Nine pages of specialist reports cove

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.

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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?

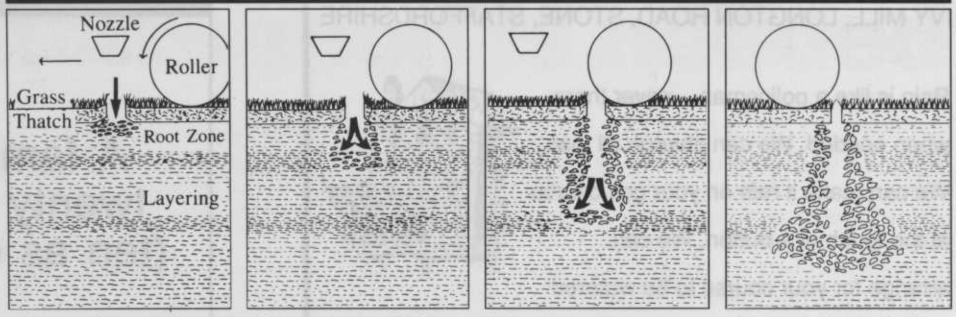
In Britain, irrigation is usually applied after visual assessment by the greenkeeper. Drought is far less common in the UK than in continental Europe or the USA and, because of this, much less money is spent on systems and their control. In the US, where drought is a regular occurrence, much more effort 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.

Shot in the dark

Heralding Water Injection Cultivation, a technical breakthrough

How water-injection cultivation works



1. Bursts of energized water are shot down into target zone, penetrating turfgrass and thatch. (Light arrows indicate direction of equipment and roller travel.)

2. Force of energy begins to spread below surface, loosening surrounding soil and helping to break up any layering.

3. Impact continues to spread outward as burst travels deeper. Roller begins to smooth minor turf and thatch disruption resulting from burst's initial impact.

4. At target depth of 4-8 inches (using standard nozzles), remaining energy dissipates when soil resistance attenuates further impact. Roller completes smoothing.

A major problem in golf course management until now has centred on the need to find the right balance between maintaining quality and flexibility of greens and the pressure to keep putting surfaces playable. This problem has been compounded by the fact that since traditional core aeration is stressful to the turf, it can usually only be applied in spring and autumn when recovery is most rapid.

A new technique developed by Toro now offers all the advantages of conventional methods – without the drawbacks. Known as water-injection cultivation (WIC), it offers less stressful and more effective cultivation, thereby ensuring greater flexibility in turf management.

The main complaint about core aeration is the disruption it causes to the putting surface. Player complaints and green committee pressure have often forced many Clubs to cut back or eliminate aeration, with an inevitable negative impact on the quality of such greens. Even when aeration is carried out, the benefits can disappear long before the procedure can be repeated. Recent University research in the USA has shown that the effects of spring hollow-core tining are almost gone by August.

Unlike conventional methods, water-injection cultivation does NOT disrupt the putting surface. Entry holes, in fact, are almost invisible shortly after treatment. As a result, aeration programmes can be continued and expanded.

The benefits of what happens below the surface are equally significant. Water injection cultivation penetrates twice as deep as hollow-tine techniques. This offers two major advantages. One is the potential for increased root penetration resulting in a stronger plant. The second is the penetration of the compaction pan that may develop as the result of repeated cultivation to a uniform depth.

It should be noted that water-injection cultivation is not designed to replace conventional core aeration, since coring is still the best method for incorporating sand into the green profile as well as for thatch management. Where water injection cultivation scores so impressively is in enabling aeration programmes to be maintained when conventional methods are not feasible or desirable. The long-term benefits can be measured in terms of improved soil structures, healthier greens and fewer disease problems – with a subsequent reduction in the need for fungicide applications.

