Progress in Irrigation Management and Scheduling for Container Nursery Stock©

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INTRODUCTION

Water is no longer a cheap and unlimited resource for U.K. nurseries. Growers are being forced to re-evaluate how efficiently they are using water because of new restrictions on obtaining extraction licences, increasing costs of mains water, and legislation affecting supply and the fate of drainage water. However, there are always other economic benefits from improving water management through improved productivity, crop quality, and labour savings.

This review covers some recent work undertaken at Horticulture Research International (HRI) Efford, including part of a 4-year LINK project involving other research and industry partners. It concentrates on improving efficiency of water delivery and use in container-grown crops, including scheduling systems. Other equally important measures not covered here, but which should nevertheless be considered within an integrated water management policy for nurseries, include rainwater harvesting, runoff water recapture, and cleaning and storage of water for re-use.

FACTORS AFFECTING IRRIGATION OF PLANTS IN CONTAINERS

Most irrigation and water management in horticulture is concerned with crops grown in soil and in the field. Traditional concepts of field capacity, soil moisture deficit, available water capacity, evapotranspiration, and millimeters of irrigation need to be applied with care to the unique environment of the containerised crop. Plants in discrete units, whether cuttings in plug trays or large specimens in 10-L containers, have a water supply restricted to whatever gets in via the top or bottom of the pot. There is no opportunity for significant redistribution of water into the root zone between irrigation events such as can occur in field soils (apart from Efford sand beds with a water table, for example). Container crops are thus very susceptible to poor water distribution. The foliage canopy can still upset delivery of water to the pot, even from uniform overhead systems or rainfall.

Container plants in a well drained growing medium typically undergo more rapid wetting and drying cycles than plants in the soil, leaving little room for scheduling errors. Conversely, the base of pots stood on noncapillary bases such as gravel can remain waterlogged due to "perched" water tables, particularly in winter, leading to root loss. The natural tendency on nurseries, with a typical overhead irrigation system and limited time for spot watering by hand, is to over-irrigate a large proportion of the crop to ensure all pots "get enough". The result is wastage of water, leaching of nutrients, excessive weed, moss, and liverwort growth, poor control of crop growth and, frequently, problems with disease and grade-out.

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IMPORTANCE OF UNIFORMITY OF APPLICATION

Good irrigation uniformity underpins all other measures to schedule irrigation and improve efficiency of water use. This has been recognised by the nursery industry in New South Wales, Australia, where irrigation systems have been evaluated against a set of performance standards. Application rates and uniformity can be simply measured using 30 or more equal sized collecting dishes (e.g., pot saucers) distributed over a representative area of production bed, including the edges and corners. The system is run at normal operating pressure for a known period. Volumes in each dish are then measured. A spreadsheet program has been developed to easily calculate the following three coefficients, and graphically present results:

- **Mean application rate (MAR):** 15 $mm \cdot h^{-1}$ (i.e.,15 $L \cdot m^{-2} \cdot h^{-1}$) max. This average irrigation rate is a guide to the maximum rate growing media can absorb water without excessive run-through.
- **Coefficient of uniformity (CU):** This is the overall uniformity of water distribution for the area sampled. Aim for better than 85%.
- **Scheduling coefficient (SC):** The ratio of the average irrigation rate to lowest measured. This represents the extra time you would need to run the irrigation system in order to wet up the driest zone compared to a perfectly uniform distribution (SC 1.0 is therefore the ideal; you should not be above 1.5).

A survey of 180 Australian nursery systems revealed that only 13% achieved these targets and that more than 30% of systems had SC values greater than 3.0. Research experience so far indicates U.K. nurseries perform no better.

SPRINKLER LAYOUTS

Overhead irrigation remains the most widespread and least costly method of watering container nursery stock. While less efficient than other methods, many installations suffer from poor design and operation. Correct selection of sprinkler type and nozzle combination at the right spacing, and run at the design pressure, is essential to achieving an appropriate application rate and uniformity. Design software is available to correctly match these factors to arrive at the most appropriate system for a customer's bed area and layout, and should be used by reputable suppliers and consultants.

A common fault is to use too few sprinklers to give an even overlapping pattern up to and beyond the edges of the cropped area. With the relatively low cost of some plastic sprinklers and fittings, this can be a false economy. It can be shown that a system with more sprinklers giving a uniform output can be run for a shorter time and use less water than a poorer designed one which needs to be run much longer in order to adequately water the dry corners and edges. The "overspill" from the uniform system also gives some buffer against wind drift, which would otherwise further affect distribution. Where nurseries are collecting surplus run-off, further savings can be made.

