Methods and equipment for matching irrigation supply to demand in container–grown crops

Figure 1. Efficient irrigation relies on both uniform application and accurate scheduling to meet the demands of the crop

This factsheet introduces the application of current technology for irrigation scheduling in container-grown hardy nursery stock (HNS) that has largely been developed as part of AHDB Horticulture-funded project HNS 97, as well as describing other methods and equipment also available.

Action points

- **Regularly inspect, measure the output from, and maintain the irrigation system to ensure that its performing according to the manufacturer's recommendations**
- **Consider some form of irrigation scheduling, whether its via the monitoring of plant and container weights, an estimate of evapotranspiration or the use of moisture sensors to more accurately apply irrigation**
- **If using estimates of evapotranspiration to schedule irrigation, ensure that species specific crop factors are updated regularly**
- **When using a moisture sensor to schedule irrigation, ensure that its calibrated and inserted into the growing media correctly to ensure accuracy**
- **Select low discharge emitters, pulse irrigation applications and use media wetting agents to minimise irrigation run-through**
- **Try and group plants on the nursery by their irrigation need to make irrigation scheduling easier (Figure 1). Where applicable consider the use of regulated deficit irrigation to assist in the control of plant growth**

Introduction

Along with all other sectors of horticulture and agriculture, improving water use efficiency has become a major concern for nurseries growing crops in containers. Much is being driven by ongoing legislation dealing with the supply of limited water resources and potential pollution in drainage and run-off water. However, the significant productivity, cost savings and crop quality benefits to be gained from improving efficiency should also be a motivating force to seriously examine nursery practices.

Many nurseries can often water to excess in order to make sure everything has received a sufficient amount, and rely on surplus water draining to waste. However, even when the irrigation system operates efficiently, it is often found that nurseries place different types and sizes of plants, in different container sizes and growing media, all under a single irrigation regime.

While this may give acceptable growth for some crops grown in free-draining media, the practice is wasteful of water, results in excessive leaching of nutrients and pesticides, may exacerbate liverwort, moss, weed and disease problems, and environmentally is becoming an untenable option.

Improving water use efficiency requires two steps:

- Optimising the uniformity of water application to, and minimising the loss from, the crop
- Accurately scheduling irrigation to match the needs of the crop

The first step should precede the second, because accurate scheduling is impossible to achieve on a crop where the water status is already variable because of a poorly designed and often inefficiently operated, sprinkler system, or where the crop dries out at different rates. The first step is addressed in AHDB Horticulture Factsheet 17/17 'Measuring and improving performance of overhead irrigation for container-grown crops' and the second will be addressed in this factsheet.

Principles of scheduling irrigation

Scheduling is all about matching the supply of water to the plant with that lost by evaporation from the growing medium plus transpiration by plants (evapotranspiration or ET) and drainage.

There are four main methods used to schedule irrigation:

- Fixed irrigation intervals (time clock controlled)
- Judging plant condition by eye (ideally before wilting is evident)
- Determining the moisture content of the growing medium (by weight, appearance, or sensors)
- Estimating crop water need from environmental or meteorological data

A novel approach related to the second point, uses plant tissue temperature as an indication of water status in the plant itself. Elevated leaf temperatures measured by infra-red sensors and imaging techniques can give early indications of water stress in the plant. The practical application of this technology is now available and it was a major component of AHDB Horticulture-funded project HNS 97b.

Factors affecting water gain and loss from container-grown crops

Knowing when and how much to irrigate container-grown crops can be more difficult than in the case of field-grown crops because of the extra factors affecting water loss and gain from the container.

Efficiency of capture

Only a proportion of rain or overhead irrigation gets into the container. This is determined by the foliage canopy and space between containers.

Drainage from the container

The medium does not have to become saturated before drainage occurs from the container. A proportion of water entering the container can run straight through if irrigation rates exceed the absorption rate of the growing medium, or if the medium dries out and becomes hydrophobic.

Water holding capacity of the growing medium

This can vary enormously as a result of the wide range of ingredients with different proportions of particle sizes used in the creation of growing media, as well as how they have been handled. For general nursery stock mixes, a readily available water capacity of at least 20% by volume is desirable. However, this may be much less in very open mixes with a high air filled porosity (AFP) rating, and thus require more frequent watering. For example, a three litre container may actually contain 2.8 litres of media with a 17% readily available water capacity, ie a 475ml useable water reserve from container capacity.

Size and shape of the container

Bigger containers obviously hold more water, but a tall, thin container at container capacity will hold a higher proportion of air and less water than a short, wide container of the same volume (Figure 2).

Standing base

Unless containers are in capillary contact with a standing base holding a significant water reserve, (eg a sand bed), the water reserve available to the roots can be much less than in the soil. Irrigation is therefore usually needed more frequently, even up to two or more times a day for rapidly growing stock in small plug trays. The smaller the buffer of available water, the more finely balanced the irrigation scheduling needs to be to match evapotranspiration losses.

Other constraints on the timing (or method) of irrigation also have to be considered:

- Access by staff working in the crop, or customers
- Times of peak demand elsewhere that might affect water pressure, particularly if relying on mains supplies
- Avoiding overhead irrigation when too windy, or very sunny
- Increased disease risk with some crops if foliage is left wet overnight
- Use of off-peak electricity supplies

Together with all these factors, the range of growing environments, plant types and growth stages on a typical

Figure 2. Size and shape of container, standing base type and growing media mix all affect water gain and loss in container-grown crops

nursery adds to the complexity of irrigation management compared with field-grown crops. Despite these complexities, many nurseries can make significant improvements with their irrigation scheduling by using some of the equipment now available and techniques described in this factsheet.

