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Are we ready for another drought? Undoubtedly, this question hangs on the lips of every greenkeeper, with water conservation issues of such national importance. Consultant Agronomists JOHN HACKER and MIKE HARBRIDGE conclude their observations on irrigation with some timely advice on estimating water needs

Despite the rain and snow we had this winter it is more than likely that certain parts of Britain will be in drought again this summer. For those of us who get our water supplies from lakes and reservoirs, there is usually more than enough rainfall. This year, however, even in the North West, the reservoirs were still not full at the beginning of March. In southern regions where water is taken from underground aquifers, rainfall was still below average before Christmas. It was only the January rainfall which led to drought orders being removed in certain regions.

Whilst we do not know how much it will rain in the future, it is clear that reserves are lower than normal. If we get another dry summer we may be restricted in the use of water sooner than we would like. Getting irrigation rates correct not only ensures a green course but conserves water supplies for everyone.

'How much water should I apply' is perhaps THE question on every greenkeeper's mind. Indeed, it is the most difficult to answer because there are so many variables which need to be taken into account – many of which the greenkeeper cannot control. Here are the major points which need to be considered before irrigation of greens, tees or fairways.

To be able to estimate water requirements for turf it must first be known at what stage a lack of water becomes detrimental to grass growth and survival. To allow soil water to deplete so much that the grass dies (permanent wilting point) would obviously be foolish. However, should the soil be kept at field capacity, the point at which soil is most susceptible to destructuring and compaction? Clearly there exists a mid-point when adequate growth will occur without the extreme repercussions of either too much or too little water.

Unfortunately, little research has been undertaken on this subject in Britain although some has been conducted abroad. For the British greenkeeper the most common, and subjective, method of water requirement is a visual assessment. This is based on the reaction of the grass plant to water stress and the experience of the greenkeeper. Drought symptoms include:

- A darkening of grass colour.
- Footprinting – grass taking time to stand up again after being walked upon.
- Reduction in grass clipping production.
- Localised drought on high spots prior to droughting in other areas.

By using these visual warnings and by examining soil cores the experienced greenkeeper can make an estimate of when water may be needed. However, it is difficult for him to know how much is needed or indeed whether stress was caused to the grass before the drought symptoms were noticed and water applied.

To be able to predict drought we need to be able to measure the depletion in soil water before it causes visual symptoms to occur. Fortunately there are several ways of measuring this:

- Monitoring the Soil Moisture Deficit (SMD) – the amount of water necessary to bring the soil back to field capacity.
- Using soil tensiometers.
- Using soil electrical resistance sensors.

ng ● Water-injection cultivation ● Storing water ● ...and the seasonal issue:

DROUGHT

Clay soil: holds a lot of water and cracks when dry;

Drought symptoms: footprinting on a tee

- Using heat sensors.
- Using the plant.

All of these methods allow you to apply water at a predetermined deficit or tension. However, knowing what that predetermined level should be for a given location poses a real problem.

Soil moisture deficit

The Ministry of Agriculture has found that the growth of agricultural grass swards is reduced once the SMD exceeds 25mm and is substantially reduced at 50mm deficit on soils. So once the SMD is between 25-50mm it is necessary to irrigate to bring the SMD back above 25mm but not to field capacity (zero SMD). True, this has been suggested for agricultural grasses and its suitability for golf green swards is open to question. However, it's the best guide-line for SMD we have so far. How then can the SMD be estimated? The usual way is to compile a Water Balance Sheet.

Water balance sheet

A water balance sheet (see diagram) attempts to balance water inputs (rainfall) with water losses (evapotranspiration, or ET). The difference between the two will be shown as either drainage or run-off (if rainfall is greater than ET), or as the SMD (if ET is greater than rainfall).

Rainfall can be measured by the greenkeeper on site or obtained from the local weather station. The ET can be taken from MAAF reference book 435 and adjusted weekly with the known value for potential transpiration – available from the Met Office through ADAS. Some irrigation systems use a mathematic equation to determine an estimated ET rate based on climatic data.

An SMD figure should be predetermined at which irrigation is to be applied, for instance the greenkeeper can decide to apply 25mm of water when the SMD reaches 35mm. This will return the soil to 10mm SMD, which is below field capacity but high enough to prevent drought symptoms from occurring. Research from abroad has suggested that 60%-65% of nett evaporation should be applied as irrigation. For instance, if the rainfall for a week (say 15mm) is deducted from the evaporation for that same week (say 75mm) then the nett evaporation would be 60mm. Applying 65% of this would mean irrigating with 39mm of water during the following week. In the first example of a SMD of 35mm this would mean applying 22.75mm of water.

In the diagram, hypothetical gains and losses of water have been monitored from spring, showing a SMD on July 1st of 30mm. Showing the gains and losses for one week, there is an initial loss of 5mm in the first two days, taking the SMD over the 35mm mark, at which point the greenkeeper decides to irrigate the next day. On the 3rd day a further 2.5mm of water is lost through ET but the greenkeeper applies 25mm of irrigation. This takes the SMD up to 12.5mm and 15mm the next day. On the 5th, 6th and 7th a total of 25mm of rain falls which, after the estimated ET has been deducted, takes the SMD above zero. Clearly, once the soil has regained field capacity it cannot hold more water against drainage and so the 2.5mm excess drains off leaving the SMD at zero.

