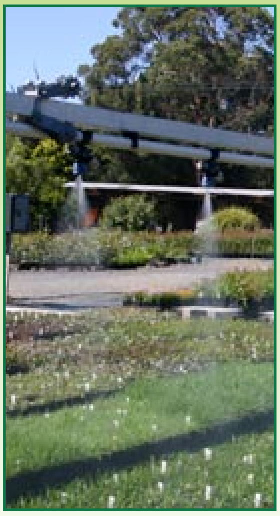
NURSERY PAPERS

OCTOBER 2008 Issue no.8

Do soil moisture sensors have a role in containerised nursery production?

As an industry we are dependent upon reliable access to water of suitable quality and quantity. In recent years we have been significantly impacted by climate change, drought, water restrictions, water recycling, desalination, prescribed environmental flows and the plethora of water legislation which governs our entitlements to securing water for our needs.



The focus on water use efficiencies has become more stringent and there is a call for all industries to be accountable for their water use, however the finger has definitely been pointed to the irrigation industries and outdoor water use. In response to a need to offer improved water use efficiency techniques and encourage adoption the NGIA commissioned the Department of Primary Industries & Fisheries Queensland to undertake work in assisting adoption of innovative irrigation technologies.

This is the first of a series of Nursery Papers on this topic. In this Nursery Paper, Michael Danelon, Nursery & Garden Industry NSW & ACT (NGINA) Industry Development Officer, (IDO) explores the use of soil moisture sensors and the ability of these devices to be applied to soilless based containerised nursery production to appropriately monitor and schedule irrigation and hence optimise crop production whilst achieving water use efficiency.

Do soil moisture sensors have a role in containerised nursery production?

Industry statistics

In 2003 the Nursery & Garden Industry Association (NGIA) conducted a survey to determine the number of nurseries throughout Australia, the average size of a nursery, the volume of water used per nursery and whether water recycling or water saving technologies are being used. In 2006 NGIA commissioned a team of environmental consultants to conduct a National Water Use Survey of both production and retail businesses (refer to Nursery Paper January 2007, Issue 1) to establish industry data on water use.

The results of both surveys were surprising and indicated wide variations in the level of irrigation water use in megalitres per hectare (ML/ha). Variations in water use are dependent on several factors: location, crop types, growing media, irrigation source, irrigation system and method of delivering irrigation (scheduling). According to the data, annual water consumption for a production nursery can vary from as low as 4ML/ha up to as high as 25ML/ha. Studies have suggested as much as 50 to 70 percent of the higher water usage figure is wasted water because of poor irrigation systems (excess irrigation application rates, poor uniformity and the need for increased run times), an absence of recycling systems and inappropriate scheduling practices in delivering water when it is actually needed.

Feedback from industry indicates many nursery managers use a variety of methods to control and schedule irrigation, such as analysis of rainfall (effective rainfall or not), consideration of evaporation data or physical assessment of the growing media to determine container moisture content.

The knowledge required to determine optimal irrigation applications and irrigation scheduling is acquired through many years of experience. However, some of these methods can be inefficient due to the time required to monitor all areas of a nursery and some do not actually measure the available pot moisture content (usage of rainfall and evaporation figures).

Nursery & Garden Industry Australia

• Your Levy at Work •
The production and distribution of Nursery Papers is funded jointly by your Nursery Industry Levy and the Commonwealth Government via Horticulture Australia Limited

HAL
Know-how for Horticulture™

Limited technology transfer across industry

Although a number of innovative products (by example wastewater reuse and irrigation tools utilising high-end IT technology) are currently available, they are yet to be widely incorporated by the nursery and garden industry despite their potential to substantially increase productivity and profitability by reducing input costs in areas such as water and fertilisers usage.

In many cases low adoption of technology has been due to a lack of specific cost/benefit data and a lack of independent verification of claims made by equipment suppliers. Up until recently, the evidence of product efficacy has been anecdotal or based on insufficient scientific analysis, which has usually been commissioned by the manufacturer or marketer of the product, which further adds to the reluctance of producers to invest in them.

Overseas there is widespread adoption of automated irrigation systems in hydroponics and soilless based containerised nursery production systems. The ability to monitor and regulate the container rootzone environment can influence the plant physiology by regulating the free water and dilution of nutrient salts and acids to govern the availability and uptake of water whilst limiting the amount of leachate generated in each irrigation event.

Within Australia the majority of moisture sensors have been developed for inground or soil based field production systems which are typically applied to broad acre production and monocultures such as cotton, vines and pasture where a uniform plant demand is the norm.

Research project focuses on innovative irrigation technologies

During 2007 the Department of Primary Industries and Fisheries, Queensland (DPI & F, Qld) undertook research to "Increase Adoption of Innovative Irrigation Technologies in Australian Nurseries" on behalf of NGIA. The project aimed to identify and quantify new technologies, which can increase productivity through more efficient water use, reductions in associated costs and evaluation of alternative irrigation scheduling practices.

