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Developing a physiological-based, on-demand irrigation system for container production

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ABSTRACT

A demand-based irrigation system was developed for *Hibiscus rosa-sinensis* 'Cashmere Wind' based on the relationship between photosynthesis and substrate moisture level (moisture response curve). An experiment was conducted to evaluate the premise that biomass would decrease only when substrate moisture levels caused a significant reduction in photosynthetic rate. Irrigation set points were based on the moisture response curve and corresponded to 49, 41, 30, and 22 $m^3\ m^{-3}$ volumetric water content (89–61% container capacity). Gas exchange and leaf water potential were greater for plants in the three wettest irrigation treatments. Plants under these treatments used 1.4, 1.2, and 1.05 times more water during the experiment than plants in the driest treatment. Biomass metrics were generally unaffected by treatments or were greater for one or both intermediate treatments. This research demonstrates that a demand-based irrigation system with a physiological basis (predicated on the relationship between photosynthesis and substrate moisture potential) could be an effective biorational approach for scheduling irrigation and reducing water consumption in container-grown nursery crops.

1. Introduction

Nursery crop production is a high input form of agriculture, intensively using water, nutrients, and pesticides (Beeson, 2010; Bethke and Cloyd, 2009; Wilson and Albano, 2011). Improving irrigation strategies is critical to managing nutrient- and pesticide-laden runoff, mitigating water shortages, and optimizing production schedules (Bilderback, 2002). Nursery growers commonly use static, timer driven irrigation systems that do not respond to environmental or plant-based demands (Fare et al., 1992). Such systems are subject to over-application (i.e. volume of water applied not attenuated to daily changes in precipitation or evapotranspiration) and concomitant fertilizer and pesticide leaching. Historical irrigation use estimates for container nursery production are as high as 2900 mm applied annually with as much as 33 mm applied daily (Beeson and Brooks, 2008; Fare et al., 1992).

Global water availability is a current issue for agriculture, and concern for future water availability is heightened by predicted increases in the global population and the effects of climate change on evaporative demand (Turral et al., 2011). Currently, agriculture is responsible for 70% of worldwide water consumption, and irrigated cropland is projected to almost double from 1961 to 2050 (Turral et al., 2011). Agriculture, and specifically the Green Industry, face multiple threats from water shortages, including those from drought (Ding et al., 2008). For example, during 2011 in the USA 50% of the top 10 nursery-producing states were experiencing drought (National Drought Mitigation Center, 2011). Irrigation restrictions are in place in Florida, USA, limiting the cumulative irrigation application to 1800 mm annually near growing metropolitan areas (Beeson and Brooks, 2008). Scientists and nursery producers predict a reduction in water availability for future nursery crop production and increased regulation of runoff (Beeson et al., 2004; Wilson and Albano, 2011), thus industry adoption of technology that is sensitive to actual plant and environmental demand will be necessary to conserve water.

Advances in nursery irrigation technology are largely substrate moisture-based or plant-based. Plant-based systems can be accurate but are difficult to automate and are not yet widely available in the marketplace. Substrate moisture-based systems for container production include applying irrigation based on daily water use measured gravimetrically or estimated by substrate moisture probes (Garcia-Navarro et al., 2011; Warsaw et al., 2009) and the use of substrate moisture sensors to initiate irrigation based on set points that are not established on a specific physiological relationship (Burnett and van Iersel, 2008; Grant et al., 2009; Miralles-Crespo and van Iersel, 2011). Application of soil water balance calculations using evapotranspiration estimates and

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