MAKING SENSE of GREENHOUSE IRRIGATION

SENSOR-CONTROLLED IRRIGATION CAN REDUCE PLANT LOSSES; LOWER FUNGICIDE, FERTILIZER AND WATERING COSTS; AND DECREASE A GROWER'S ENVIRONMENTAL IMPACT.

By David Kuack

Marc van Iersel, professor of plant nutrition and physiology at University of Georgia in Athens, is a big believer in sensor-controlled irrigation.

"Most growers underestimate the importance of sensor-controlled irrigation and how much money it costs them when they over-irrigate," van Iersel says. "Where they lose money is with shrinkage. Most diseases are linked to improper irrigation practices. Many growers don't make that connection. If they realized how many plants in a greenhouse are thrown away, that is a lot of money.

"Then there are the fungicide drenches that have to be applied to reverse the impact of root pathogens. That can be a significant amount of money. Reducing shrinkage and the economic benefits is very important. Sensor-controlled irrigation gives growers more control over plant quality."

Van Iersel says sensor-controlled irrigation not only prevents overwatering and under watering, but also it can control how fast a crop is going to grow.

He has been working with a nursery grower in Georgia who has installed a sensor-controlled irrigation system. One of the benefits of the system is the grower was able to reduce production time of 2-gallon gardenias from 14 months down to nine months.

"We have seen with poinsettias that we can control plant height by simply irrigating more or less and do that based on whether the plant is growing faster or slower than what a grower would like," van Iersel explains. "Using sensor-controlled irrigation can reduce or even eliminate plant growth regulator applications. Then there are the labor costs associated with applying the PGRs.

Better irrigation practices may also reduce fertilizer requirements.

"Based on the type of irrigation system a greenhouse uses, we estimate that in many cases up to half of all the fertilizer is leached out of the bottom of the pots," van Iersel says. "Regardless of how growers fertilize with liquid feed or slow release fertilizers, typically leaching takes fertilizer out of the pots. If growers reduce the amount of fertilizer applied by 25 to 50 percent that can be a significant economic benefit."

Van Iersel says one of the positive effects of reducing leaching and runoff is limiting growers' environmental impact.

"This is going to become more important in the future," he states. "If you look at what is happening in Florida right now, growers are facing very strict regulations regarding runoff. The growers there have no choice in regards to changing the way they do things. They may need to have 100 percent containment of irrigation runoff. This means reducing the amount of runoff that they produce. Even if 100 percent containment is achieved, it's cheaper if growers irrigate more efficiently because a much smaller system is needed to contain all of the runoff."

Van Iersel says the benefits of sensor-controlled irrigation may continue once the plants leave the greenhouse and enter retail and consumer settings.

"No one has looked at the postharvest life of the plants produced with sensor-controlled irrigation," he says. "I think the plants will hold up better. Plants grown with sensor-controlled irrigation have root systems vastly superior to typical plants. If growers have control over irrigation it becomes a lot easier to harden off the plants. As growers get closer to selling their plants, they can gradually reduce the amount of water

The plant on the far left was kept short by keeping the growing substrate wet at all times. The plant on the far right was grown in a substrate kept constantly moist. The two plants in the middle were able to be grown to target heights by adjusting the substrate water content as needed. (Photo: Marc Van Iersel, University of Georgia) and expose the plants to a controlled level of drought with sensor-controlled irrigation.

"A lot of bedding plant growers who want to harden off their plants basically stop watering until the plants start to wilt. At that point the plants are exposed to severe drought. Most growers typically have no control over how much stress they expose their plants to. That is something that they could do much better with sensor-controlled irrigation."

Real World Experience

Flowers by Bauers in Jarrettsville, Md., has been in the retail flower business for 38 years. The company began its own flower production in 1996. It grows cut snapdragons year-round in 20,000 square feet of greenhouses and markets the flowers to 130 retail florists.

