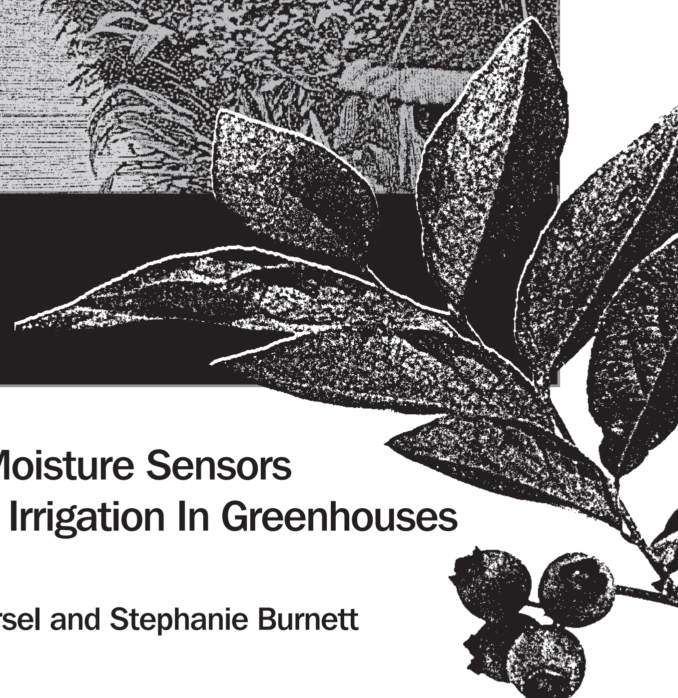
Gauging the Green

Premier Issue

Newsletter for the horticulture, nursery, and greenhouse professional.

Greenhouse Seedling



Greenhouse Blueberries

Using Soil Water Sensors For Efficient Irrigation In Greenhouses

Marc van Iersel and Stephanie Burnett with the University of Georgia

MANUAL IRRIGATION is labor-intensive and repetitive, so it is one of the first greenhouse tasks that should be automated. Although automating irrigation is easy, automated systems are not necessarily water efficient. Many growers use timers to control irrigation, but timers do not account for day-to-day changes in plant water use caused by natural fluctuations in temperature, light and humidity levels. In addition, plant water use increases as plants grow. This makes it difficult to obtain efficient irrigation using a timer. Given the

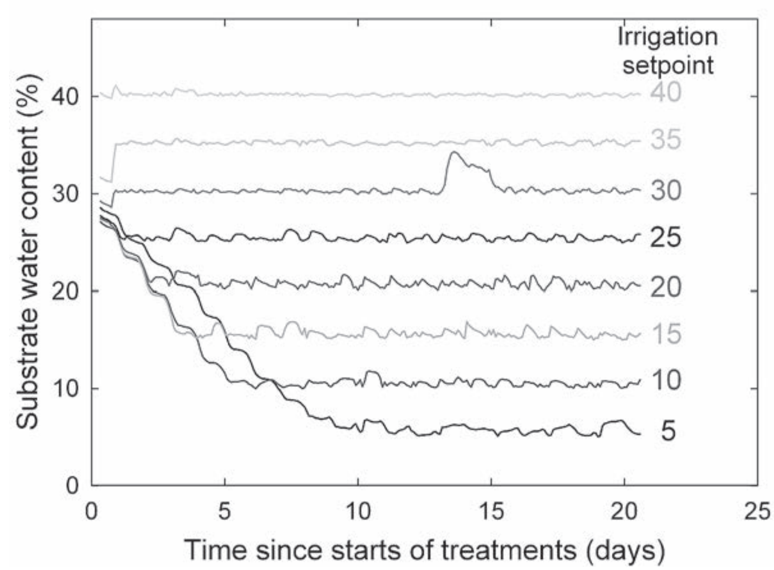
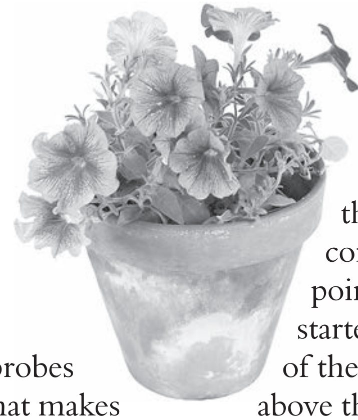


