IRRIGATION MANAGEMENT

Sustainable Turfgrass Management in Asia 2013
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INTRODUCTION

Water is a valuable and often a scarce resource that must be managed responsibly and used efficiently and is a considerable cost on all golf courses, whether it is the direct cost of the water supply or the cost of pumping it. A high degree of irrigation efficiency and therefore making the most of the available water is a function of; good system design, flexible control, maintenance of the irrigation system, understanding plant water use requirements and good turf management.

IRRIGATION DESIGN

Good design, installation and maintenance of irrigation systems ensure uniform and efficient distribution of water, thereby conserving water and protecting water resources. There are numerous technologies available that can be incorporated into design to assist in achieving high water use efficiency. These technologies can be grouped broadly into the following categories; water application and irrigation scheduling.

Connellan (2007) detailed several key criteria for irrigation system design that allows for optimizing water use efficiency;

Valve in head sprinklers: The ability to deliver water effectively to each area of the golf course, which has its own water requirements (due to shade, aspect, soil type etc.), is possible using valve in head sprinklers. The combination of valve in head sprinklers and sophisticated controllers can deliver a high degree of application efficiency.

Improved sprinkler uniformity: A fundamental requirement of any sprinkler irrigation system is that it be designed to apply water uniformly and that the system be maintained to ensure ongoing high standard performance. Technological developments that have improved uniformity include sprinklers with distribution profiles that achieve higher Distribution Uniformity (DU) values and nozzle designs that reduce wind distortion.

Data on uniformity testing: The Center for Irrigation Technology, Fresno, provides comprehensive test data through the "Space" program. New irrigation systems can be designed to high uniformity standards and replacement sprinkler heads can be selected on the basis of detailed uniformity results. As a guide, uniformity values of not less than DU 85% should be selected.

Nozzle replacement: The wearing of metal nozzles can significantly affect the system performance and the consequences include higher flows, lower uniformity, less than optimum operating pressure, excessive pipeline friction and increased pumping costs. In a study conducted by the Center for Irrigation Technology, Fresno, (Zoldoske, 2003) it was reported that golf courses replacing nozzles improved uniformity and reduced water consumption by an average of 6%

The golf course maintenance program should include a policy that replacement nozzles are matched to original design sizes.

Adjustable trajectory nozzles: The ability to adjust the vertical alignment (for example, 7º to 30º) of the sprinkler nozzle has application in some golf situations. Vegetation obstructing stream distribution, windy conditions and sloping ground slope can all negatively impact on system performance. These situations can be potentially accommodated through on-site adjustment of the nozzle.

Watering zones – dual sprinkler design: There is a move towards more defined targeted watering of areas that have unique watering requirements such as the use of dual sets of sprinklers around golf greens to water the putting surface and the surrounds independently.

IMPROVED SCHEDULING EFFICIENCY

Weather stations and ET based Irrigation scheduling: Irrigating according to plant water is critical in achieving efficient water use. The irrigation decision making process should be based on the ET (evapotranspiration) rate of the turfgrass species.

A weather station that measures all relevant climate factors (such as solar radiation, air temperature, wind speed and relative humidity) is an excellent means of fine tuning irrigation scheduling.

Soil moisture sensors: Soil moisture sensor technology has the potential to provide turf and landscape managers with up to date, accurate readings of the moisture level within the soil profile. Trials carried out on turf at University of Western Australia demonstrated savings in the range of 25% compared to current industry best practice (Pathan et al, 2003).

For the turf manager the sensor needs to provide representative and accurate readings of the soil moisture level (tension or water volume), be reliable and be suited to turf management practices at the site. These requirements are quite demanding as the irrigation and soil conditions can vary considerably and the root zone is relatively shallow so the sensing device needs to be in close proximity to the surface (risk of damage from ground machinery/equipment).

For the golf course manager the soil moisture sensor can provide valuable information not only to directly assist with control decisions (timing of irrigation) but also on rates of turf water use, turf stress due to low moisture or water logging, effectiveness of irrigation application and rainfall and drainage rates.

Salinity and temperature sensors: As a consequence of using treated effluent water and other high salinity water sources, there is a greater need to monitor the water, soil and vegetation. Sensors that measure the salinity are now in more common use, particularly with the availability of wireless communication.

Controller developments (central control): Irrigation controllers continue to develop in terms of programming capacity, flexibility, output function and communication capability.

Central control has become the industry standard and some of the key functional developments in recent years include:

- Cycle and soak to ensure effective water penetration.
- Pump Station monitoring and the ability to react to pump or station failure.
- Switching programs for multiple water supplies where slightly more saline water, or less desirable water can irrigate fairways and the better quality placed on the greens.
- Chemical dosing such as fertilisers, wetting agents and acids for balancing pH levels.
- For multiple site systems, global programming for things such as quick shut down that saves not only water resources but energy and manpower resources.

The modern irrigation controller allows the integration of all of the factors and systems that may impact on irrigation decision making. Features offered by manufacturers include ET calculation, rainfall measurement (totals and instantaneous rates), pumping system optimization, flow control optimization, graphics with integrated site, vegetation and irrigation, GPS based mapping data incorporated, on screen operation, single head operation, individual valve and head status report and compatibility with latest Microsoft operating environments.