By installing a sensor-controlled irrigation system, Charles Bauer (left) and his son Matt increased the grade No. 1 snapdragons they produce from around 70 to 86 percent. (Photo: Marc van Iersel)

"All of our snapdragons are produced hydroponically in perlite grow bags with zero runoff to the Chesapeake Bay water shed," says Charles Bauer, who is a company partner/grower. "We collect all of our water, store it and reuse it. We have some perlite grow bags that have been in production for eight years with no sterilization. We just filter the water. We add well water, which has no alkalinity, so we actually have to add some potassium carbonate to it. We have very good water quality for hydroponic production.

"The first year I grew the snaps in composted bark and then switched to perlite. I have not treated for root disease since 1997. We do not treat for root diseases at all."

Bauer says he was approached by researchers at University of Maryland and Carnegie Mellon University in 2009 about incorporating a sensor-controlled irrigation system into his operation.

"At the time we could look at the plants and tell if they were growing right, but we never had a quantitative way of saying why we did it that way. It was more than seat-of-the-pants because I had been growing snapdragons for a long time. But we didn't have any other way of making our decisions based on anything else other than gut feelings as a grower."

By incorporating sensors and data loggers or nodes into the irrigation system, Bauer was able to systematically measure and collect soil moisture data. A SensorWeb computer program developed for the project by Carnegie Mellon Robotics Institute enables Bauer to look at trends over a day, week, month or year. For his 20,000-square-foot greenhouse, Bauer has installed 40 Decagon moisture sensors and eight wireless nodes that collect and transmit the data to the computer in his office. He can log into the computer from anywhere he has internet access.

Left: *The growth of bedding plants can be manipulated by maintaining different substrate water contents. From left to right on each shelf: impatiens, dianthus, petunia and ageratum. From top to bottom shelf: plants grown at substrate water contents of 15, 25, 35 and 45 percent. (Photo: Marc van Iersel)*
Above: *All of the snapdragons grown at Flowers by Bauers are produced hydroponically in perlite grow bags with zero runoff. Some of the perlite bags have been in production for eight years with no sterilization. (Photo: Edwin Remsberg, Univesity of Maryland)*

"Using sensor networks allows us to collect data from various benches with different stages of crop development for charting and analysis," Bauer explains. "The next step was to use the control function of more advanced sensor nodes to implement automatic irrigation control based on daily water use of the plants on each bench. This is done by setting points at which the sensors turn on irrigation solenoids and then automatically switching them off when a grow bag has reached the optimum moisture content. This critical water content really determines how many grade No. 1 snapdragons we can produce. Prior to using the sensors we typically produced 68 to 70 percent grade No. 1 snaps. Last year we produced 86 percent grade No. 1 snaps. Once the set points were determined, our production became much more predictable."

Getting Started

According to Bauer, growers interested in using sensor-controlled irrigation should begin with monitoring and learning about the stress areas in their greenhouses.

"A grower using sensors wants to

Top: *A SensorWeb computer program developed by Carnegie Mellon Robotics Institute enables Charles Bauer to look at irrigation trends over a day, week, month or year.* ***Bottom:*** *Bauer installed Decagon moisture sensors and wireless nodes that collect and transmit data to his office computer. (Photos: Edwin Remsberg)*

first identify the stress areas and then he needs to come up with a substrate moisture scale that is optimum for his specific crop," he says. "For snaps, we work with a very narrow range of volumetric water content or the amount of water that is in the perlite bags. Snapdragons are very sensitive to water stress, especially when they are mature and have a large leaf area. We work on a scale between 24 percent volumetric water content up to 31 to 33 percent. If a grower monitors the stress areas and then monitors the non-stress areas, he is going to see a difference right away to illustrate what his ideal substrate water content should be."

Bauer says the number of sensors needed in a greenhouse is based on the ability of the grower and the efficiency of the irrigation system to deliver water uniformly to the plants.