Figure 1. The water content of the substrate over the course of the experiment. Irrigation was controlled using EC-5 probes, and a small amount of water was added to the substrate automatically whenever the substrate water content dropped below the irrigation set point. There were eight different treatments with set points ranging from 5 to 40%.

increasing strain on water resources in many parts of North America, the greenhouse industry needs to move towards more efficient irrigation systems.

Soil water sensors provide promising new opportunities for automating greenhouse irrigation according to plant need. We have worked extensively with Decagon Devices' EC-5 probes,



◄ **Petunia** *(Petunia Hybrida)*
Petunias come in every color except orange. Petunias are part of the nightshade family, which also includes tobacco and tomato.

which are small enough to fit into a 4" pot, and have found that these probes accurately measure the volumetric water content of soilless substrates. We have integrated EC-5 probes into an automated irrigation system that makes it possible to irrigate plants based on actual plant water use.

The basic idea behind using soil water sensors to control irrigation is simple: when plants use water, they take it up from the substrate, so the water content of the substrate decreases. Soil water sensors detect these changes and can be used to open an irrigation valve when the substrate water content drops below a user-determined set-point. This results in frequent applications of small amounts of water, and the frequency of irrigation is adjusted automatically based on the rate of substrate water depletion. This irrigation approach automatically replaces water that is used by plants or lost through evaporation and assures that plants are never exposed to drought stress. By irrigating with the amount of water actually needed by the plants, water use and leaching can be reduced greatly. This minimizes pollution without using expensive recycling irrigation systems or large ponds to capture runoff.

Does it really work?

To test this irrigation approach and to determine how much water petunias need for good growth, we grew them at substrate water levels ranging from 5 to 40%. Irrigation was controlled with EC-5 probes in the substrate, which were connected to a datalogger. For the first nine days after transplanting seedlings, all substrates were kept well-watered to allow the plants to establish. Afterwards, our irrigation system maintained substrate water content (treatments ranging from 5-40%) for 20 days and then plants were harvested.

Our irrigation system performed very well throughout the entire study (Fig. 1). As soon as the substrate water content in a particular container had dried out to the irrigation set point, our automated irrigation system started irrigating that tray. The water content of the substrate generally was kept slightly above the set point.

A higher substrate water set point for irrigation resulted in more frequent waterings. Although the irrigation quantity increased with increasing substrate water levels, there was no leaching in any of the treatments. Even the largest plant received only 650 mL (about 21 fl. oz.) of water during the last 20 days of the experiment. Daily water use in the treatment with the highest water use ranged from only 15-20 mL/plant/day (just over one tablespoon!) when the plants were small to 45 mL/plant/day (3 tablespoons) at the end of the experiment.

Plant growth increased with increasing substrate water content, but there was little difference between the 25, 30, 35, and 40% treatments (Figure 2 left, 3). Since plant growth was highly correlated with the amount of water the plants received (Fig. 2 right), controlling irrigation based on substrate

