at 20 percent. A good high point would be 22 percent and low point would be 18 percent.

Inground soil moisture sensors are best used for scheduling irrigation. To schedule irrigation, wait until the average soil moisture drops to your low point, and then irrigate until you reach your high point. You will quickly learn whether your selected parameters result in the desired turfgrass conditions. As you gain confidence in the method and your numbers, you can adjust them to attain the optimum field conditions. I often find that superintendents lower their optimum number quickly as they gain confidence in the measurement. It is important to understand that the more measurements across a site, the more accurate the irrigation scheduling. When placing inground sensors, it is best to start with one sensor in a consistently dry location, one in an average location and another in a consistently wet area. All locations should have a similar soil texture and be under similar management. If more sensors are used, those should be placed in areas under different management or with a different soil texture. At a minimum, I recommend three sensors on a site.

> Since soils vary, superintendents should calibrate their sensor to the soils they want to measure.

Portable soil moisture readings are effective for scheduling hand-watering activities. One method is to have someone collect soil moisture measurements and highlight the areas on a map that are below optimum. That map can be used by the person hand watering. Another popular method is to send a sensor with the person who is hand watering to look for dry spots and then immediately apply water. Portable soil moisture sensors can also be used to schedule irrigation. To do this, measurements are collected over time in the same location, and that data is used just as inground sensor data to schedule irrigation. This method of scheduling irrigation is time consuming compared to using inground sensor data.

With increasing demand to demonstrate environmentally friendly practices, reduce water use and still produce quality playing conditions, superintendents need to manage water precisely. Soil moisture measurement technology has great potential to improve water management. Ideally, a golf course would have three or more inground soil moisture sensors to schedule irrigation and two or more portable soil moisture sensors for hand watering and spot-checking areas.

Aaron Johnsen is an adjunct lecturer at the University of Wisconsin-River Falls and owner of Turf Intelligence LLC, where he uses measurement technology to diagnose problems and develop maintenance plans. He can be reached at turfintel@yahoo.com or www.turfintel.com.