The equipment needed for water-injection cultivation is the Toro HydroJect 3000, which incorporates a pump; an accumulator; a single valve and set of nozzles. Once the unit is filled with water (it uses approximately 150 gallons to aerate a 7000 square foot green), the positive displacement pump maintains a constant 5000 psi water pressure on the system accumulator, which acts like a capacitor in an electrical circuit. Output from the accumulator is controlled by a valve which, when opened, releases water to the nozzles in short cycles of a few milliseconds. On reaching the nozzles the water is pulsed at a very high velocity numerous times a second, enabling it to penetrate from four to eight inches into the soil with a single shot. The unit is actually capable of penetrating the soil up to 20 inches or deeper with repeated shots.

The Toro HydroJect 3000, seen here in action at Westurf '91, deploys two additional swing-up wheels for transportation

As the pulse of water enters the ground, its action is similar to that of a bullet. The entry point on the surface is about 1/8 inch in diameter and horizontal dissipation takes place deep into the soil below; where adjacent layers of soil are shattered by the pressure of the water – the system does not rely on physical impact, abrasion or erosion of the soil.

Considerable engineering problems – to ensure high performance, reliability and safe operation – had to be overcome in building the HydroJect 3000. All connections, for example, are hard-coupled throughout and extensive use is made of stainless steel and other corrosion-resistant materials.

Exhaustive tests of the system have been conducted during a three-year research project at Michigan State University. This provided conclusive proof that plots undergoing water-injection cultivation had a more uniform turfgrass quality than plots which did not receive this treatment. Compared to both hollow-tine cultivation and non-cultivation, plant growth also improved – in the case of hollow-tine cultivation, the difference was probably due to the loss of crown tissue.

The research demonstrated water-injection's potential for encouraging deep rooting, which should increase the stress tolerance of turf. Soil physical properties were improved compared to non-cultivated plots and were similar or superior to the traditional vertical hollow-tine method. Using water injection, soil was cultivated deeper in the soil profile compared to hollow-tine cultivation and soil strength measurements showed that it was effective to a depth of four inches – hollow-tine cultivation was effective to only two inches.

Data showed that with time and continued traffic there was a need to re-treat the soil eventually – whichever method was used. However, with the disruptive and injurious nature of hollow-tine cultivation, it is imprac- → 32

Water injection cultivation

From Page 31

tical to consider this on a frequent basis. Since water-injection cultivation appeared to be the aggressive cultivator, yet caused significantly less damage, it can be used on a more frequent basis to manage compaction-prone soils. The shape of the channel created by water-injection cultivation varied with soil texture and strength. A long, slender channel is created in soils of low strength, while soils of higher strength have a reduced channel depth although the channel will have a larger diameter at its lower end.

Jim Murphy, leader of the research project, concluded that water-injection cultivation was much more effective than non-cultivation in improving soil physical conditions, such as bulk density, aeration porosity and saturated conductivity. Compared to hollow-tine cultivation, it ensured greater depths and, consequently, management of a larger soil volume. This offers the facility to break through and disrupt subsurface layers – like a cultivation pan – which inhibit water and gas movement as well as deep root growth. And since all this can be achieved with less turf damage than is possible with vertical operating hollow-tine cultivation, it is a more feasible method for frequent cultivation of compaction-prone soils – including before or during conditions considered too stressful for other methods.

● For further details and an address to write for full technical data, see back cover.

Presenting the case for water, water everywhere

From the increasing pre-occupation of greenkeepers, course developers and pundits generally with the subject of water, golf could perhaps light-heartedly be classed as almost an aquatic sport.

Certainly a drought can change the whole playing complexion, whilst at the same time being responsible for serious turf deterioration. Yet a high proportion of courses in the UK lack any adequate water storage, though drought conditions continue, with last year's rainfall being the lowest since 1976. It is understood that a licence application may well fail if water storage is not provided. Indeed, abstraction of water may be prohibited for periods as much as three months.

The National Rivers Authority therefore encourages on-course storage. The average use of water on a course for greens and tees is some 20,000 gallons per day, say four million gallons over seven months. Virtually no rain at all would mean relying on finding something like five million gallons.