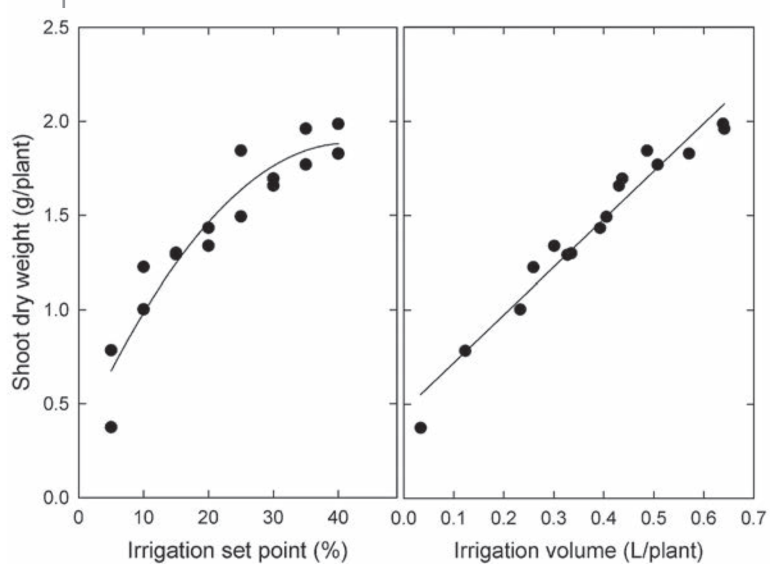
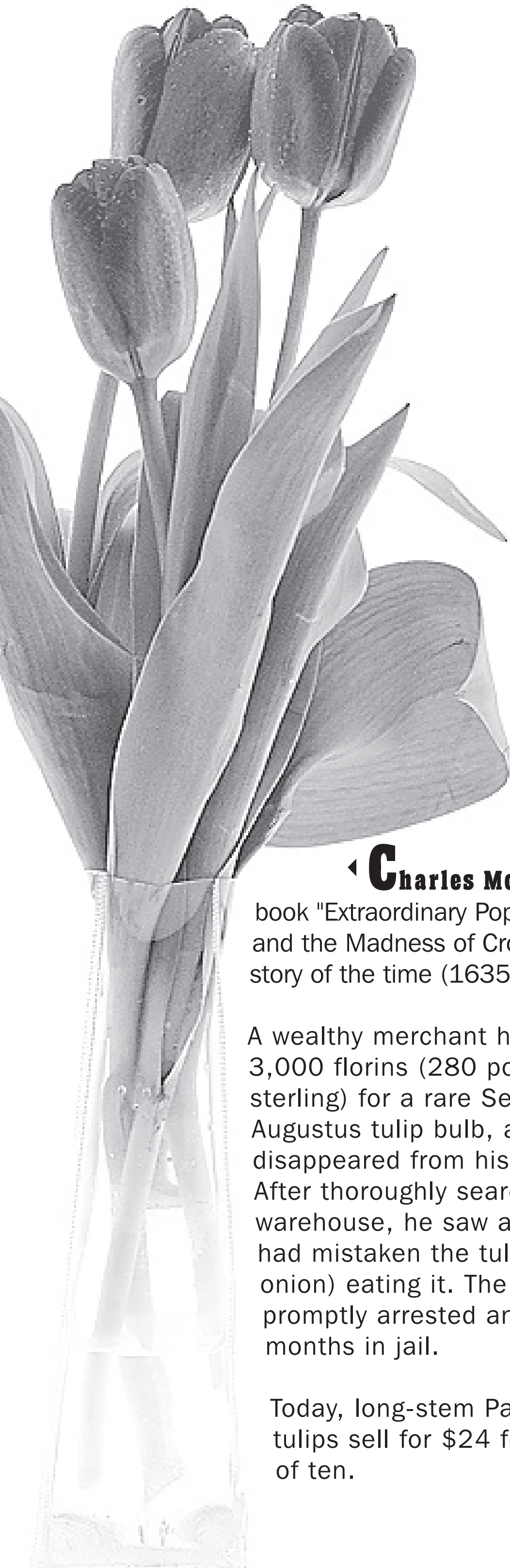


Figure 2. The effect of the substrate water content (left) and the total irrigation volume (right) on the dry weight of petunias. Controlling irrigation by controlling the substrate water content proved to be an effective way to control plant growth.