To achieve this, the project was separated into two parts. Part 1 *(covered in this Nursery Paper)* focused on identifying and evaluating soil moisture sensors for adaptation to a containerised production nursery environment, and discussing the issues identified in implementing such technologies and the benefits (i.e. water savings) achieved in relation to current practices. Part 2 *(covered in a Nursery Paper yet to be released)* focused on retrofitting the irrigation systems of two production nurseries with more efficient technologies to quantify the potential savings and provide data on the financial feasibility of retrofitting an irrigation system.

Project Aim – soil moisture sensors

The project aimed to identify whether soil moisture sensors are appropriate for use in a containerised production environment and to evaluate the effectiveness of soil moisture sensors for irrigation scheduling in organic based growing media. More specifically, the project aimed to determine:

- Whether soil moisture sensors can be adapted for use in above ground containers growing environments
- Whether soil moisture sensors have the potential to increase water use efficiencies by controlling irrigation frequency and duration and
- The potential benefits of soil moisture sensors compared to standard timed and deficit irrigation scheduling practices.

The research was conducted in 2 stages.

Stage 1 –

Identifying and evaluating soil moisture sensors for adaptability to a containerised production nursery environment

The research conducted by DPI & F, Qld (Redlands Research Station) suggests the use of soil moisture sensors are a viable method to manage irrigation scheduling and improve water use efficiency. However there are a number of factors to consider when implementing a soil moisture sensor controlled irrigation system within containerised nurseries. It is paramount the decision to use a soil moisture sensor either for monitoring and or controlling irrigation scheduling be supported by assessing the irrigation system (reference to benchmark criteria), irrigation controller (scope/flexibility), container size (fit for purpose) growing media type (properties) and the type of plants being grown.

There are a variety of soil moisture sensors available:

1) Insertion units (monitoring tool) with moisture, temperature & electrical conductivity (EC)
   - Simple, quick, requires little technical experience
2) In-situ units (monitoring or automation tool)
   - Technical experience needed to install
   - Can be connected to irrigation controller
   - Generally more expensive

The work undertaken looked at five soil moisture sensors and set about identifying the right soil moisture sensor to use with the criteria being:

- Size of sensor - the sensor needs to fit into growing containers (numerous types of containers being used, ie tubes, 100mm diameter pots and upwards)
- Type of sensor - volumetric or soil potential sensor and be robust and provide reliable data
- Cost - should be financially viable for smaller nursery operators
- Availability - should be readily available with after sales technical support
- Simplicity/ease of use - can be installed and maintained by the nursery staff
- Interface/connection - the product can be connected to existing irrigation controllers

From the above criteria two of the five soil moisture sensors were chosen to trial in wider irrigation scheduling trials - the AquaSpy soil moisture sensor and ECH20 soil moisture sensor with both being capacitance sensors, 200mm in length and measuring volumetric moisture content.

Interfacing soil moisture sensors with older and low cost irrigation controllers will limit the use of sensors as they require certain connection and signal types for interfacing. In some instances, certain irrigation controllers may be inappropriate due to their coding and connectivity to a moisture sensor.

The uniformity of the irrigation system can have a major impact on the accuracy of the soil moisture reading within the container relative to the surrounding container moisture levels. If the irrigation uniformity is poor, the interpretation of an individual container/pot reading, in relation to surrounding containers/pots, needs to be considered to allow a suitable tolerance that accounts for this poor uniformity. Once the irrigation system performance is addressed and the moisture delivery is more uniform then irrigation savings will be realised.

Utilising soil moisture sensors to schedule irrigation events requires an understanding of plant water usage and crop factors to fine-tune irrigation trigger points. Limited research has been conducted on trigger points and this is an area which needs to be applied to an individual crop of which there are thousands commercially grown by production nurseries – far beyond the scope of this research.

Nurseries utilising an organic based growing media would need to conduct a sensor calibration if an actual percentage moisture content of the growing media is required. It is also important to ensure there is good contact of the growing media with the soil moisture sensor. In most instances, a trend of moisture content can be graphed to monitor moisture content over time, a soil moisture sensor can be connected to a rain sensor to override irrigation once moisture levels reach a predetermined level.

Whilst there are some preliminary areas to optimise, soil moisture sensors are capable of being adapted and utilised to operate within a containerised production nursery environment.

Aquaspy and ECH2O soil moisture sensors shown placed within the growing media.

Stage 2 –

Quantifying and comparing the potential water use efficiencies of soil moisture sensors to standard timed and deficit irrigation scheduling practices

Upon completion of the work in stage 1 above, a production growing trial was implemented from August 6 to November 16, 2007, to evaluate the effectiveness of the two soil moisture sensors to automate irrigation scheduling and compare water use efficiencies to "standard" timed irrigation and deficit irrigation scheduling.

Timed irrigation was prescribed to mimic standard nursery practices (10 minutes morning and afternoon) which rarely change in response to actual demand conditions to suit a wide range of plants grown in an irrigation block/zone. It should be noted the deficit irrigation was set by measuring the evaporation within the plant environment (weather station inside greenhouse) and applying a crop factor for turf to mimic the evapotranspiration conditions, ie loss of water from plant transpiration and evaporation from the growing media.

