Making sense of ET: new ways to optimise use of water

For many readers the term ET, or 'evapotranspiration', will have a familiar ring but most would be hard put to define it. In this article, Richard Harrison-Murray and Chris Burgess explain what it is, why it is important and how it can be measured. They also describe exciting developments in measuring equipment that will help growers use water more efficiently and effectively, all the way from misting of cuttings to large scale irrigation.

What is ET?

Evapotranspiration is a measure of water use by a crop, combining evaporation directly from the soil and/or pots and transpiration from the plants themselves. It depends on both the energy available for evaporation and the air movement required to carry away the evaporated moisture. It therefore varies with the weather, particularly solar radiation, humidity, wind speed and temperature. Like rainfall it is usually expressed in millimetres.

It also depends on the nature of the crop, its stage of development and whether it has plenty of water. For that reason measurements generally relate to a standard reference crop, usually an extensive area of short grass, well supplied with water, known as 'potential evapotranspiration', ET_0 or ET_{ref}.

Why is ET important?

ET is important because estimates of how much water a crop is using can be used to decide when we need to irrigate. This not only saves precious water, it can help avoid damaging crops by over or under watering. Investing in technology to match irrigation to crop demand not only helps reduce water bills and meet regulatory requirements for water use efficiency, it can also improve crop quality. This is particularly true for ornamentals.

For cuttings the situation is slightly different. Without roots, they can only take up water very slowly so propagators must restrict ET to a level the cuttings can tolerate. Most commercial propagation depends on mist or fog, carefully regulated to limit ET without excessive wetting.

How can ET be measured?

The most widely used method takes data from a meteorological station (radiation, temperature, humidity, and wind speed) and plugs the figures into a complex mathematical model (e.g. Penman-Monteith) to come up with an estimate of ET_{ref}. To convert this to an estimate of water use by a particular crop, a grower either needs to know the appropriate 'crop coefficient' to apply or else the means to estimate it.

An alternative to this mathematical approach is to use a physical model that behaves in a similar way to a transpiring crop such as a shallow layer of water in an 'evaporation pan'. Such instruments are simpler and cheaper than running a complete met station but until recently they did not lend themselves to automation. The advent of the Evaposensor and development of suitable electronics to interface it to irrigation controllers has removed that obstacle.

What is the Evaposensor?

The Evaposensor is a physical model of a transpiring leaf that is unique in giving a continuous electrical output proportional to the rate of evaporation. This makes it ideal for control of mist or fog to protect cuttings during rooting. However, by integrating the output over time it can also be used to estimate ET_{ref} for scheduling of irrigation.

It consists of two leaf-like probes, one of which is kept wet by a wick (Fig. 1) and it is the temperature difference between the probes that generates the electrical output. Superficially similar to a wet and dry bulb thermometer for measuring humidity, it works on a very different principle (Harrison-Murray, 1991). Invented and developed as a research tool at East Malling during the 1990s, grower-friendly equipment from E&TS has recently reached the market, encouraged by an HDC project to assess the value of the technology to commercial growers. That project demonstrated benefits for propagators in terms of rooting success and ease of management (Burgess and Harrison-Murray, 2009). Other research has demonstrated the feasibility of automatic scheduling of irrigation to a wide range of HNS container crops by reference to a single Evaposensor. This is now an area of active development with many nurseries interested in adapting the technology to suit their existing equipment, crops and management preferences.

How is the Evaposensor used?

The equipment from E&TS is called an Evaposensor Controller Interface (ECI) to reflect its versatility for linking the Evaposensor to other equipment (Fig. 2). It can also be used as a high specification mist controller in its own right.

In propagation, the Evaposensor is generally placed at cutting level so that it is exposed to the mist or fog, giving closed loop control (Fig. 3). The 'Wet Leaf Depression' set point determines the evaporative demand that will trigger a mist burst and an 'Interval' setting sets a minimum time between bursts.

For irrigation scheduling, the Evaposensor is placed in a representative location, well above the crop (Fig. 4). Its output is integrated over time to produce a value proportional to ET. The system then schedules irrigation automatically either by varying the amount applied at a fixed interval (e.g. daily) or by varying the interval between irrigations. The beauty of the automated system is that it takes care of the day to day variations in water requirement so that the grower's skill is concentrated on fine tuning to suit the needs of different crops, based on relatively infrequent inspections (Fig. 5).

Where next?

Evaposensor technology is opening up cost effective ways for almost all HNS growers, and no doubt many in other sectors, to regulate their use of water in line with crop requirements. If you are interested in learning more please contact Richard Harrison-Murray (01732 847 403, richard@rhmscience.co.uk) or Chris Burgess (01202 470 435, home.burgess@ntlworld.com)

Burgess, C.M. & Harrison-Murray, R. S. (2009) Final report on HDC Project HNS 159. Horticultural Development Company, AHDB, Stoneleigh, Warwickshire, UK. 59 pp

Harrison-Murray, R.S. (1991) An electrical sensor for potential transpiration: principle and prototype. Journal of Horticultural Science 66,141-149

Fig 1. The Evaposensor has been available commercially from Skye Instruments for about 10 years but, until E&TS developed a versatile control interface, its use was limited to research.

Fig. 2 The new Evaposensor Controller Interface from E&TS (right) linked to a Heron irrigation control panel (left) to achieve automatic scheduling of irrigation based on ET registered by an Evaposensor

Fig. 3 The aim of misting is to limit the rate of transpiration from cuttings and an Evaposensor placed among the cuttings is the ideal way to control it.

Fig. 4 An Evaposensor crudely fixed to the south side of a glasshouse stanchion in a successful trial of “Evapo-irrigation”, that is automatic scheduling of irrigation in line with ET as registered by an Evaposensor.

Fig. 5 A fine crop of Syringa 'Red Pixie' grown under "Evapo-irrigation". Irrigation was applied daily but the amount varied automatically in proportion to ET as registered by an Evaposensor. Using settings adjusted to match different crops, the system could control all beds in the glasshouse from one Evaposensor.