MORE PAGE 6 ►



◂ **Charles McKay,** in his book "Extraordinary Popular Delusions and the Madness of Crowds", tells a story of the time (1635):

A wealthy merchant had paid 3,000 florins (280 pounds sterling) for a rare Semper Augustus tulip bulb, and it disappeared from his warehouse. After thoroughly searching his warehouse, he saw a sailor (who had mistaken the tulip bulb for an onion) eating it. The sailor was promptly arrested and spent months in jail.

Today, long-stem Parrot-type tulips sell for $24 for a bunch of ten.

Discuss these newsletter topics on the GREENHOUSE FORUM at www.soil-moisture.org

Wireless Monitoring of Wholesale Nurseries: Is it possible?

REMEMBER THE DAYS when you ran back and forth between your office and your plants to check the moisture and temperature of your growth medium? Nursery and greenhouse managers with smaller operations may be able to get away with this method. However, managers of large facilities will often spend many hours a day checking environmental conditions in multiple fields and greenhouses. Fortunately, new tools have been created to help nursery and greenhouse managers monitor environmental parameters from the comfort of their desks. One tool currently undergoing field trials is Decagon Devices' new wireless ECH_2O monitoring system, which measures and monitors a variety of environmental parameters. The ECH_2O system is showing promise as an innovative tool for managing large-scale greenhouses and nurseries. ▶

▲ Lauren Bissey (Decagon) inserting ECH_2O-TE sensor into Maple sapling rootball.

◂ ECH_2O system.

Monitoring with Sensors and Dataloggers

One such field trial was held at a wholesale nursery, Bountiful Farms, in the Willamette Valley of Oregon. The ECH_2O system was tested to see if it could help the Bountiful Farms nursery manager monitor water use across various fields. ECH_2O systems were installed in five fields and one greenhouse in the spring of 2007 to determine if soil moisture sensors, which are typically used in research agriculture, could be used to understand water use in nurseries and greenhouses. Each system consisted of two ECH_2O-TE sensors (soil moisture, temperature, and electrical conductivity), one leaf wetness (LWS) sensor, a rain gauge monitoring irrigation (ECRN-50), and a wireless data logger (EM50R), which transmitted data back to the nursery office via a Data Station. At any given time, the nursery manager could look at each of the six locations on her office computer and see the volumetric water content, EC, and temperature of her pots.

Using the Data

To date, the nursery manager has been using the data set from the five fields as a water management tool. For example, the volumetric water content data are being used to determine if watering is really occurring when the irrigation system is scheduled to turn on. More advanced use of the data set includes determining how much water is enough for the plants while at the same time preventing excess leaching from the pots. In the greenhouse, an installation scheme which has ECH_2O-TE sensors in both pots on the edges and the interior of the greenhouse has allowed the nursery manager to ensure that the irrigation water is being applied equally to all of the plants. The installation scheme has also allowed the manager to observe the efficiency of the greenhouse watering system.

Understanding Environmental Clues

▲ Todd Martin (Decagon) and Elise Ross (Bountiful Farms Nursery Manager) test ECH_2O system communication using a hand-held PC.

Data, however, are not only used to schedule or monitor irrigation. For example, by monitoring the soil temperature, the nursery manager was able to understand how an overnight freeze had affected the root temperature of plants in both the nursery and the greenhouses. Leaf wetness sensors were used to determine if leaves were staying wet for too long, thus increasing chance for disease. Decagon is currently working on recommendations to nursery and greenhouse managers on how to use the bulk EC measurements taken by the ECH_2O-TE sensors as a tool in fertilizer scheduling. Possibilities are limited only by the grower's creativity. ■

◂ Dolphin shrubs at Bountiful Farms.

▲ **Figure 3.** The effect of substrate water content on the growth of petunias. The picture was taken after a one-month growing period. Irrigation was controlled using EC-5 probes during the last 20 days of the trial.

