TECHNICAL

NURSERY PAPERS

**September 2013** Issue no.8

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## Automating Irrigation Scheduling in Nursery Production

Traditionally irrigation scheduling in production nurseries has been determined by past experience (gut feel) and the setting of specific run times depending on the season. Other common methods employed include manual moisture assessment of individual containers, daily evaporation measurements or using a weight method to determine a container's water holding capacity. In this month's Nursery Paper Queensland Industry Development Manager John McDonald and Research Scientist David Hunt describe the water use efficiency and cost savings achieved through the automation of irrigation scheduling.

# Automating Irrigation Scheduling in Nursery Production

Managing plant production and increasing productivity through reduced input cost is an ongoing issue for all production nurseries. Whether the crop is vegetable or forestry seedlings, containerised fruit trees or ornamental plants, the resource inputs and costs of production are a constant. Retail prices may fluctuate due to post-production expenses and varying profit margins but the actual resources and costs involved in producing a plant are relatively fixed. Therefore developing new methods and technologies to assist producers in managing input resources and costs e.g. water, nutrients and energy is paramount for ongoing sustainable development of the horticultural industry.

Irrigation scheduling for nursery crops is the science of establishing a balance between the application rate of an irrigation system and the time period that is required to replace the amount of water previously lost from a container or to re-fill the container to the capacity of the growing media. It allows us to replace the water lost through plant transpiration and evaporation (Evapotranspiration) and maintain the growing media water content at a point that does not drought or waterlog the crop, therefore providing the optimum growing conditions.

Modern manufacturing techniques and design methods allow irrigation distribution systems, e.g. pipes, pumps and emitters, to be designed with highly accurate and constant application rates, if installed and maintained correctly. The use of blended organic growing media with known and relatively stable water holding capacity, air filled porosity and infiltration rates are available and only change due to plant/root growth. As the physical properties of the irrigation system and growing media remain fairly constant, developing an irrigation control system that responds to the plants daily water requirements can help to reduce input costs and improve both water and energy use efficiency.

**NGIQ Weight Based Irrigation Scheduling Controller (WBIC) research project - Redlands Research Station**


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Most of the current systems employed by production nurseries to schedule irrigation are either dictated by the season, e.g. summer = two irrigations/day (am & pm) at 20 minutes each and in winter = one irrigation/day at 10 minutes or variations to this based on "testing" container moisture content by feel and visual assessment or weight by lifting a container. A system also used in the past by a few growers has been through the measurement of daily evaporation (Class A Evaporation pan) and replacing the water lost each day in the next day's irrigation.

The operating parameter common to all of the above scheduling systems is they are all an approximation, at a given point in time, of the amount of water lost to evapotranspiration and what is required to re-fill to container capacity. With many growers unsure of the initial total water holding capacity of their growing media, crop wilting points, container recharge points, etc the whole scheduling system requires greater and more accurate tools for production nurseries.

Over the past four years NGIQ has been actively researching the technology available to automate irrigation scheduling in container crops through a dedicated research program funded under the South East Queensland-Irrigation Futures (SEQ-IF). Field based crops have for many years been able to use a range of soil moisture measuring tools from tensiometers, neutron probes, capacitance probes and Enviroscans to support infield irrigation scheduling and apply water at the precise time the crops require it. The research has shown that many of the technologies used in soil based cropping are either not suitable or will require alterations to container cropping practices e.g. reduced air filled porosity, that render them inappropriate for use.

The one area that has shown promising results in container irrigation scheduling is through the use of electronic loadcells measuring the container weight and through basic calibration the water content of a container (container capacity). The loadcells can take a number of "sample" containers in-situ that represent the crop in the field and through the averaging of the weights give a very accurate water content measurement at any given time. As a result of the NGIQ research the gravimetric weight method utilising loadcells has been developed into a complete weight-based irrigation controller (WBIC) that monitors plant container weights and triggers irrigation according to the plants daily water use. The WBIC has the flexibility to allow pre-set irrigation times, multiple zones, frost settings, individual trigger points for both re-charge and container capacity and can operate off a PC or a standalone touch screen controller.

