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Calibration of Capacitance Sensors to Precisely Measure Water Availability in Soilless Substrates

Felix R. Arguedas, John D. Lea-Cox and Andrew G. Ristvey

Abstract Text:

The Nursery and Greenhouse Industry requires a precise method to schedule irrigations, since current methods are subjective and contribute to water and nutrients running from production areas. We are using Ech20 capacitance sensors (Decagon Devices, Pullman, WA) to accurately sense plant-available water (PAW), as these may provide a reliable and affordable method to develop sensor networks for large-scale growing operations. Other sensing methods (tensiometers, gypsum blocks) have been show to be less reliable in soilless substrates because of high porosities. To implement best nutrient management practices in these operations, we need to improve water management practices, to increase interception efficiency and reduce leaching fractions from each irrigation water application. We are focused on the root zone, to calibrate sensor performance with daily plant water use. Using a modified tension table, we calibrated various Ech20 sensors in five commercial soilless substrates, with varying physical properties and air contents, by applying pressures from 01-100 kPa, the range in which most PAW is held in soilless substrates. By measuring the water expressed from 10 replicate columns at each pressure and simultaneously measuring the output from a sensor embedded in each column, we developed a series of calibration curves for each substrate and sensor type. All fitted regression curves of sensor output (mV) versus pressure applied (kPa) had R2 values greater than 0.95 ($P<0.0001$; $n=10$), with excellent fits to actual water displacement curves. Confident that capacitance sensors can provide precise measurements of PAW in the soilless substrates, we have now integrated these sensors into a wireless data logging and control system developed by the Carnegie Mellon Robotics Institute. Currently these calibration data are been used to schedule irrigation applications with this integrated wireless sensor network, in a research study to compare sensor-driven irrigation to current 'best' irrigation practices.

Impact Statement:

Accurately sensing the amount of water in soilless substrates will allow us to match irrigation applications to daily plant water use, in ornamental plant production. This however, requires the precise calibration of these sensors in these substrates, as they typically have large particle sizes and high air-filled porosities. We have shown that these versatile sensors do provide accurate data which can then be used for real-time monitoring and control of irrigations to a variety of soilless substrates. More precise applications of water will allow us to conserve water and reduce nutrient leaching and runoff from container-nurseries and greenhouses.