Monitoring, alarms and reporting: The capacity to monitor and record the environmental conditions and the system operation is becoming increasingly important in golf course water management. Alarms that indicate malfunction assist with both equipment safety, prevention of waste and fault finding. Irrigation systems, which consist of many functioning components, require ongoing monitoring and regular maintenance.

The correct functioning of sprinklers, sprays and valves also needs to be constantly monitored to ensure that flow and pressure is correct. Flow and pressure sensors, strategically positioned throughout the system, allow the irrigation to be monitored and action taken to alleviate problems. Monitoring of the system also provides valuable information (e.g. water volumes) that can be used to evaluate the performance of the irrigation.

Reports that include water consumption and are linked to historical weather data are invaluable in assessing the performance of the irrigation.

Pump Stations: With the introduction of Variable Frequency Drive (VFD) technology over the last 10 years there has been constant improvement in the configuration, the components and the way they are controlled.

Pump station output can be accurately matched to the hydraulic demand in the field and thereby savings in energy use, wear and tear on pumps and most significantly softening" the impact on irrigation systems due to ramp up and ramp down capability when starting and stopping.

Controls can now have advanced graphical interfaces for better visual understanding of the operation of the station but of more significance the protection, remote monitoring, reporting and notification of problems is easily achieved.

IMPROVING IRRIGATION EFFICIENCY

The efficient use of the available water supply is not only environmentally responsible but also affects the quality of the playing surfaces. More water does not result in better turf quality.

Irrigation systems can be inefficient for several reasons.

Factors affecting irrigation efficiency include:

- Poor sprinkler uniformity
- Leaks (e.g. from valves, pipework, sprinklers)
- Inadequate operating pressure
- Malfunctioning valve
- Sunken sprinkler heads
- Incorrect nozzles
- Incorrect rotation of sprinkler heads
- Inadequate control system

These all contribute to the ineffective application of water and uneven watering. As a result, the system will be operated to pick up dry areas, which in turn will result in the over-watering of other areas. This not only wastes water, it also results in a turf of uneven health and quality as a playing surface.

The performance and management of the irrigation system must be evaluated on a regular basis (Connellan 2000). This includes both the performance of the irrigation system (i.e. the mechanics of the system and how uniformly water is applied) and how well the system was managed over the irrigation season (i.e. the amount of water applied compared to the amount that should have been used).

IRRIGATION MANAGEMENT INDICATOR

The quantitative measure of how much water is applied versus the demand can be used both as a post-mortem of the water use for the previous season and as a prediction of the expected water use for the season ahead. The irrigation index is a seasonal performance indicator that can be used to compare the amount of water actually used versus the estimated quantity required (Connellan 2000). It is expressed as follows:

$$\text{Irrigation Index (I)} = \frac{\text{Water applied to site}}{\text{Estimated water required}}$$

The amount of water applied can be easily determined from total water consumption at the site and the size of the area being irrigated. To assist in this process, regular meter readings should be taken. Modern pumping and control equipment will also provide this information.

The estimation of water required or plant water use is the estimation of the amount of water that should have been used by the site over a particular period or season and is somewhat more involved; however, the basic information is readily available. Plant water use or evapotranspiration (ET) can be calculated using local climatic data and, in particular, evaporation from an A-pan evaporimeter.

$$\text{Plant water use (ET) in mm} = E_{pan} \times \text{Crop Factor (CF)}$$

The value of CF will vary depending on the turf type, available soil water, management practices and most importantly the quality of turf required. Crop factor and turf quality relationships are provided as follows;

- CF = 0.8 + is used for bermudagrass that is very green and at a very high level of presentation. It does not necessarily relate to optimum putting quality.
- CF = 0.7 is used for bermudagrass that is green and at a high level of presentation. This is typical of tees, the aprons and surrounds of greens and firm/fast putting surfaces.
- CF = 0.5 is considered the minimum water requirement for bermudagrass while providing reasonable “greenness” and a good playing surface.
- CF = 0.25 is considered the minimum amount of water for bermudagrass survival while maintaining a playable surface.

Rainfall needs to be factored into the water requirement equation and, most importantly, the amount of rainfall actually used or available to the plant, i.e. the effective rainfall. The effective rainfall is that proportion of the rainfall that is used by the plants after all the rainfall losses have been taken into account. The main factors to consider are:

- Rainfall in excess of soil storage capacity is lost through drainage beyond the rootzone.
- Rainfall intensities greater than the infiltration rate of the soil will result in some runoff.
- Very small amounts of rainfall will add very little water to the rootzone due to losses by evaporation from the turf surface. Rainfall of less than 2 mm can be ignored.