"If you have a poor ability to irrigate your plants and your irrigation system is not well designed and inefficient, then you are going to need a lot of sensors because there is poor uniformity and a lot of stress areas," he states. "Trying to determine where those stress areas are, a grower needs to look at his greenhouse and ask, "Where do I have problems growing plants, where do I have more disease, where do I have smaller plants, where do I have plants that are infested with more insects?" The answers could all be related to the amount of water. For example, those areas that are drier may create better environments for mites and thrips."

Installing leaf wetness sensors has also enabled Bauer to be proactive when it comes to reducing the foliar diseases of Botrytis and snapdragon rust.

"We are now starting to develop a set point or correlation between the amount of moisture on a leaf and the number of minutes the leaf is wet," he says.

Knowing the total time that leaves are wet during the day enables Bauer to adjust venting cycles to increase aeration and reduce leaf wetness for rust control.

John Lea-Cox, professor and nursery research and extension specialist at the University of Maryland, who is working with Bauer, says in order to use this system in various applications, the equipment has to be "robust," reliable and not require a lot of power. The sensor nodes run on five AA batteries. The nodes, which can be set up in very remote areas, monitor on a 15-minute basis and were developed in partnership with Decagon Devices. The SensorWeb software used to collect the data and control the irrigation solenoids was developed by scientists at Carnegie Mellon Robotics Institute.

"Very smart software had to be developed to talk to these nodes in order to be able to adjust the set points over the internet," Lea-Cox says. "The sensors measure the water content of the substrate and the nodes average those readings whenever necessary. Based on an average water content set point, the nodes then make an automatic decision whether or not to irrigate."

Lea-Cox says the software provides the ultimate control by the grower, since it allows him to adjust the time of day the nodes can irrigate and the length of the irrigation cycles. Once this is set, the node makes an automatic decision based on how much water the plant uses each day. On cool cloudy days, irrigation is typically limited to a few minutes a day. On hot sunny days, irrigation events could be longer and more frequent.

Developing an Affordable System

Lea-Cox says this USDA-funded project that he is leading with van Iersel, along with other university researchers and commercial growers aims to primarily benefit small and medium size growers.

"Small- to medium-sized growers who have very simple irrigation systems have been our target group of growers, since they require cost-effective, efficient systems," Lea-Cox explains. "Most growers are very smart about their production. They know what their problem crops are and the problem areas in their greenhouses. There is an economic advantage to being able to grow difficult crops well. It is understanding how to do this that can offer a niche or competitive marketing advantage. That is the way we are approaching this research. We are developing reliable, low cost sensor systems that provide growers with an effective way to reduce costs, increase crop productivity and quality and provide an economic advantage."

Lea-Cox says the researchers have always had a base system price of $5,000 in mind. The starter system would allow any grower to begin collecting the basic information. Growers could upgrade the system with additional sensors based on their needs.

Although the research being done is focused on greenhouse and nursery production, it has application to large scale container and field nurseries and agriculture in general, including greenhouse vegetables and other crops.

"We haven't done anything yet with greenhouse vegetable growers because they are usually very large and sophisticated," he says. "They have irrigation systems that are very efficient and typically have integrated greenhouse control systems. However, operation size doesn't really matter. We have to develop a system that is cost effective for any size grower."

Bauer says a sensor-controlled irrigation system can reduce labor and increase quality for any size grower at a relatively inexpensive price.

For more information: Marc van Iersel, University of Georgia, Department of Horticulture, 706.583.0284; mvanier@uga.edu. Charles Bauer, Flowers by Bauers, 410.692.5141; bt2cb@mindspring.com; www.flowersbybauers.com. John Lea-Cox, University of Maryland, Department of Plant Science and Landscape Architecture, 301.405.4323; jlc@umd.edu.

David Kuack is a freelance technical writer based in Forth Worth, Texas. He can be reached at dkuack@gmail.com.