**Research Results**

The use of loadcells to schedule irrigation has demonstrated significant savings in water use and energy consumption as well as improving the overall operation of the irrigation system by removing the 'human factor' from most of the decision making. Data from a trial completed in 2010 is described below which demonstrated water saving between WBIC and timed irrigation can be as high as 70% (Figure 1). Water use for the trial was calculated on the output flow rate of four MP1000 sprinklers (6.93 L/min) per irrigation zone. The irrigation system met NGIA best management practice for minimum requirements of uniformity with the system measured at 85% coefficient of uniformity, mean application rate of 17.7 mm/hr and a scheduling coefficient of 1.5.

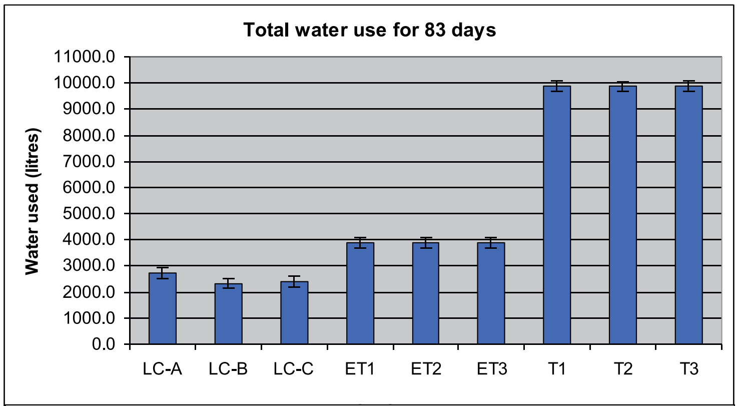



**Figure 1: Water use for each replicate**
(LC = Loadcell; ET = Evaporation and T = Timed irrigation)

Irrigation events were initiated within seconds of container weights reaching the lower trigger weight and continued until the upper stop weight was reached. Irrigations varied between the three loadcell groups according to plant water use. An irrigation event is characterised by a sharp increase in weight, while the rate of water use is represented by the angle or slope of the decline in weight and shows that during the period of high evapotranspiration two irrigations were triggered during the day and the rate of moisture loss was high, represented by the steep decline in container weight (Figure 2). During periods of lower evapotranspiration (B), only one irrigation occurred and the rate of moisture loss was slower, represented by a slower decline in container weight. Evapotranspiration reduces or stops during the night and is seen as a constant container weight or horizontal line between 6 p.m. and 6 a.m.

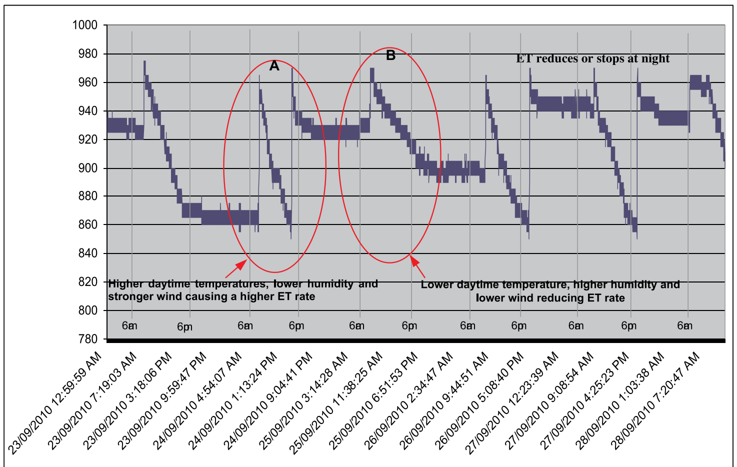



**Figure 2: Irrigation data 23/09/10 to 28/09/10 (5 days)**

The research also identified the need to accommodate plant growth and the impact on the weight of the container and the relationship to the re-charge/re-fill trigger. A pre-set stop weight would need to be adjusted to account for weight increases attributed to foliage or root growth, and a reduction in the water holding capacity due to growing media degradation. The development of a self-adjusting or feed-back mechanism that identifies when the maximum water holding capacity of the container, or a state of constant weight, has been reached would account for these variations and is being built into the WBIC.