The irrigation requirement to satisfy plant requirements can then be expressed by:

Net Irrigation Requirement (IR) in mm = ET – Effective Rainfall

Due to inefficiencies, the sprinkler system needs to apply more water than the estimated irrigation requirement (IR). Some water is lost due to wind drift and evaporation, some may drain below the rootzone and there is always unevenness in application. The system efficiency, which accounts for the losses, can range from 50% to 90%, with a minimum acceptable efficiency of 80%. The water required can then be calculated as follows:

$$\text{Water required in mm} = \frac{\text{Net Irrigation Requirement (IR)}}{\text{System Efficiency (use 75\% as a minimum)}}$$

The various Bureaus of Meteorology have excellent websites where climatic averages are available for various locations. This information can provide a very good predictive model.

As an end-of-season assessment of irrigation efficiency or on a month-by-month assessment, the irrigation index should be calculated and ideally will be about 1.0.

SPRINKLER UNIFORMITY PERFORMANCE

It is not possible to achieve efficient irrigation if the water is not applied uniformly. The ‘catch can’ test is used to determine sprinkler uniformity. Cans are placed at regular sprinkler intervals within the sprinkler pattern and the system is then run for sufficient time to ensure that a measurable amount of water is collected (figure 1). The preferred measure of uniformity for turf is DU (Connellan 1997). The DU places emphasis on areas of turf that receive low amounts of water and is calculated by comparing the average of the lowest 25% of can readings to the overall average. The equation is as follows:

$$DU\ (\%) = \frac{\text{Lowest 25\% of readings}}{\text{Average of all readings}} \times 100$$

A DU greater than 85% is considered acceptable for turf sprinkler systems. The can test not only provides information on system uniformity, it also gives a precipitation rate in millimetres/hour. Too often, irrigation is scheduled on run times in minutes, rather than the amount of water applied.

MAINTENANCE PRACTICES WHICH CAN ENHANCE EFFICIENT WATER USE

Plant water use is not only species and variety related but can also be manipulated by the way the turf sward is managed. Mowing height, fertilising, irrigation strategy and cultivation all affect water use.

Controlling growth: Slow vertical leaf extension leaf (i.e. vertical growth rate) is an important component of water saving strategies. Excessively vigorous growth is related to increased photosynthesis and therefore increased water use.

Mowing: The mowing frequency should be kept to a minimum, however, this depends on the quality of the surface and type of use. The more frequently grasses are mown the greater is their water use. More importantly is the quality of the cut in that grasses mown with mowers that are dull, improperly sharpened and poorly adjusted have a greater rate of water use due to the mutilation of leaf tissue.
By raising the mowing height, particularly on areas that don't have an exacting surface requirement stimulates a deeper root system which will give a stronger plant with greater water scavenging potential.

Fertilising: The application of nitrogen fertilisers stimulates leaf growth and with an increase in leaf extension there is an increase in evapotranspiration. Only sufficient nitrogen should be applied to maintain satisfactory turf quality. Excessive applications of nitrogen produce excessive leaf growth to the detriment of root growth and depth.

Another important nutrient affecting water use is potassium. Potassium hardens the plant giving it greater heat and drought tolerance and improved wearability.

Root system development: It is desirable to have a deep, healthy root system and a large volume of roots so that maximum exploitation of the available soil water can occur. A deep, extensive root system not only allows better water use but improves heat and drought tolerance.

Spot watering: Hand watering of localised dry spots is a common practice on golf greens and assists in maintaining a more uniform surface without over-irrigating areas that do not require water. With valve in head sprinklers it is also possible to spot water dry areas without the need to turn on multiple sprinklers unnecessarily.

Soil management: Soil conditions that restrict root growth and depth such as compaction and soil layers must be avoided. In compacted soils there is an increase in the roots in the surface few centimetres and a dramatic decrease in deep root-growth.

Soil layers and compaction restrict water penetration and increases the risk of water loss due to run-off. Management practices must be undertaken to improve soil conditions so that deep root systems are encouraged. Poor soil conditions usually require more frequent, light irrigations in order to maintain surface quality (e.g. not too soft). This increases the opportunity for water wastage, deterioration of root systems and reduced turf vigour and health.

Compacted layers can be broken up by slicing, coring and vertidraining. Breaking compacted layers increases soil porosity, stimulates root growth and improves water penetration. On heavy clay soils, gypsum can also be incorporated to help improve soil structure and reduce compaction.

Organic matter control: Turf swards accumulate dead plant matter in the form of thatch and root mat. This highly organic material restricts water movement into the profile and has very high moisture retention, therefore resulting in soft and wet surfaces. Excessive organic matter when it dries out also becomes hydrophobic and becomes very difficult to wet up.

To improve water penetration and plant health, regular scarifying, sand topdressing, dethatching and hollow coring is required. Wetting agents (surfactants) are highly effective on hydrophobic soils and thatch as well improving the evenness of water penetration on a range of soil types. Wetting agents can be applied on golf course fairways through direct injection into the irrigation system.

CONCLUSION

Making the most of the available water for irrigating golf courses is a combination of; good system design, flexible control, regular maintenance and auditing of the irrigation system as well as having a good understanding of plant water use requirements. Turf management also strongly influence water management and water use efficiency. The effective use of the available water resources cannot be achieved without considering all of these aspects. If one or several of these aspects is neglected, efficient water use cannot be achieved.

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