How much water do plants need?

This partly depends on what is being grown and whether the objective is to encourage vigorous growth or produce a 'harder' and possibly more compact plant. Figure 3 illustrates three possible irrigation regimes.

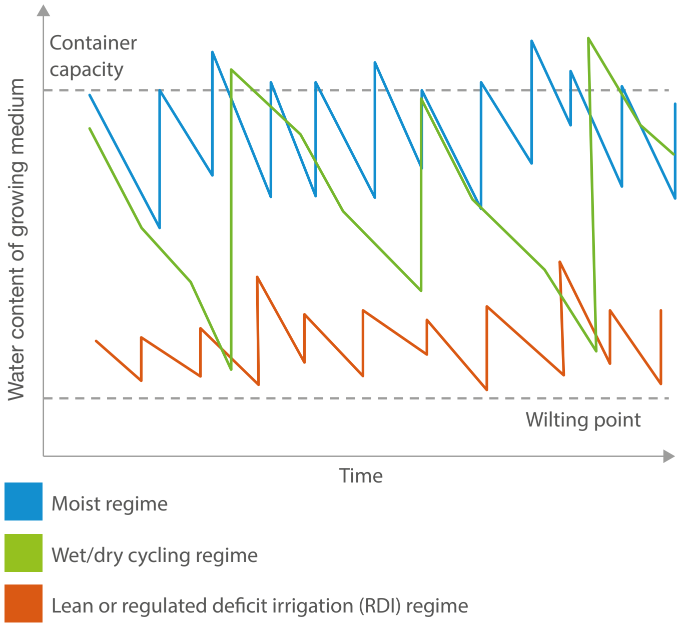


Figure 3. Three contrasting irrigation regimes: moist, lean and wet/dry cycling

A plant that has been fully saturated and allowed to freely drain is at container capacity. From container capacity, the first amount of water is readily available to the plant, but as the medium dries, it holds the remaining available water increasingly tightly, and the plant has to work harder to extract it. At wilting point the tension exerted by the medium exceeds the plant's maximum 'suction' ability, and the remaining water in the medium is unavailable. The total available water capacity (AWC) for a particular combination of plant, container and growing medium, is thus the difference in the water content at container capacity and wilting point. In practice, the working water capacity for an irrigation regime will always be less than the available water capacity, because it is undesirable for the crop to reach wilting point before watering.

Moist regime

Maintaining a moist regime near to container capacity with 'little and often' watering can encourage vigorous growth and maximum weight gain, provided that the growing medium also contains sufficient air for the roots and is not kept saturated.

Lean regime

Conversely, a lean regime or regulated deficit irrigation (RDI) can be imposed by keeping the growing medium dry enough to induce and maintain water stress on the plants, but not to the point of wilting. Plants will decrease their transpiration rate under these conditions, and will use much less water than a plant with freely available water at the roots. RDI regimes apply a proportion of the potential evapotranspiration (ETp) of well watered plants.
With little, but frequent irrigations (eg 50% ETp applied daily), more compact growth requiring less pruning, or the use of plant growth regulators, has been demonstrated for a range of plant species, as well as large water saving benefits (Figure 4). Achieving RDI in practice requires uniform irrigation (drippers can work well), and precise control, to reduce the risk of patches of plants becoming over-dry and possibly damaged. Protection from rain is also important, as growth reduction effects can be undone following a short period of wet weather.

(a)

(b)

(c)

(d)

Figure 4. Growth control effects of different irrigation regimes on various plant species: (a) *Choisya*, (b) *Lonicera*, (c) *Cornus* and (d) *Cotinus*. For each species from left to right, moist regime (200% ETp), lean regimes (50% and 25% ETp)

Wet/dry cycling regime

A wet/dry cycling regime is easier to manage than a lean regime and water can still be used efficiently although without the marked growth control effects of RDI. It makes good use of the available water capacity by allowing the medium to dry down extensively before applying enough irrigation to bring the medium in the container back to full capacity. Plants will experience moderate stress at the dry part of the cycle, but this is short lived.

This regime is easiest to manage with plants in containers of at least two litres capacity where, even in sunny summer weather, intervals between irrigations of at least two or three days may be possible.

Methods of determining the need to irrigate

Gravimetric (weighing) method

Weighing lots of growing plants each time they are irrigated is clearly impractical on the nursery. However, some time spent weighing a sample of plants as a calibration exercise remains the best way to gauge what level of irrigation is needed for a particular crop and growing medium, and to measure how much is actually reaching and staying in the container.

Choose a sample of at least eight equal sized containers representative of the size and type of plants being irrigated in the block and tag these for reference. Ensure the block is well wetted and the growing media is at container capacity (best to water sample plants well by hand and allow the surplus to drain for 30 minutes). Weigh and record each tagged plant. Leave the block to dry back to the stage at which irrigation is judged necessary. This may mean checking the tagged pots twice a day, and perhaps turning some out to look at the moisture status of the rootball. When the plants are judged to be at the right stage for irrigation, weigh and record each tagged plant and subtract these from the container capacity weights to get the water loss for each plant. The mean of these water loss values gives an indication of the working water capacity for this crop/container size/growing medium combination.

Remember 1g of water = 1ml, so a mean weight loss of 260g/container equates to 260mls water/container.