SCHEDULING

One objective of a recent LINK (funded by industry and Department of Environment, Food, and Rural Affairs) research project, was to develop practical methods and equipment for scheduling overhead irrigation of outdoor container nursery stock. Two approaches were investigated. The first was based on estimating evapo-

Figure 1. Skye Evapometer and Evaposensor.

transpiration water losses and subsequent gains through irrigation. The second was direct sensing of moisture in a representative pot, linked to a switching circuit and solenoid valve to automatically turn irrigation on and off.

Estimating Evapotranspiration. One advantage of containerised plants is that water availability to the root zone, evapotranspiration losses, and irrigation/rainfall gains can all be accurately measured by simple weighing (gravimetric analysis). While this may be tedious on a large scale, it is a straightforward method providing a benchmark to test and calibrate other indirect methods. Good crop managers will already be informally using a "gravitational assessment" as they lift samples of pots before and after an irrigation to judge watering need, and effectiveness of irrigation distribution and uptake into the pot. In addition to calibrating sprinkler uniformity using the pot-saucer method described above, weighing a representative sample of pots before and after irrigation can be a useful exercise on the nursery. This is to determine how long to irrigate to effectively bring containers back to pot capacity without excessive drainage. "Run-through" losses can be estimated by placing a sample of container plants inside smaller empty pots (e.g., 3 L into 2-L pot lined with a polythene bag). A gap above the collected water will prevent re-absorption by the growing medium.

The evaposensor (Fig. 1) was originally developed at HRI East Malling as part of a control system for mist and fog propagation installations. It consists of a wet and dry temperature probe, and should be placed above the crop canopy where it will be influenced by the four environmental parameters driving evapotranspiration, namely solar radiation, air temperature, humidity, and wind speed. The temperature difference between the probes can be logged and integrated over time by the Evapometer, developed and commercialised by Skye Instruments Ltd as part of the

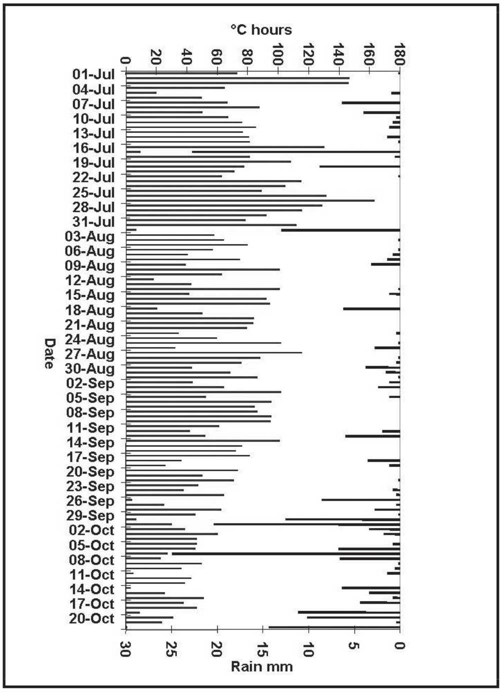

Figure 2. Twenty-four hour Evapometer outputs and daily rainfall.

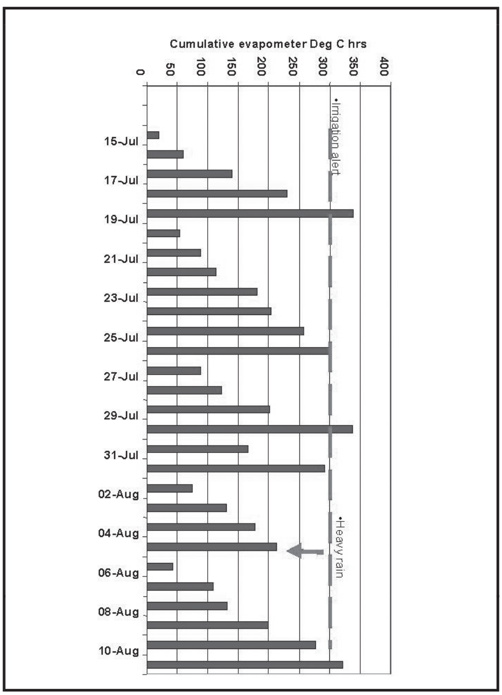

Figure 3. Using the Evapometer to schedule irrigation.

LINK project. The output from the Evapometer in °C h can be read from the display as a cumulative total (since last being reset), and in the current and previous 24-h period (e.g., from 9:00 AM or any time preset by the user) (Fig. 2). This data correlates very closely with evapotranspiration calculated using the Penman-Monteith equation using meteorological data, but at much lower cost than a weather station installation.