EFFICIENT IRRIGATION ▼
CONTINUED FROM PAGE 3

water content may be a feasible method for controlling growth of rapidly elongating plants.

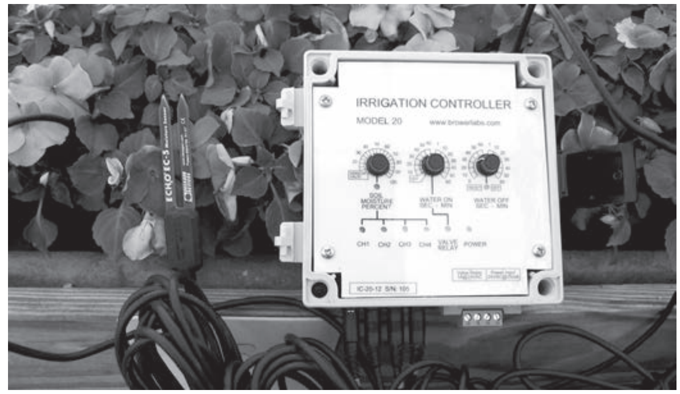
How can growers use this?

Several brands of greenhouse control systems can measure EC-5 probes, and could be used to automate irrigation based on these measurements. Growers should check with the manufacturer of their control system to see if it can measure these probes. For growers who prefer a stand-alone controller, we have collaborated with Brower Electronics Laboratories (Pittsboro, NC) to develop a controller that can irrigate plants when the substrate water content drops below a grower-determined set point (Figure 4). This controller also allows growers to set irrigation duration and a minimum time period between subsequent irrigations.

Growers who are not ready to turn over irrigation to soil water probes, could get valuable information about plant water needs by using EC-5 probes with a handheld meter or datalogger from Decagon. The handheld meter allows growers to place sensors in some of their pots, and to periodically measure the water content of the substrate. A datalogger can send data wirelessly to your computer which allows you to monitor changes in substrate water content in real-time through graphical displays (see article on page 4.) Using this technology would give growers a much better idea of how much water plants need, and will help in making better irrigation decisions.

SUMMARY

- **EC-5 sensors accurately measure volumetric water content in soiless substrates.**
- **No water leaching occurred in any of the treatments.**
- **Sensors can either be used to control irrigation or monitor water use.**



▲ **Figure 4.** We developed an automated irrigation controller in cooperation with Brower Electronics Laboratories. This controller uses 1 to 4 ECH_2O

Conclusion

It appears that in the near future growers may automate irrigation using sensors to water plants efficiently and improve plant quality. The technology is currently available, and guidelines for its use are being developed. But, what's next? In the future, we wish to gain a better grasp of how water use changes depending on the location of a crop in the greenhouse (for example, proximity to cooling pads or fans), the number of plants grown, and environmental factors. An exciting new development is that the newer ECH_2O-TE probes can measure substrate EC, soil temperature, and water content. This may allow growers to control both irrigation and fertilization simultaneously. ■

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■ Stephanie Burnett is an assistant professor in floriculture at the University of Maine; stephanie.burnett@umit.maine.edu

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▲ **The EC-5** soil moisture sensor was designed for greenhouse growers.

- Size permits placement in small starter pots.
- Innovative sensor design is appropriate for both soil and soilless media with minimal EC effect.
- Applications include monitoring irrigation schedules, preventing plant water stress, and spatial variability studies.

advertisement

▲ **Greenhouses are** increasingly important in the food supply of high latitude countries. The largest commercial greenhouse complex in the world is in Willcox, Arizona, USA where 262 acres of hydroponic tomatoes and cucumbers are entirely grown under glass at Eurofresh Farms.

The first modern greenhouses were built in Italy in the sixteenth century to house exotic plants explorers brought back from the tropics. They were originally called giardini botanici (botanical gardens). The concept of greenhouses soon spread to the Netherlands and then England, along with the plants.

