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22. Understanding container moisture. Owen, J., Stoven, H., and Bailey, D. Digger 55(7):41-45. 2011.

Understanding container moisture

Researchers are developing monitoring systems that can prevent overwatering and underwatering

OREGON STATE UNIVERSITY

Researchers at Oregon State University have been studying how soilless substrates can be used together with moisture monitoring equipment to get the best results while reducing the need to irrigate.

By Jim Owen, Heather Stoven and Daniel Bailey

For the past 10 years, we have been working towards understanding water flux and availability within the black box, the container in which we grow ornamental trees and shrubs. To this end, we have advanced our understanding of the hydrology of soilless substrates, the effect of irrigation type, and the influence of crop-related management decisions such as size, pruning and plant growth regulators.

This journey has led to new partnerships within academia and industry to: 1) characterize Pacific Northwest soilless substrate mixtures, and 2) develop a wireless moisture monitoring system that can help growers better manage their irrigation of containerized material.

The use of real-time moisture monitoring and control has many potential benefits. It could reduce daily watering needs. As a result, irrigation systems may not need as much capacity either in terms of storage or flow. Growers may not use as much energy, and there may be less need for water treatment.

The implementation of such monitoring or control systems, coupled with substrates having the correct balance of air and water, could yield other potential value-added benefits. These include decreased root pathogens and increased worker access.

Within this article we will share lessons learned on Douglas-fir-based soilless substrates and substrate moisture monitoring at OSU-NWREC and nurseries in the Pacific Northwest.

Soilless substrate

When considering soilless substrate components and mixtures, one must take into consideration their physical and chemical properties, ensuring they are suitable for prolific and fast root production that yields a quickly salable ornamental crop.

Water flux and availability is a result of the properties of substrate components, such as bark, *Sphagnum* peat and pumice. Various mixes made from these components retain water differently and construct pores differently. Large particles, when combined together, create large pores that contain the air space needed for root growth. The inclusion of fine particles results in small pores that yield a mixture of avail-

42 ▶

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	At time of potting		After 12 months	
	Water holding capacity	Air Space	Water holding capacity	Air Space
	(% by volume)		(% by volume)	
	Douglas fir bark (3/8" minus)			
Fresh (coarse)	27	59	34	50
Aged (fine)	42	46	58	29
	Sphagnum peat			
15% by vol.	55	33	54	28
30% by vol.	66	23	71	22
	Screened Pumice (1/16" to 3/8")			
15% by vol.	54	32	51	35
30% by vol.	45	40	48	40

Pumice grade	Particle size	Water holding capacity	Air space
		(% by volume)	
Slo-6	fines to 3/8"	54	28
Screened	1/16" to 3/8"	52	31
Double screened	1/16" to 3/16"	54	34

These tables show how air space and water holding capacity are affected depending on the bark used and the addition of peat or pumice.

able and unavailable water. (Available water supplies needed solutes, while unavailable water is water held beyond the permanent wilting point.)

In comparing two 1-gallon containers, one filled with fine (aged) bark and a second filled with medium (fresh) bark, both the water distribution and overall amount of water in the container are affected. The container filled with fine bark held 12 ounces more water.

The fraction of available water has been shown to be the portion of water that corresponds with plant growth. This relationship was illustrated in a recent study in which both azalea and weigela had increased shoot growth with increasing percent of *Spahgnum* peat. The resulting increase in available water was proportional to the increase in water holding capacity from incorporating *Sphagnum* peat.

Inorganic components, such as pumice, are included in soilless substrates to increase porosity. Material with fine components, such as slo-6 pumice, result in decreasing air space due to particle nesting. This decreases total porosity (water holding capacity plus air space). The use of screened pumice (without fine particles) has been shown to be beneficial in creating pore stability. This results in maintaining needed air space (approximately 30 percent by volume) as the roots of containerized crops grow or organic materials decompose to produce more fines.

When looking to water management, one should choose a soilless substrate mix that will be stable for the duration of the crop and provide adequate air space while matching the texture with type of irrigation to ensure adequate rewetting throughout the container.

Water management

Irrigation delivers the water that

is essential for the crop to survive. However, if over-applied or delivered ineffectively, it can move agrichemicals from where they were applied, wasting money and energy. Therefore, the goal should be to replace only the water that was removed by the crop and evaporation, applying when and where it is needed.