This is the basis for calculating how much irrigation is needed to fully rewet the crop back to container capacity from the need to irrigate stage, without applying excess. AHDB Horticulture Factsheet 17/17 describes the procedure for measuring the mean application rate and uniformity of overhead irrigation systems using saucers. It also explains the basis of irrigation or rainfall measurements expressed as mm depth of water (1mm = 1 litre/m^2). Figure 5 can be used to find the weight loss equivalent to 1mm of water according to container diameter.

For example, for a 190mm diameter container, a 1mm water loss equates to 28g loss.

Therefore a 260g weight loss = $\frac{260}{28}$ **= 9.3mm**

If the irrigation system has a mean application rate (MAR) of 12mm/hour, and a scheduling co-efficient (SC) of 1.4 (ie the factor needed to ensure the driest areas get fully irrigated), then the irrigation duration needs to be:

$$\frac{9.3\text{mm x 60 mins x SC 1.4}}{\text{MAR 12mm/hr}} = 65 \text{ mins}$$

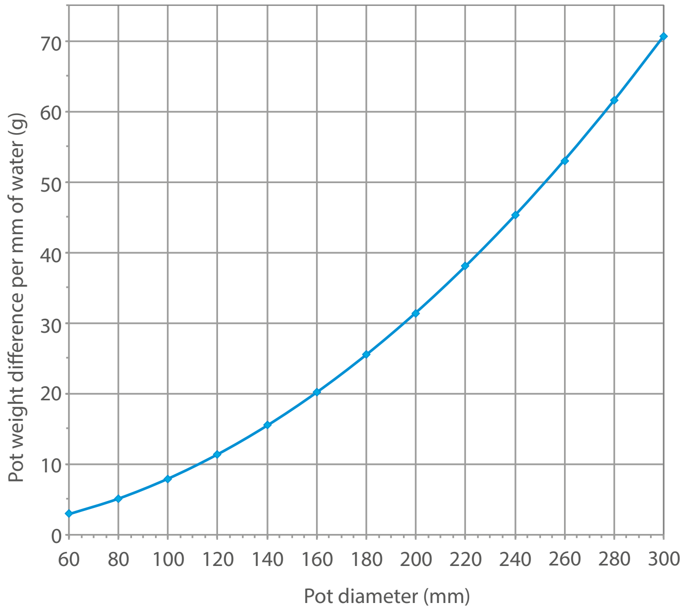


Figure 5. Weight change per mm water (gain or loss) for different pot sizes

Once the MAR and SC of the irrigation system is known, a spreadsheet can be used to calculate irrigation times needed from an average container weight loss.

The calculation then needs to be tested in practice by reweighing sample containers after the irrigation period and the duration adjusted accordingly. The foliage canopy is likely to interfere with water capture compared to wetting up containers of media without plants in, and again there is a need to note what effects this has for each crop. Also, a proportion of the captured water will drain through some containers. This is because the application rate can exceed the absorption rate of the growing medium, and because some containers will get some surplus water under a less than perfectly uniform irrigation system. A method for checking the proportion of run-through is described later in this factsheet.

Using plant weights to determine irrigation needs is more straightforward with drip irrigation once you have measured dripper outputs. However, run-through losses can still be high where drippers apply water too fast, particularly if the medium is dry. Choosing low discharge emitters, pulsing the irrigation and using growing media wetting agents can all help.

In practice, trying to irrigate to full container capacity across the whole crop with most overhead systems will result in a lot of wasted water. But using container capacity reference weights coupled with some measurements of run-through is a good way to arrive at an irrigation dose that balances crop need with water use efficiency. It should be borne in mind that plant growth (and cultural activities such as pruning) will require some recalibration of reference weights during the season.

Estimating evapotranspiration

Potential evapotranspiration (ETp) can also be used to determine when a plant needs irrigating. It can be estimated by applying a complex formula known as the Penman-Monteith equation to measurements of the four main climatic drivers: air temperature, solar radiation, humidity and wind speed. This is the basis for dedicated irrigation management software, often linked to mini-meteorological stations, and increasingly being used by growers of large scale field-grown crops.

As explained previously, the complexities of container cropping can make it difficult to accurately apply a strict 'water balance sheet' approach to estimations of available water in the growing medium, and how much to irrigate.

Nevertheless, ETp estimates can be used as follows:

- In conjunction with a gravimetric calibration procedure to relate ETp units to weight loss in containers. Daily irrigation doses can then be applied to replace water lost according to the ETp estimate for the previous 24 hours. Alternatively, a fixed dose of irrigation sufficient to bring dry plants back to near container capacity can be applied once accumulated daily ETp readings exceed a threshold value
- As a relative measure to make daily adjustments to baseline irrigation schedules to cope with fluctuations in the weather. Thus irrigation dose settings on time clocks or a control panel for different stations around the nursery may be set to suit the high water use conditions of a warm sunny summer day. If weather the following day is cloudy with an ETp reading 40% lower, then the irrigation settings are reduced accordingly. Many irrigation controllers enable a percentage adjustment to be set across all stations at once

The gravimetric calibration used to relate ETp units to container weight loss and thus irrigation requirement in mm, effectively combines the type and size of crop, efficiency of water capture and retention by the container etc into a single ‘crop factor’. However, it is important to understand that this will require some recalibration and adjustment through the season as the crop develops.