At Efford, we weighed samples of pots on a daily basis, before and after irrigations over a few weeks, and correlated this with Evaposensor output to calibrate it for a crop of *Hydrangea* growing in 3-litre pots. We were then able to use the Evaposensor to schedule irrigation applications. In practice, it was found that 300 °C h could be accumulated before a fixed irrigation dose was applied, sufficient to bring containers back to near pot capacity. This might occur over just 2 to 3 days in hot weather, or a week or more if dull. Rainfall contribution was not formally accounted for, but in practice after significant rainfall we simply reset our accumulated °C h total back to zero (Fig 3).

An Evaposensor and meter has the advantage that a single unit on a nursery will monitor the environment for all outdoor crops (with others required for protected environments). However, separate calibration factors are needed to schedule crops in different sized containers at different growth stages, etc. Another way Evapometers could be used, is to provide a daily (or periodic) relative adjustment factor to time-clock-based irriga-

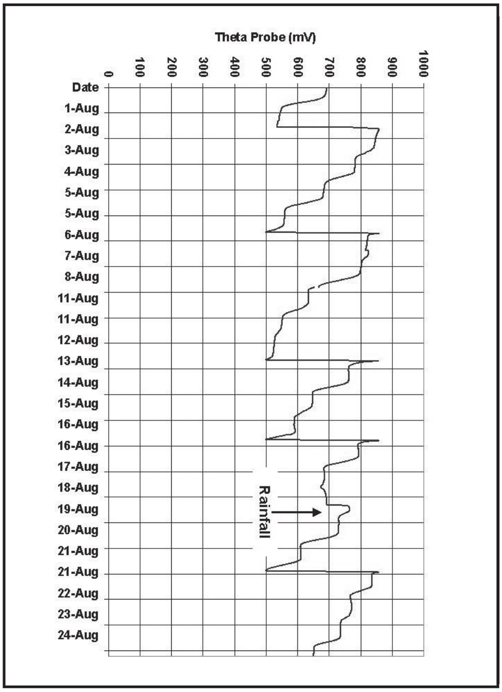

Figure 4. Theta probe output triggering irrigation.

tion. For example, a system may be set up to provide a daily 20-, 40-, 10-, and 50-min irrigation dose to stations A to D, correct for a sunny summer's day, correlating to 200 ºC h. If only 100 ºC h accumulates the next day, irrigations can all be reduced by 50%. Several irrigation controllers now enable a percentage adjustment to be set for all stations at once.

In-Pot Water Sensing Using a Delta-T Theta Probe. The Delta-T Theta Probe is a scientific instrument for measuring water content of soil and other growing media using frequency domain reflectometry (FDR) technology. The unit outputs a low voltage signal according to the water content of the medium within an area of about 25 mm diameter and 60 mm deep enclosed within an array of four stainless steel probes. A prototype electronic switch was developed by Delta-T Devices Ltd in the LINK project. This was used to trigger a 24V AC solenoid irrigation valve to open and close according to "dry" and "wet" set point values from the Theta Probe signal (Fig. 4). Initial "calibration" of the set points was done empirically by inspecting the crop and growing medium at the "dry" point when irrigation started, and at the "wet" point when irrigation stopped. A Theta Probe inserted into a single representative container within a crop was sufficient to control irrigation automatically, with little or no manual intervention, over several months under a reasonably uniform sprinkler system. The system was also tested successfully on commercial-scale crops on two nurseries, where water savings of 30% to 40% were made compared with manually controlled irrigation.

Direct in-pot measurement is a "closed-loop" control system with the advantage that it accounts for the complex factors influencing water loss and gain, rainfall, leaf canopy structure, size of plant and container, etc. However, a representative plant needs to be chosen with care, irrigation distribution must be good, and separate units are required for each irrigated block. A less expensive sensor than the Theta Probe is currently being developed by Delta-T Devices Ltd. for controlling irrigation, where absolute measurements are not required.

CAPILLARY MATTING SUBIRRIGATION

The use of capillary matting irrigation is widely used for pot and bedding plants under protection. It is sometimes used with container-grown nursery stock, but often in conjunction with overhead sprinklers as a secondary system to help redistribute otherwise wasted water. However, its use for primary irrigation is less common, even though it has the potential to increase the efficiency of water use by both reducing consumption and improving uniformity compared with overhead sprinklers. Capillary matting beds (capillary flow beds) are less expensive to install than drained Efford sand beds, but do require care in setting up if they are to perform adequately. Key features of the capillary flow bed are:

A smooth firmed base lined with polythene and with a gentle slope (typically 2%) across the bed to aid water distribution and allow surplus to drain. The vertical fall over the width of the bed should be well within the capillary lift of the matting (e.g., 50 mm for a 2.5-m wide bed).