Two organic growing media (85% pinebark/15% sand and 85% pinebark/15% coir) with air-filled porosity readings of 22-25% were used to compare variations within commercial growing media in use across industry and within the 4 scheduling treatments. The potting trial was conducted at the DPI & F, Qld Redlands Research Station within an environmentally controlled greenhouse to limit external climatic factors.

The trial utilised four x 200mm containers per irrigation schedule treatment with treatments randomly placed on a raised bench and surrounded by a row of guard plants to limit the influence of edge effects within a production nursery. One container in each scheduling treatment was designated as the primary container from which all leachate was captured and included the soil moisture sensors. Each bench was replicated three times with all 200mm containers planted with a potted colour seedling of Petunia and irrigated with a uniform drip irrigation system to match the absorption rate of the growing media.

A two wire network irrigation controller (Teven Logic(R)) was used and operated independently for each of the two soil moisture, timed and deficit irrigation treatments. Due to the nature of the AquaSpy soil moisture sensor a separate regulator connected to a rain switch input was required to register a signal.

The irrigation scheduling trial ran for 4 months with the first 2 weeks of the treatment including a priming of the irrigation content of the growing media in each treatment to establish a base moisture content prior to planting the petunias. Each scheduling treatment was focused on for one month (October 17 to November 16) to allow the irrigation frequency/delivery to influence the moisture content, potential leaching volumes and plant response and conduct measurements. Daily adjustments were made to apply the evapotranspiration value (deficit) and fine tune the AquaSpy soil moisture sensor to allow water replacement for plant and growing media during the trial.

Assessing overhead sprinkler systems is critical in determining how much and how well water is being applied so scheduling can then be optimised.

Results

The timed irrigation used the greatest volume of applied water, followed by the deficit treatment, ECH2O and Aquaspy using the least water. In comparison to the timed irrigation the Aquaspy used 53% less water, the ECH2O 44% less water and the deficit using 22% less water. Consistent with less water being applied was reduced leaching amounts in the treatments during the focus period.

Early plant assessment indicated improved plant growth for the first two weeks from planting, however at the duration of the trial there appeared to be no significant differences in plant growth between treatments.

The leachate generated by the four treatments was assessed for pH, electrical conductivity and various other chemical components. There was some variation in the chemical values (not ranked as significantly different) suggesting there is a tolerance in the plant moisture requirements throughout the container (height/depth) to allow similar plant growth under varying pot moisture contents and rootzone environments in Petunias. The main variation was a higher pH within the timed treatment leachate compared to the soil moisture sensors and deficit irrigation treatments.

Conclusion/Findings

The results of the trials suggest the soil moisture sensors tested can be used to either monitor or automate the irrigation system to improve water use efficiency in comparison to timed and/or deficit irrigation. The tangible benefit here is reduced leaching and hence the opportunity to preserve the overall water storage if water recycling systems are not installed to manage run off and preserve water budget.

Prior to using a soil moisture sensor as the basis to manage irrigation scheduling there are several factors to address to ensure the sensor provides suitable readings as outlined within this Nursery Paper. The key area here is to optimise the irrigation system (uniformity and control flexibility) to limit the potential moisture variations between the monitored containers in relation to whole crop moisture status to achieve optimum conditions for plant growth.

The potential cost and complexity of purchasing and implementing a soil moisture sensor may be an impediment to many nurseries. For nurseries still utilising timed irrigation and observations to schedule, an immediate improvement in moving toward measuring and monitoring the evapotranspiration rates (either by Class A evaporation pan or a weather station) could see deficit irrigation implemented as a tool to improve water use efficiency.

In an ever changing environment where the evaporation rates often change daily it is paramount to modify the irrigation delivery to suit the plant and growing media without sacrificing the water asset. Think of it this way "the person who controls your irrigation also controls your profit" – save water and save money!

Efficient irrigation system via boom, however water use efficiency relates to how much the plant and growing media requires.

References

- Nursery Industry Water Management Best Practice Guidelines (updated 2005) available to download from the NGIA website www.ngia.com.au
- Managing Water in Plant Nurseries (2nd edition) available to purchase from the NGIA website www.ngia.com.au
- Nursery Papers May 2006 Issue no. 4, How efficient is your business water management?
- Nursery Paper August 2006 Issue no. 8, Scheduling irrigation to maximise efficiency
- Nursery Paper January 2007 Issue no. 1, Water use in the nursery and garden industry

Acknowledgements

- David Hunt, Scientist,
  Department of Primary Industries and Fisheries, Qld
- Michael Danelon
  IDO, NGINA

Compiled and edited by Sarah McMahon, NGIA Publications & Web Coordinator; banner photography by Anthony Tesselaar.

Nursery & Garden Industry Australia

Published by NGIA, PO Box 907 EPPING NSW 1710.