Dealing with rainfall

Water gain from rainfall, as well as from irrigation, also needs to be allowed for when using ETp measurements to schedule irrigation of outdoor crops. A good quality and accurate plastic rain gauge costs less than £20, and is a worthwhile investment if sited carefully on the nursery, and recorded daily.

Rainfall can be very localised, so unless a reliable source of meteorological data is available nearby, it is worth nurseries collecting their own. Container-grown crops are irrigated relatively frequently, so that local rainfall patterns are probably more significant than for field-grown crops where there is typically a larger buffering effect of available water over time.

Rainfall records can be simply subtracted from estimated irrigation requirements, but note that a given quantity of rain may actually be more efficient at wetting up plants than the same mean dose applied through sprinklers, because rainfall usually falls more uniformly and more gently. Conversely, small quantities of rainfall (eg up to 2 or 3mm) may have negligible impact on the irrigation schedule and can be ignored, and any rainfall above that needed to bring plants back to container capacity will, of course, be surplus and will drain to waste.

Equipment for controlling irrigation

Time clock controllers

The simplest form of semi-automatic irrigation scheduling is by the use of time clocks. Even the most basic units will enable both the duration and frequency of irrigation doses to be controlled. A major limitation of fixed dose irrigation scheduling is, of course, that plant requirements can vary considerably from day to day with the weather as well as more gradually with the season and plant growth. The gravimetric method described earlier can be repeated after rainfall and the timers adjusted. While using timers will probably give more efficient water use than relying on manually turning on and off sprinklers, especially over several units, further significant improvements are possible with the intelligent use of evapotranspiration estimates to modify settings. Growers with production areas remote from mains electricity will welcome the availability of battery powered and solar powered, stand alone timers, some with integral solenoid valves see Figure 6 for an example.

Figure 6. Battery powered timers and valves are now available for sites remote from mains electricity

Some timers accept inputs from sensors that prevent irrigation after a specified amount of rain. Developments have also enabled timers to work with other devices such as soil moisture probes or ETp meters to improve control.

Evaposensor and evapometer

The evaposensor was originally developed at HRI East Malling (now NIAB EMR) to help control mist and fog propagation environments, but its potential for estimating ETp for irrigation control was developed further in AHDB Horticulture-funded project HNS 97. The evaposensor should be sited in a similar environment to the crop and above the foliage canopy where it will be exposed to solar radiation. The temperature difference between the special wet and dry probes is proportional to evapotranspiration rate, and this can be logged using an evapometer developed and commercialised by Skye Instruments Ltd (Figure 7), and subsequently other companies, as part of the project.

Figure 7. Evapometer and evaposensor for logging evapotranspiration

The output from the evapometer in °C hours can be read from the display as a cumulative total (since last being reset), and also in the current and previous 24 hour period (eg from 9.00 am or any time set by the user).

The data generated correlates very closely to ETp calculated from meteorological data, but at a significantly lower cost than a weather station installation.

There is no single conversion factor for °C h to units for water loss or irrigation requirement, as this will depend on the size and type of the plant, container size and other factors. The most accurate way to determine the appropriate irrigation dose required for a given °C h value is to use the calibration procedure using pot weights as described earlier. This will also take into account evaporation from the surface of the growing media and efficiency of water capture by the plant during irrigation etc. Alternatively, evapometer readings can be used as a relative measure to make daily or periodic percentage adjustments to a set of already established ‘typical’ station settings on an irrigation control panel.

A nursery might have a separate evapometer/sensor for outdoor crops, a glasshouse and a shade tunnel for example. All crops could be monitored with a single unit for that environment, but clearly the calibration for watering threshold or conversion of ETp value to irrigation dose will vary for different blocks according to plant and container size etc.

Figure 8 illustrates how the evapometer output was used to schedule irrigation for a crop of hydrangea growing in three litre containers. It was found that about 300°C hours could be allowed to accumulate before applying an irrigation dose of about 15–20mm to return the dry crop to near container capacity. This might occur over just two or three days in hot weather or a week or more if dull. Daily evapometer readings were accumulated until the threshold was exceeded, when water was applied and the evapometer total reset to zero. In this case rainfall was ignored unless it was heavy enough to significantly re-wet the growing media (eg above 5mm) when the evapometer total was also reset.

Pan evaporimeter

Evaporative demand can also be estimated by measuring water loss from an open water surface using a pan evaporimeter. This is less compact and convenient to read and maintain compared to the evaposensor and evapometer arrangement, but may nevertheless appeal.

The Class A pan evaporimeter conforming to USA weather bureau standards is a galvanised metal circular container 121cm diameter by 25.5cm deep (Figure 9). However, a round, straight-sided container at least 30cm diameter by about 30cm height, such as a cut down metal or plastic drum, is adequate, provided the outside is painted a light colour or covered with reflective foil. The container should be placed level on blocks about 15cm above the ground and covered with wire netting to prevent birds or animals drinking from it. The surrounding area should be open and free from vegetation that would shade or shelter the pan from wind.

A plastic ruler marked in mm is attached to the inside with the zero at the rim. At the start of the production season, with the crop fully wetted and the water in the pan adjusted to, say, the 50mm mark, readings are taken daily, and recorded. Gains from rainfall will be automatically adjusted for except if very heavy rain overflows the pan. The water level and record sheet should, however, be reset to 50mm if the level drops below about 130mm because the reduced volume of water and the sides of the pan will affect the rate of evaporation. The easiest way of allowing for any overhead irrigation getting into the pan is to take a reading before irrigation starts and remove added water back to that mark immediately afterwards. Clean the evaporimeter occasionally, and add a little bleach to the water to reduce algal growth.