The cost of abstracting water from borehole or stream is given in pounds per million gallons:

	WINTER	SUMMER
Wessex	17.73	53.19
South-West	29.52	39.36
Southern	59.46	336.96

Cost of abstracting water from main supply = £2350 per million gallons.

Water storage, now of increasing importance in course irrigation, fits neatly into the operations of OCMIS Irrigation, the Martock, Somerset based company who have enjoyed considerable success as irrigation specialists in agriculture and fineturf.

Their infrastructure includes expert consultation and design and in keeping with their policy of keeping abreast with the latest developments they monitor and study the subject world-wide.

An immediate plus is their close affinity with the water companies, which at first might appear routine enough, but in reality means a saving of several days of reconnaissance and consultation, mapping out the nearest boreholes etc. and having access to records. Liaison with the electricity companies is equally well advanced in facilitating sources of single-phase power where three-phase is not available.

The use of attractively landscaped lakes as storage is one possibility where there is enough water available for topping-up purposes, another being the use of special irrigation tanks.

Such tanks need to be well sited, either above or below ground level.

It is in this respect that OCMIS have achieved great success in agriculture and are on course to repeat this in golf, where almost a month's supply of water can be easily stored on or adjacent to the course.

Joint Committee sets out to improve the lot of the greenkeeping profession

The great cause begins

by ERIC SHIEL

The R and A creation of the Joint Golf Course Committee is a major boost to the well being and future of the greenkeeping profession. With the formation of this committee the R and A have extended their horizons beyond the playing of the game into concern for the surface upon which the game is played.

The message to greenkeepers is that help is coming to them in a way that could not have been imagined as little as five years ago. But for the intervention of a green committee chairman, the much acclaimed discussion document 'The Way Forward' might never have seen the light of day. Thanks also to the ghost of Old Tom Morris or someone of that ilk, Eddie Park took his duties at Lindrick Golf Club seriously. Devoted to the teachings of Jim Arthur, then Championship Agronomist to the R and A, Park saw his problems as endemic to the game. As the Lindrick course gradually gained its self respect, so the great cause began.

Armed with this experience and knowing the extent of the problems by personal visits to the many Clubs around the British Isles, Eddie Park approached the Home Unions for their support. With little prompting they readily agreed and the R and A gladly pitched in.

Number one priority for this Joint Committee is to find ways to improve the lot of the greenkeeping fraternity. This will be by way of enhancing educational opportunities, recruitment policies to encourage quality entrants into greenkeeping and provision of higher technical standards. This technical knowledge will come out of the committee's panel, which will be a gathering of the best minds specialising in the likes of agronomy, science, course design, nature conservancy, environmental issues and allied subjects. The Sports Turf Research Institute will be highly visible in these deliberations.

Greenkeepers can only benefit from these initiatives. Independent voices and influential organisations will be speaking and working on their behalf. There will be little need for greenkeepers to blow their own trumpets. The policy shapers for the future of golf courses in Britain and Ireland will be Tim Taylor, R and A; Peter Wilson, English Golf Union; Gerry O'Brien, Golfing Union of Ireland; Lindsay Stewart, Scottish Golf Union; and John Vaughan Evans representing the Welsh Golfing Union. The ultimate philosophy is that greenkeepers deserve more attention and support, not to forget consideration. Club members will have to understand that if they want good looking courses, playable 12 months a year with no temporary greens (barring Mother Nature) and no mats on tees, they will have to start backing the greenkeeper like never before. Everything to do with providing all golfers with the best possible playing conditions at the most reasonable cost on traditional British courses will be addressed by the Joint Golf Course Committee. BIGGA will play a major role. Keep a watchful eye in Greenkeeper International for further reports.

● Eric Shiel, the Executive Director of the Joint Golf Course Committee, is a native of Carnoustie recently returned from America, where for nine years he was with the USGA Green Section in charge of regional affairs and public golf: in his own words – 'taking golf to the people'.