Irrigation lines spaced appropriately to evenly wet the matting. Three lines of "T-tape" about 0.75 m apart, offset with the first line along the upper side of the bed, has given good results for a 2.5-m wide bed.

Hard water should be acidified to prevent build up of carbonate deposits that reduce capillarity of the matting.

Matting types without an integral hardwearing surface should be covered with a permeable groundcover such as Mypex or Tex-R, although such mattings will need to be run wetter to maintain capillary contact with the potting medium.

Scheduling should aim to maintain reasonably constant moisture in the pot rather than large wet/dry cycles. There should normally be little or no irrigation run-off from the bed. Once capillary contact is broken with drying pots, manual drenching is required to re-establish it.

Time clocks will require adjustment according to weather and stage of growth. Automatic control using a "Waterbug" controller (Flowering Plant Ltd.), which works on a similar principle to the Theta Probe plus switch, can also give good results.

Water consumption is typically similar to sand-beds and about 25% to 30% that of a well designed sprinkler layout.

WETTING AGENTS AND MULCHES

It is well known that dry peat becomes water repellent. Dry pots that are difficult to wet up initially or rewet after drying out contribute to problems with water management, particularly the need for labour intensive spot watering. Wetting agents

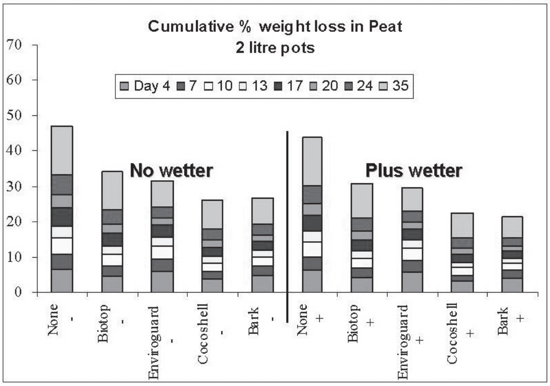

Figure 5. Effect of mulches and wetters on evaporation from pots (without plants).

(but not polymer gels) and mulches were investigated to see whether they might improve water management *within* containers; i.e., rewetting, redistribution, and retention. A standardised "pour through" test for water retention efficacy and longevity of wetters over 6 months was developed using 9-cm pots. Proprietary liquid and granular wetting agents were compared in both 100% peat and peat-free Sylvamix — a proprietary growing medium based on treated forestry residues. Sylvamix was easier to rewet when dry than peat, although being more open, retained less water once hydrated. Wetters were more beneficial for peat. The activity of some newer formulations including Saturaid Granular, Suffusion Liquid, and Psimatrix Liquid remained very good after 6 months compared to some other products including some "organic" ones based on plant extracts.

Addition of a wetter had little effect on water loss through evaporation from the growing medium surface. A 15 to 20 mm depth of a coarse mulch such as Cocoshell or Cambark 100 reduced evaporation to half that of the control (Fig. 5). They were more effective than finer materials such as Biotop (chopped *Miscanthus*) or Enviroguard (pelleted paper waste), which maintained more capillarity with the growing medium.

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Facing the Challenge of Wild Flower Production©

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INTRODUCTION

The nursery was started in 1986 with the help of a government enterprise grant. For this I needed to fulfil certain requirements including 6 months unemployment and having £1000 in the bank. A bank loan was also obtained.

THE NATURE OF THE PRODUCT

A plant is considered a wild native of the U.K. if it has been present since the last ice age. One dictionary definition is "a flowering plant that grows in a natural, uncultivated state/the flower of such a plant." The Wild Flower Society says "A species unplanted and uncultivated." These days most of the general public believe a wild flower is anything not in a garden that you can see on a walk, and a recent book lists 50 species horticulturists would consider alien weeds. A campaign for "county flowers", by the conservation charity Plantlife, lists eight species that have only arrived in the U.K. in the last 100 or so years.

There are other examples of confusion. The charity suggests dandelion for Cardiff — but which one? There are 229 different microspecies, of which *Taraxacum texelense*, is endemic to Lancashire, *T. cambricum* mostly in Wales. We grow *T. obliquum*, a coastal species. There are also 261 microspecies of hawkweeds, of which we grow seven, one of which is endemic to Cardiff and would be a better choice than dandelion. (Author's note: Populations of hawkweeds and dandelions in U.K. only reproduce apomictically. Hence distinct local types occur which do not interbreed with neighbouring types.)