As with the evaposensor and evapometer, a calibration 'crop factor' needs to be applied to convert mm evaporation losses recorded from the pan to actual losses from a particular crop. Evaporation from a crop, even with 100% crop cover over the growing medium, is usually less than that from a free water surface.

This factor may be between 0.6–0.9 for a vigorously growing crop with a foliage canopy about equal to that of the container diameter. For example, for a factor of 0.6

Figure 9. Pan evaporimeters can also be used to estimate evaporative demand

for a crop with overhead irrigation, and a difference in evaporimeter readings of 15mm, then apply 15 x 0.6 = 9mm (or 9 litres/m^2) to restore this water loss. However, as plants become much larger in containers, the crop factor will increase (even as high as 3 where there is a lot of foliage and a relatively small container).

Some work has been done in Australia where irrigation drippers have been setup to drip into the pan to give the same irrigation rate as received by the plants, thus giving a direct link between irrigation times and pan readings. This might be worth considering where an evaporimeter can be dedicated to large areas of a single crop.

Note that any irrigation scheduling based on the estimation of evapotranspiration will only be as good as the calibration of 'crop factors' used. In practice adjustments by trial and error are needed. Firstly, choose factors that seem right based on an initial calibration, and following observations of the crop and records of ETp irrigation and possibly rainfall, raise or lower the factor accordingly to give the minimum water that gives the plants the required appearance and growth rate. After gaining experience, measuring and recording evapotranspiration should take little time which is repaid through more accurate irrigation scheduling, efficient water use, and ultimately better plant quality.

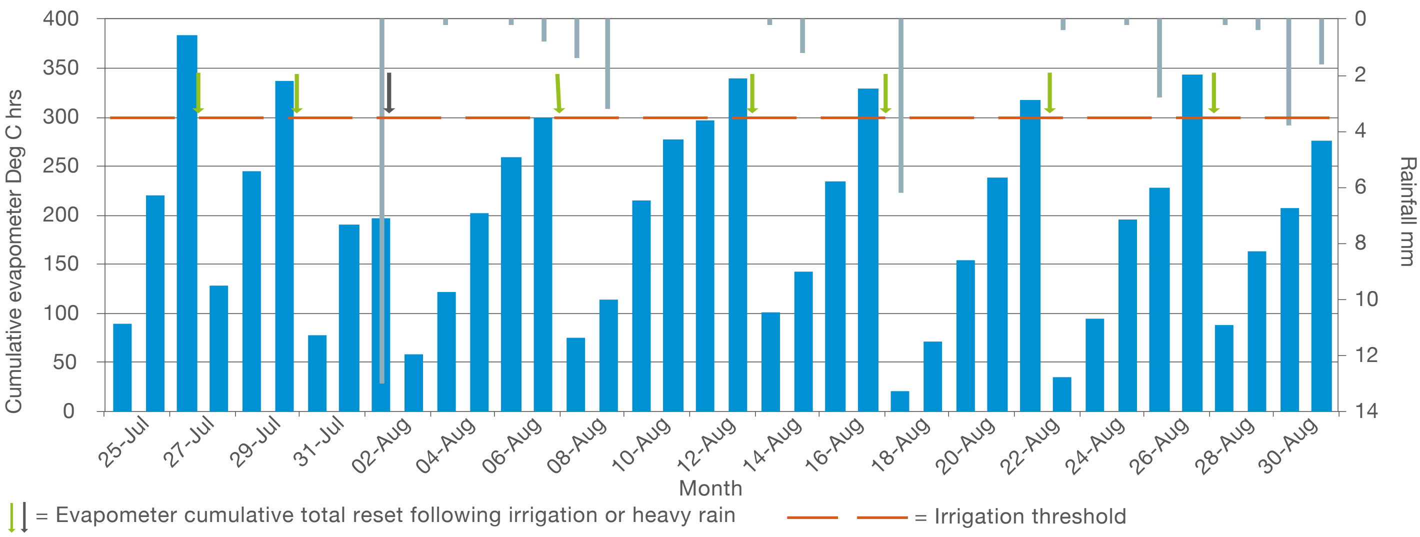
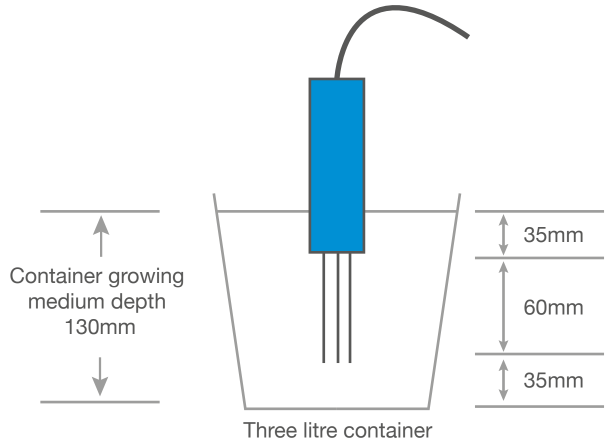


Figure 8. Using evapometer readings to schedule irrigation

In-container sensors for irrigation control

An entirely different approach to scheduling irrigation relies on direct measurement of the moisture status of the growing medium using a sensor or probe. Output from instruments such as capacitance probes and mini-tensiometers can now be used to trigger irrigation systems automatically. Such closed-loop control systems have the major advantage that the complex range of factors influencing water loss and gain are automatically accounted for.



