Increasing Irrigation Efficiency: Water Requirements of Petunia and Salvia

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Significance to Industry: More efficient water use would reduce water needs for irrigation, as well as the potential for leaching and runoff of water and fertilizer. Using soil moisture sensors may help to achieve this goal: growth of salvia and petunia can be controlled by adjusting the amount of water the plants get using such sensors. Even rapidly growing plants needed surprisingly little water, from approximately 15 ml per plant per day during early growth to about 40 ml near the end of the experiment. Using soil water sensors to control irrigation may be an effective way to use water more efficiently and adjust the volume of the applied irrigation water automatically based on plant needs.

Nature of Work: Since manual irrigation is labor-intensive and repetitive, it is one of the first greenhouse tasks that should be automated. Although automating irrigation is easy, current systems are not necessarily efficient. The greatest challenge in setting up efficient irrigation systems is that there is little information on how much water plants actually need. More efficient irrigation systems would reduce the amount of water needed to produce a crop, while also reducing leaching and runoff of water and fertilizer.

There are a few problems that prevent growers from irrigating according to the actual water needs of plants. Since plant water use, and thus the required irrigation frequency, increases as plants grow, it is difficult to irrigate efficiently using a timer. In addition, timers do not adjust irrigation based on environmental factors such as light and humidity levels. The use of soil water sensors, such as ECH_2O probes (Decagon Devices, Pullman, WA), can overcome these problems. 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 substrate water level drops. Soil water sensors detect these changes and can automatically turn on irrigation when the substrate water content drops below a grower-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. By irrigating with the amount of water actually needed by the plants, water use and leaching can be reduced greatly.

The objectives of this study were to determine whether ECH_2O-10 soil water probes can be used to automate greenhouse irrigation, and quantify water requirements of salvia and petunia.

Standard 1020 greenhouse trays were filled with a peat/perlite substrate (Fafard 2P, Fafard, Anderson, SC) and 35 g of incorporated 14-14-14 Osmocote slow release fertilizer. One half of each tray was seeded with salvia (*Salvia splendens* 'Bonfire' the other half with petunia (*Petunia* × *hybrida* 'Dreams salmon'). Both species were grown together in the same tray to assure that they were exposed to the same substrate water level. Substrate water levels were measured every 20 min with ECH_2O-10 soil water probes, connected to a datalogger. The datalogger then controlled irrigation by turning on a drip irrigation system that applied 30 ml of water per tray whenever the substrate water content was below the set point for a particular tray (Nemali, 2005). Set points were 9, 13, 17, 21, 25, 29, 33, and 37% substrate water content (v/v). Measurements included plant dry weight at 37 days after the start of the treatments, and the daily amount of water applied in each treatment. Water use efficiency (plant dry weight / liter of water) was calculated from these data. The volumetric water content of the substrate was measured weekly with a ThetaProbe (delta T devices) to check the accuracy of the ECH_2O-10 probes.

Results and Discussion: Initially, the automated irrigation system appeared to be working well, but after comparing the ECH_2O-10 measurements to data collected with the ThetaProbe, it became clear that not all ECH_2O-10 probes were working correctly. ECH_2O-10 measurements became less accurate during the course of the experiment. Thus, instead of analyzing plant growth as a function of the set point for the substrate water content, data were analyzed as a function of the amount of water applied to each treatment. The amount of water applied ranged from 8 to 23 liters/tray during the 37 day treatment period. Plant growth of both petunia and salvia was closely correlated with the amount of water applied ($r^2 \geq 0.92$, Fig. 1). This indicates that plant growth can be controlled by adjusting the amount of irrigation. The total amount of water used per plant was surprisingly low. Plants with the most growth used approximately 1 liter of water/plant during the 37 day period, or on average 25 ml/day (Fig. 2). Water use efficiency was not affected by treatments and averaged 3.5 g/liter for both salvia and petunias. There was no leaching in any of the treatments, even though some trays remained very moist.

Although the performance of the ECH_2O-10 probes was disappointing, the data show that plant growth can be controlled by adjusting the amount of water applied. We do not recommend the ECH_2O-10 probes for irrigation control in greenhouses, but newer and better sensors are now available. Decagon Devices now has ECH_2O-5 and ECH_2O-TE probes, which have low sensitivity to temperature and EC and perform much better in soilless substrates than ECH_2O-10 probes. In addition to measuring the water content of the substrate, the ECH_2O-TE probes can measure the substrate EC, thus potentially allowing for control of both irrigation and fertilization. These probes may be interfaced with greenhouse control systems, which allows for completely automated control of irrigation, based on plant water needs. Such automated systems are likely to be much more water efficient than existing automated systems.

Literature Cited:

1. Nemali, K.S. 2005. Water requirements of bedding plants: managing substrate water content and studying physiological and growth responses of plants to varying levels of water content. PhD dissertation. University of Georgia.

Figure 1. The correlation between the water quantity applied during a 37 day period and the final plant dry weight. Dry weights are the total for 12 plants, while the irrigation volume is the amount of water applied to those 12 plants.

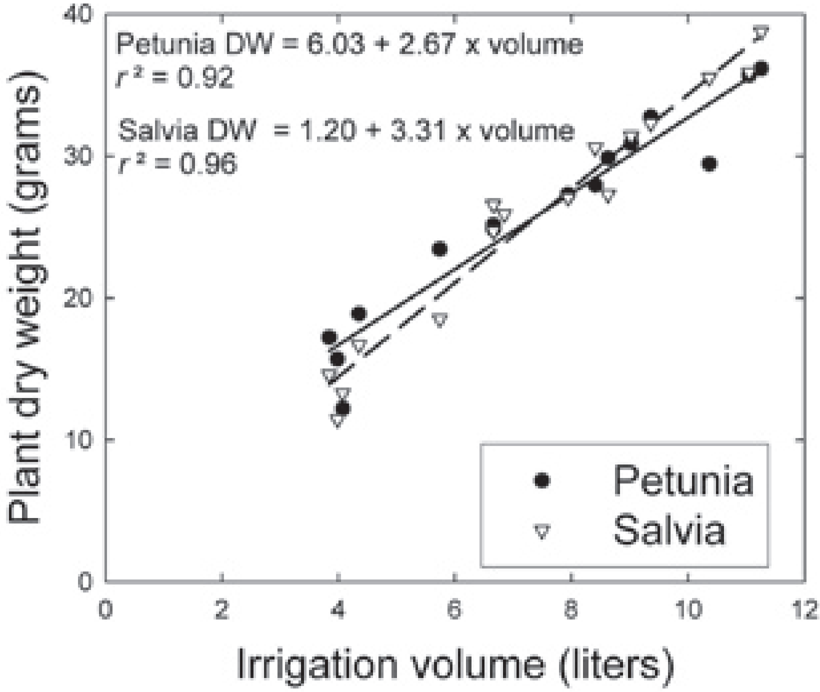

Figure 2. Daily irrigation volume during the experiment for plants in two treatments with good growth. Although there was a trend indicating increasing water needs during the experiment (due to increasing plant size), there are large day-to-day fluctuations in the volume of irrigation water applied. These fluctuations are at least partly due to changing weather conditions. The dotted line represents the average amount of water applied per plant per day. This makes it clear that applying the average amount of water each day would over-water the plants during the early part of production and underwater them later.