**Weight Based Irrigation Controller (WBIC)**

The weight-based irrigation controller (WBIC) was developed by Pacific Data Systems Pty Ltd (PDS) specifically for the NGIQ research trials (*Figure 3-7*). The system uses a 2-wire network to communicate between the master controller and remote nodes positioned throughout the production area. Each node has the capability to connect a variety of digital and analogue sensors, solenoids or inputs. Other systems and sensors such as pump and filter pressure transducers could be connected as an advance warning of equipment failure or an entry switch could be connected to pause irrigation for zone access.


**Figure 3: An in-field WBIC network node for connection solenoids, weighing devices and other sensors**

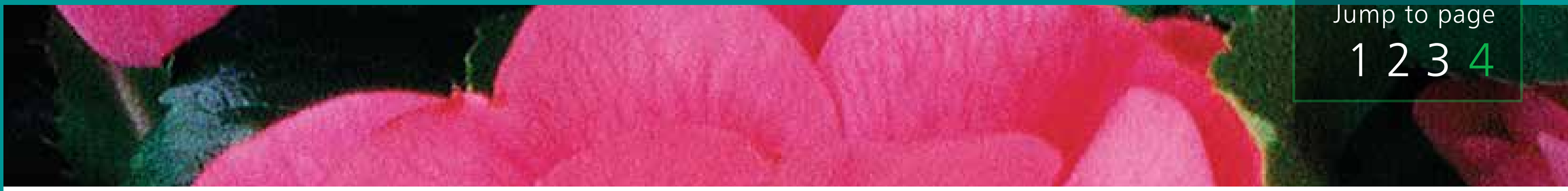

**Figure 4: WBIC unit with touch screen interface**

**Figure 5: Loadcell used to monitor plant weights and trigger irrigations**


**Figure 6: WBIC unit with touch screen interface and security logon screen**

The WBIC can be programmed with different levels of security using passwords to allow access to different functions. The nursery manager could setup a low level password for staff to use for minor adjustment or corrections but restrict access to the core program. Several irrigation alarms have also been included to monitor any system failures. For example, a wilt alarm can be programmed to inform the manager that an irrigation zone needs immediate attention or a high water alarm can be programmed to trigger if container water content goes above the irrigation stop point. These will provide a self-check mechanism to ensure that plants are not over or under irrigated and highlight any issues with the irrigation system or program.

The main difference between this irrigation controller and other irrigation controllers is it incorporates the use of loadcells, or a weighing device, to monitor plant growth and water use. The WBIC uses a method similar to the gravimetric water holding capacity method mainly used for research to determine the water holding capacity of a growing medium. The WBIC combines this with the concept of evapotranspiration (ET) to control and trigger irrigation according to the plants water usage. This weight-based irrigation scheduling method has the potential not only to improve water and energy use efficiencies in a containerised production nursery, via reduced pumping times, it also allows the plant to control irrigation in real-time as the growing environment changes.



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### Weight Based Irrigation Controller (WBIC) Features