Capacitance probe

The ThetaProbe from Delta-T Instruments Ltd generates and detects an electrical signal via an array of stainless steel rods. Due to the dielectric property of the growing medium, the proportion of the generated signal reflected back to the probe depends largely on the moisture content. The mV output from the probe increases with moisture content.

Figure 10 illustrates how the output from a single ThetaProbe was used to automatically trigger irrigation through an electronic switch in one of the HNS 97 project experiments. Sprinkler irrigation was set to come on when the growing medium dried down to a probe output level of 500mV and switch off when it wetted back up to 850mV. Over the July–October period of this experiment with hydrangea grown in three litre containers, the frequency of irrigations varied from two to five days dependent on the weather, and required virtually no manual spot watering.

The electronic switch and ThetaProbe were powered by the 24 volt AC supply to the irrigation solenoid. It was important to position the probe to monitor the central zone of the root ball where moisture levels were most representative (Figure 11). Also a typical sized plant was selected in a position on the bed where it was unlikely to experience extremes of wetting up or drying out.

Upper and lower set points for switching on and off the irrigation were initially determined using a well watered and dry plant, and then minor adjustments made by checking the crop after a couple of irrigation cycles.

The system has also been successfully trialled with commercial scale crops on two nurseries. Significant water savings of 30% and over 40% were achieved using the ThetaProbe control compared to a similar area where irrigation was regulated manually (Figure 12). Depending on the accuracy and uniformity of the irrigation delivery system, there is clearly potential to control the water status of the crop quite precisely using this system. However, each irrigated block will need its own sensor probe and controller.

Figure 11. Position of the ThetaProbe to monitor the central zone in a three litre container of hydrangea

The ThetaProbe was primarily a scientific instrument; other, more economical probes (such as the SM200) and irrigation controller and logger (the GP1) for nursery use are now available (Figure 13). Such equipment can be retrofitted to existing systems using standard solenoid