Monitoring leaching fraction (water leached/water applied) is one labor-intensive way to adjust irrigation application rates to minimize over-delivery. More on leaching fraction can be found in the *Digger* magazine archives and at www.climatefriendlynurseries.org/.

An alternative technique to monitor substrate moisture would be through the use of monitoring devices. Oregon State University and North Carolina State University, with funding from USDA and Horticulture Research Institute, have evaluated the gravimetric, or weight, method to measure moisture of a containerized crop.

Both institutions have found that this method is suitable for real-time monitoring of substrate moisture, as well as controlling how much water to apply at a given time or to maintain desired substrate moisture content. The information is easily interpreted, since 1 gram of water is approximately equal to 1 milliliter of water.

We found that commercially salable ornamental containerized crops could be grown using controlled release fertilizers without producing leachate. This ensures that the applied nutrients and water are used by the plant and are not being leached. There is not currently a cost effective, commercially available system to implement the gravimetric method.

Currently, academic and industry teams on both the east and west coasts are working to understand how to best deploy the least number of sensors, regardless of type, to yield information that can be used for real-time management decisions, or, better yet, auto-

44 ▶

DIGGER Marketplace

mated control. The current thought is to use a network of nodes, each with an array of environmental sensors, which provide access to the data on mobile devices via the Internet.

These issues and methodology led us to partner with Dr. Selker, OSU Biological and Ecological Engineering, as well as industry partners Wilber-Ellis Co. and PureSense Environmental Inc. to search for a potential solution.

Wireless mesh networks of limited size were deployed in 2010 at Bailey Nurseries Inc. and Woodburn Nursery and Azaleas, Inc. with both gravimetric sensors and volumetric water content sensors. These systems were used by Daniel Bailey, OSU graduate student, to evaluate the network for real-time decision making, determine the number of sensors needed for sound judgment depending on crop variability, and compare the gravimetric (weight) and volumetric (capacitance probe) methods to measure water content.

In our studies in 2010, wet and dry boundaries were set using both gravimetric and volumetric sensors. These boundaries were then used to infer when and how long to irrigate. It was also noted that the network must reliably report multiple readings of soil moisture status frequently enough to ensure water is applied before the plant undergoes stress, but stops once the water holding capacity of the substrate is met.

Both the gravimetric and volumetric sensor type provide the same data trends when monitoring the relative diurnal flux of water in the plant+substrate system. However, we observed that the volumetric sensor indicated the substrate reached the maximum water holding capacity before the gravimetric sensor. This occurred because the volumetric sensor used in this study sampled only a small volume of substrate immediately around the sensor, therefore making sensor depth critical to management decisions.

Conversely, the gravimetric sensor samples the water content entire volume of the pot but provides little insight into the container moisture profile unless known from prior substrate physical analysis. It also should be noted that proper volumetric sensor installation that results in good substrate to sensor contact is important for accurate data, but if the same installation procedure is used on all sensors, the variability should be minimized.

We continue to try to understand the variability of the overall production system and the number of sensors needed for industry use. However we have found that growers, due to their comprehensive knowledge of their irrigation systems and crops, are instrumental in pinpointing the best locations for sensor placement.

Employing an irrigation monitoring system has the potential to relay vital information on the status of cropping systems, taking into account substrate, container size, water application rate and crop. However, it is our belief that the conventional approach to monitor soil moisture — using one sensor per crop or field, as done in corn — will need to be changed in order to deploy cost effectively in ornamental container nurseries because of crop and production system diversity.

We look forward to continued use of the system in 2011 to better understand the applications and limitations of environmental wireless sensor networks in Pacific Northwest nurseries.

Jim Owen is an assistant professor of horticulture at Oregon State University. In August, he will become an assistant professor of horticulture at Virginia Tech. He can be reached at jim.owen@oregonstate.edu. Heather Stoven is a faculty research assistant at the North Willamette Research and Extension Center. She can be reached at heather.stoven@oregonstate.edu. Daniel Bailey is a graduate student in biological and ecological engineering at Oregon State University, and can be reached at bailed@spu.edu.