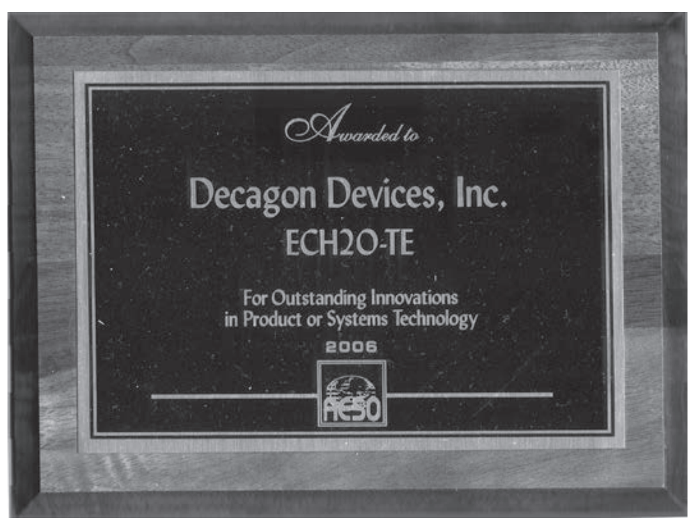
Tradeshows

HortiFair
10/9/07-10/12/07
Amsterdam

International Irrigation Association
12/6/07-12/11/07
San Diego, CA
December 9, 2007 5 PM Dr. Colin Campbell presenting "Calibration and Evaluation of an Improved Low-Cost Soil Moisture Sensor"

Virtual Seminars
1. **Soil Moisture Sensors and Irrigation Control:** Separating Fact from Fiction
   (Irrigation Association credit is given for seminar #1.)
2. **Steps to a Better Data Set:** Installing Soil Moisture Sensors
3. **Steps to a Better Data Set:** Creating a Moisture Release Curve
4. **Water Potential Soil and Plant Dynamics**
5. **No Wires No Limits:** Wireless System Installation for Measuring Soil Moisture

Contact Decagon for more information regarding these virtual seminars.



▲ **Decagon's** water content, temperature, and electrical conductivity probe wins the annual AE50 award for outstanding innovations. This award is given to new products that save producers time, cost and labor while improving user safety and operating in an environmentally-friendly fashion.

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◂ **Hothouse** tomato growers are concerned with soil temperature and production temperature for seed germination, vegetative growth, and fruit set.

Growers, Meet Decagon

YOU MAY or may not have heard the name "Decagon Devices" when talking about greenhouse and nursery management. Over the past few years, we have been dipping our instrumentation toes into the greenhouse waters to see if our products can help growers "talk" to their plants. However, Decagon is not new to the field of plant-soil-water interactions. In fact, Decagon Devices was founded in 1983 by soil scientist Gaylon Campbell. The instruments that you have been hearing about over the past three years are the results of twenty years of innovation, creativity, and hands-on experience. Decagon has been working with progressive research scientists all over the world in testing soils instruments for use in greenhouses and nurseries. Through this research, Decagon has perfected instruments that cater to the needs of greenhouse and nursery growers.

To see if Decagon Devices instrumentation can help you manage your nursery or greenhouse, stop by at one of the tradeshows or visit our website at http://www.decagon.com/irrigation/greenhouse.

Dr. Doug Cobos is the lead scientist/ enginer working with the Jet Propulsion Lab to develop a sensor designed by Decagon Devices on the 2007 Mars Phoenix Mission to measure water and other surface properties on Mars.

Dr. Colin Campbell is the Research and Development at Decagon Devices, Inc. He is also an adjunct professor at Washington State University teaching Environmental physics. Colin has a Ph.D. from Texas A&M in Soil Physics.

Lauren Bissey is the ECH_2O product manager at Decagon Devices, Inc. Lauren has a unique perspective since she was a former Decagon customer, utilizing Decagon's soil moisture sensors and porometer for her own research.