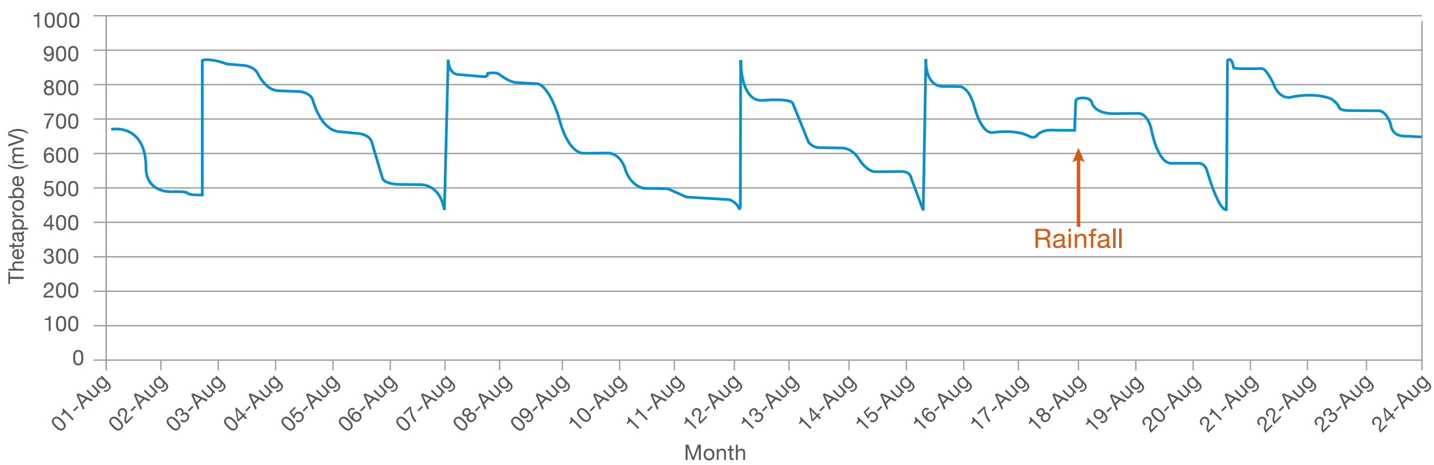


Figure 10. Output from ThetaProbe being used to trigger irrigation

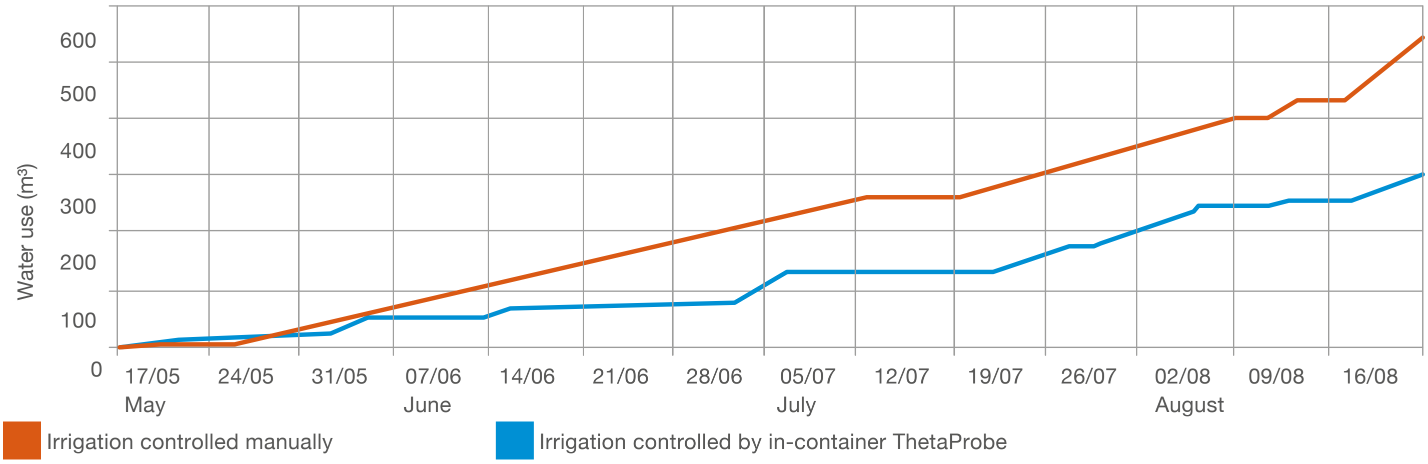


Figure 12. Automatic control of irrigation using a ThetaProbe on a commercial container bed (2002) showing a 44% water saving

valves, and work within a nursery's master irrigation panel if necessary (eg to restrict irrigation to set times of the day or to supply stations in sequence). This equipment was originally evaluated in AHDB Horticulture-funded projects HNS 97b, HNS 122 and more recently in HNS 182.

Figure 13. The SM200 sensor and GP 1 irrigation controller and logger

Mini-tensiometers

Tensiometers consist of a sealed water-filled tube with a porous ceramic tip. As the growing medium dries out, water passes out of the tensiometer, creating a partial vacuum in the tube. This partial vacuum becomes equal to the 'media suction', which is what plant roots experience as the medium dries. It can be measured either with an analogue dial gauge, or via an electronic pressure transducer. The electronic method is more sensitive and can be connected to a data logger or a device to automatically switch on and off irrigation. Small tube diameter tensiometers are suitable for use in containers (Figure 14).

As with the ThetaProbe, siting the tensiometer in the centre zone of the container is probably the most sensitive for irrigation control. However, tensiometers require careful installation to ensure good contact with the growing medium and maintenance to replenish them with water. They will not function properly if the medium dries too far, and are likely to be most successful where used to control moist irrigation regimes rather than those with large wet and dry cycles, or where RDI is being implemented.

Other new developments

Environment measurement and crop sensing systems are most well developed for protected edible crops. Equipment is available that takes plant measurements of photosynthetic rate, leaf temperature, and turgidity and calculates irrigation application rates accordingly. Brinkman, Hoogendoorn, Priva and Tomtec produce computers that take integrated weather data and assess irrigation application rates.

Project HNS 97b examined how infra-red thermometry and imaging of crop canopies could be used to quantify water stress and to schedule precision irrigation in container-grown nursery stock.

Other hand-held devices include the Procheck hand device fitted with a GS3 sensor which allows the moisture status of growing media to be measured and recorded, along with conductivity and temperature.

Figure 14. The mini-tensiometer is suitable for use in containers

Other practical considerations and checks

Run-through

The issue of run-through becomes most important where containers are standing on a free draining base, such as gravel, where surplus water is not recycled and runs to waste. With some other standing bases, a proportion of drained water may get re-absorbed, though this may be small unless the bed is sealed and surface run-off is minimal.

A simple method of checking for run-through losses with sprinkler and drip irrigation is described in this section. Prior to irrigation, label and weigh a sample of at least six containers over the bed as described earlier. Suspend these containers inside smaller empty pots (eg a three litre within a two litre container lined with a polythene bag). An air gap above the collected water will prevent re-absorption (Figure 15). Run the irrigation for the usual time and after allowing 20 minutes for drainage, reweigh each plant and container and measure the amount of drained water collected. The total amount captured, retained and proportion leached can then be calculated.

It is usual to get a little run-through unless insufficient irrigation is being applied, but if most of the containers have a high proportion of drained water, then either an excessive irrigation dose has been applied (if the container is at or near container capacity weight), or the application rate exceeds the absorption capacity of the mix. If water is being applied too fast, then select a more appropriate sprinkler or dripper type and check the application uniformity of your system (see AHDB Horticulture Factsheet 17/17), also pulsing the irrigation dose with a 25–50% on : off ratio can help.

The addition of a suitable wetting agent to the growing medium, or as a drench to established crops, will improve the absorption and spread of water particularly with peat-based mixes. Note, however, the structure of the mix will also affect absorption and capillarity as well as available water capacity.

Even with a wetting agent, getting a good distribution of water throughout the growing medium, without excessive run-through, can be difficult with very open mixes, particularly with drip irrigation.

Hand watering

While a major objective to improving irrigation efficiency will be to minimise the time spent on hand watering, it cannot be ignored totally. It is actually a skilled job if done properly, and it may be a preferable to give edge plants on a bed extra water by hand, for example, as part of a planned irrigation strategy, than trying to fully automate an imperfect sprinkler layout with the risk of over watering a large proportion of the bed. Regular crop checks are also a necessary part of gaining the experience and data with which to fine tune irrigation settings and get the best out of the equipment and scheduling methods used.

Type of irrigation system

The type of irrigation system may influence which method of scheduling and control is most suitable. Efford sand beds with a shared drain/irrigation pipe and header tank should themselves automatically regulate the water supply with little adjustment during the growing season. Overhead sprinkler, gantry and drip systems are suitable for both evapotranspiration and in-container sensor methods.