Perhaps the most accurate sensor of both soil water and atmospheric conditions is the grass plant itself. Visual assessment of the turf is the most common way the greenkeeper determines whether water is needed. If this assessment can be accurately measured in some way by machine then the system can ➡ 27

Water Balance Sheet

Date	Rainfall (mm) R	Estimated Daily ET E	H–R (mm)	Irrigation (mm)	SMD (mm)	Excess Drainage run-off (mm)
Brought forward					30	
July 1	0	2.5	2.5	0	32.5	
July 2	0	2.5	2.5	0	35.0	
July 3	0	2.5	2.5	25	12.5	
July 4	0	2.5	2.5	0	15.0	
July 5	10	2.5	–7.5	0	7.5	
July 6	8	2.5	–5.5	0	2.0	
July 7	7	2.5	–4.5	0	0	2.5

25 ➡ be automated. Infrared thermometry has been developed to do just this in a non-destructive way, measuring the leaf temperature which, when the soil is moist, will be at or near ambient soil temperature. Leaf temperatures will rise above air temperatures when soil or atmospheric stress increases. Only recently developed, it may however prove to be the most accurate way of determining water stress within the plant itself, rather than trying to predict plant needs from soil moisture content.

Water use rate

In view of the limited information given by soil sensors alone, the Water Use Rate (WUR) has been used in the USA to estimate requirements. The WUR is composed of the total ET plus the total amount of water required for turfgrass growth.

The weekly WUR for a northern temperature region of the USA having moderate summer temperatures and humidities has been estimated at between 0.9-1.0 inch/week (22-25mm/week). Many factors will affect these estimates including:

- Evapotranspiration rate
- Length of growing season
- Growth rate
- Turfgrass species or cultivar
- Intensity of culture
- Intensity of traffic
- Soil type
- Rainfall
- Available soil moisture.

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However, to estimate the total amount of irrigation water that might be needed per season, the weekly WUR multiplied by the number of growing weeks will give an estimated annual water rate. This can be compared to the known annual rainfall for an area, the difference being the expected deficit or excess of water.

This is still only an estimate, as differences will occur from area to area and year to year. Knowing the estimated WUR will, however, help when planning how much water may be needed throughout a season in a given climate zone.

How much water to apply

How much to apply at any one time will depend on many factors. The general consensus is that the irrigation period should be sufficiently long to wet the majority of the soil where the roots grow (usually between 100-200mm deep) So how much water to use will depend on the amount of water in the soil, the soil texture, and how quickly the water gets into the soil (the infiltration rate). If irrigation water ➡ 28

Detailed information is needed

27 ➡ starts to run-off then irrigation should be stopped for a while to allow the water in the soil to move downwards. It may be beneficial to lightly spike or slit the surface to encourage infiltration. On soil showing dry patch symptoms a wetting agent may also help.

Light infrequent water applications can lead to surface rooting, which in turn can lead to a need for more water. Water throughout the rootzone is necessary for a deep-rooted green – the benefits of which include:

- Less frequent watering
- More efficient use of plant nutrients
- A more drought and wear resistant sward.

If you are not in a position to calculate the exact amount of water required then the rule of thumb as advocated by McIntyre is probably best: "water grass as deeply as possible as infrequently as possible without causing damage to the grass".

Light sprays of water may however be used to syringe grass, under very hot conditions, to prevent heat stress or discourage diseases associated with such temperatures i.e. brown patch. To do this, water is applied during the hottest period of the day so that it rapidly evaporates causing the desired cooling effect.

When should you irrigate?

Having decided the grass needs water and how much to apply, this ideally should be applied when evaporation is at its lowest; when the area is not subjected to heavy play; when it will not interfere with play; when the air is relatively calm i.e. not windy; and so as not to extend the length of time when grasses are susceptible to diseases.

These criteria would suggest that early morning would be best – before play begins. Alternatively, if the area is particularly exposed and subject to winds, then late evening when it is often calm may be more appropriate. On many courses, other constraints such as the lack of an automatic system, will affect when water is applied. Indeed, water may have to be applied throughout the day if you are restricted to using mobile sprinklers causing inconvenience to players. Even with pop-up systems there is little time for irrigation at night in the summer, when play may continue until 10pm and begin again at 5 or 6am.

What really happens

So what do greenkeepers do in practice to determine when to irrigate?

In Britain, irrigation is usually applied after visual assessment by the greenkeeper. Drought is far less common in the UK than in continental Europe or the USA and, because of this, much less money is spent on systems and their control. In the US, where drought is a regular occurrence, much more effort is put into applying the correct amount. This is probably because many more courses there have the finances to install automatic systems, often linked by computer into moisture monitoring systems which can give much more precise control of water application.

In the future, when the price of water may be much higher, it may well pay even the British greenkeeper to monitor water use. What is certain is that more detailed information on irrigation requirements for this country will be needed, if water is to be applied with confidence. Until then irrigation in the UK will remain something less than a precise practice.