| WBIC Feature | | |
|---|---|---|
| Colour touch screen with graphical user interface allows setting / editing of all irrigation parameters. Wired or wireless pc link between controller and office computer | Pds-wx-3 weather station interface provides satellite positioning, rainfall, wind speed, wind direction, relative humidity and temperature information | Node inputs:<br>• Three 24-bit load cell inputs<br>• Three analogue inputs for solar radiation, relative humidity etc.<br>• Rain counter<br>• Digital inputs |
| Controls three methods of irrigation: time-based, evapotranspiration, and weight-based | Optional master solenoid control which (if selected to be used) will switch on when any zones are irrigating | List of the wbic functions and features |
| Et irrigation scheduling can use either daily et values or the accumulated et value to trigger irrigation. | Manual irrigation ability for each zone which will irrigate for the number of hours & minutes set by the operator | Easily adjustable set points for weight based irrigation |
| Irrigation zones can be created and moved around the screen over top of a plan view of the nursery | Instant summary of the last 10 irrigations for each zone presented in an on-screen spread sheet | Monitor water level in the container or total weight |
| Visual animated feedback for each zone currently irrigating | Robust ip67 waterproof enclosure | Calculates root mass and above ground weight while the plant grows |
| Maximum simultaneous irrigations parameter prevents too many zones irrigating beyond the pumps capability | Power and communication between nodes occurs over a single pair of 24vac wires (no separate communications or power wiring required) | Can be used with growing media other than soil where traditional soil moisture probes are ineffective |
| Usb download of data in csv format will load directly into spread sheet software | Controls latching or non-latching relays | Access to the settings are protected by security password |
| Data storage length: 12months | Alarm output to indicate problems | All irrigation zones can be programmed to operate within time-windows |

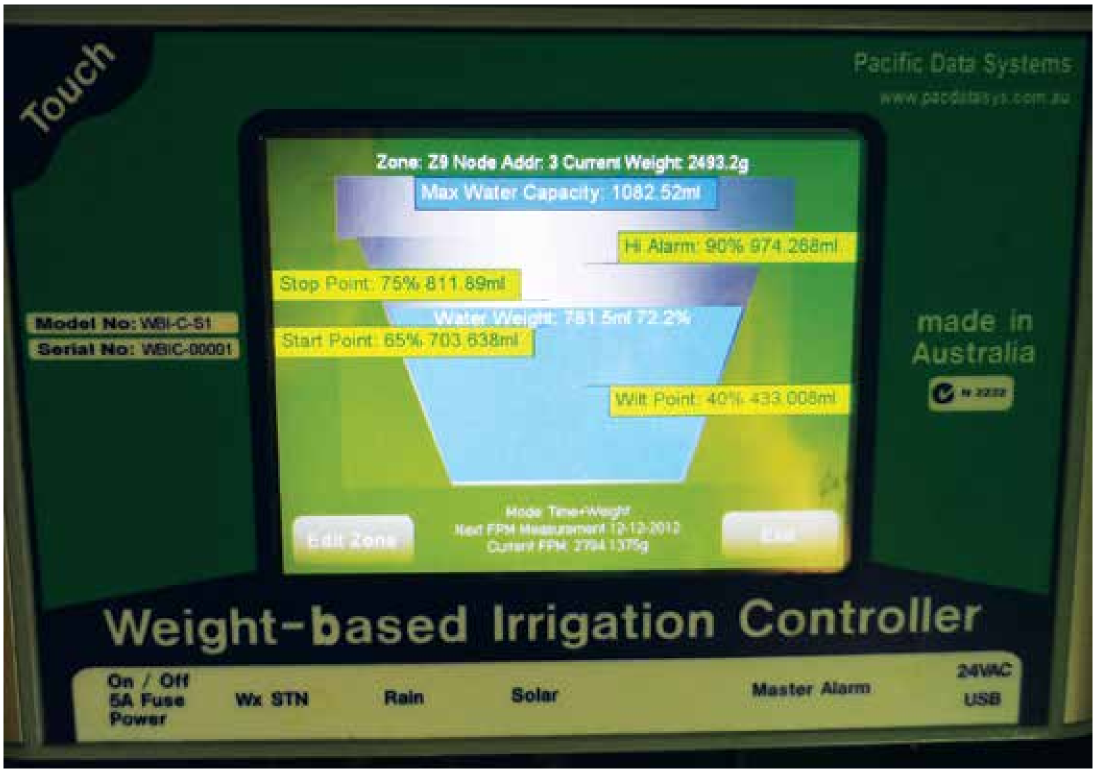


**Figure 7: WBIC Touch Screen – diagrammatic view for setting Stop Point, Start Point, Wilt Point and over irrigation alarm point.**

## Further Information

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Published by NGIA, PO Box 7129 Baulkham Hills BC NSW 2153