There is currently less trials experience using either of these methods with other sub-irrigation systems such as sand beds irrigated by low-level drip tubes, or capillary matting beds, although they should work. Mention should be made of the commercial 'Water Bug' controller (Flowering Plants Ltd) for use with capillary matting. This rests on top of the matting and senses the ratio of air to water in the matting sandwiched between the controller and a layer of foil underneath. It uses a similar capacitance probe principle to the ThetaProbe and the controller switches a solenoid valve on and off according to dial settings.

Figure 15. Using a smaller container lined with a polythene bag to collect run-through

Glossary

Available water capacity: The difference in the water content between container capacity and wilting point.

Container capacity: The volume or weight of water remaining in a container of growing media after it has been fully saturated and allowed to drain freely.

Crop factor: A crop dependant factor used to adjust or convert a measured parameter. In this context, the value of the ‘crop factor’ can also take into account container size, efficiency of the irrigation method, uniformity of water applied, water absorption and retention by the growing medium as well as the type and size of the crop. Evapotranspiration units as measured by a pan evaporimeter (mm), or evapometer (°C h) are adjusted or converted into a crop irrigation figure (eg as mm, litres/bed or minutes sprinkler duration) by multiplying by a single value established with a calibration procedure involving the change in weight of a sample of plants.

Degree C hours: The evapometer records the temperature difference between wet and dry probes on the evaposensor unit. The wet probe will be cooler than the dry probe due to the energy (latent heat of vaporisation) taken by the water as it evaporates. The more conducive the environment to evaporation (warm, breezy, bright, dry), the greater the temperature difference between the probes. When sited in a similar environment to a plant, the recorded units in degree celcius hours (°C h) are approximately proportional to the transpiration from a well watered, ie not drought stressed, plant. For example, the wet and dry probes might average 12.5°C and 16°C respectively over one hour. This difference would equate to 3.5°C h. Over the next hour, 5.0°C h might be accumulated and so on. During the summer, an evapometer and sensor outside in the open might record a 24 hour total of over 120°C h on hot, sunny days or less than 20°C h on cool and overcast or rainy days.

Media water tension: A measure of the capillary forces holding water in the growing medium and therefore the force required to remove it. Tensiometers measure water tension rather than absolute water content. Synonymous with soil moisture suction, it is measured in kiloPascals (kPa). Note that moisture tension within a container typically varies – eg lower at the base of the container where it is usually wetter, therefore ensure tensiometers are placed in the same position in each container.

mm irrigation or rainfall: An amount of water expressed as an average depth. The actual volume will therefore depend on the area. 1mm = 1 litre/m^2 or 10,000 litres (ie 10m^3)/ha. For irrigation, the volume of water measured by a water meter divided by the irrigated area defined by sprinkler spacings will give an estimate of the average amount received by the crop. However, the variability water application needs to be measured using an array of saucers as described in AHDB Horticulture Factsheet 17/07 using the AHDB Irrigation Calculator. Actual water uptake and retention by the container can also vary from that applied and is best measured by weighing. Divide the plant weight gain (g) by container surface area (cm^2) and multiply result by 10 to give an equivalent water gain in mm.

Potential evapotranspiration or ETp: The rate at which a crop would lose water under prevailing environmental conditions if water supply was non-limiting. It includes evaporation from the plant (transpiration) and from the growing medium in the container. This can be expressed as a quantity of water lost over time, ie weight, volume or mm of water per 24 hours.

Wilting point: The water content of the growing medium when a plant can no longer draw water from it. At this point the capillary forces holding the water in the medium just exceeds the capillary pull, ‘suction’ or water tension capable of being exerted by the plant.

Working water capacity: The maximum practical difference in container water content between a plant needing irrigation and one which is fully watered. An amount less than available water capacity, as it is undesirable to let a plant wilt before watering it.

Further information

AHDB Horticulture factsheets and publications

Factsheet 17/17: 'Measuring and improving the performance of overhead irrigation for container-grown crops'.

Factsheet 05/17: 'Precision scheduling of irrigation in the production of container-grown hardy nursery stock in various growing media'.

Factsheet 15/06: 'Water quality for irrigation of container ornamentals'.

Factsheet 01/06: 'Capillary irrigation of container-grown nursery stock'.

Factsheet 07/05: 'Securing your water supply for the future'.

AHDB Horticulture grower summaries and reports

HNS 182: ‘Developing optimum irrigation guidelines for peat-reduced, peat-free and industry standard substrates’.

HNS 159: ‘Nursery stock propagation: Nursery evaluation and demonstration of the Evaposensor towards its commercial availability as a mist controller’.

HNS 141: ‘Improving the quality of HNS and roses using irrigation and fertigation management techniques’.

HNS 122: ‘Container nursery stock irrigation: Demonstration and promotion of best practice’.

HNS 117: ‘Identifying the key factors controlling HNS uniformity’.

HNS 107a: ‘Improving water management within growing media’.

HNS 107: ‘Container HNS irrigation: Use of capillary matting under protection’.

HNS 97b/Horticulture LINK project HL0168: ‘Enhancing the quality of hardy nursery stock and sustainability of the industry through novel water saving techniques’.

HNS 97/Horticulture LINK project 201: ‘Improving the control and efficiency of water use in container-grown hardy ornamental nursery stock’.

Author

Chris Burgess, Horticultural Agronomist

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Produced for you by:

AHDB
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

T 024 7669 2051
E comms@ahdb.org.uk
W ahdb.org.uk
@TheAHDB