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Irrigation Frequency Alters Nutrient Uptake in Container-grown *Rhododendron* Plants Grown with Different Rates of Nitrogen

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***Abstract*. The influence of irrigation frequency (same amount of water per day given at different times) on nutrient uptake of container-grown evergreen *Rhododendron* 'P.J.M. Compact' (PJM) and 'English Roseum' (ER) and deciduous *Rhododendron* 'Gibraltar' (AZ) grown with different rates of nitrogen (N) fertilizer was evaluated. Increased N application rate increased nutrient uptake and plant dry biomass. Irrigation frequency did not significantly influence total plant dry biomass; however, more frequent irrigation decreased net uptake of several nutrients including phosphorus (P), boron (B), and manganese (Mn) uptake in all cultivars; potassium (K), copper (Cu), and zinc (Zn) uptake in AZ and ER; sulfur (S) uptake in ER and PJM; and iron (Fe) uptake in AZ. Additionally, more frequent irrigation of evergreen cultivars increased calcium (Ca) uptake. Covariate analyses were used to compare nutrient uptake among cultivars and irrigation treatments after accounting for the variability in nutrient uptake attributable to differences in biomass and N uptake. For most nutrients, the influence of irrigation frequency on uptake was partially attributable to differences in biomass and N uptake. After accounting for the variability in nutrient uptake associated with biomass or N uptake, increased irrigation frequency decreased P, S, B, Cu, and Mn uptake only in ER and increased Ca uptake in the two evergreen cultivars. Differences in nutrient uptake among cultivars in response to irrigation treatments were related to water and N availability during production and their combined influence on water stress, nutrient uptake, and biomass partitioning. Estimates of nutrient demand and uptake efficiency using nutrient concentrations and ratios are discussed in relation to nutrient management differences for different cultivars and irrigation treatments.**

Large irrigation volumes leach nutrients from containers because the growing substrate used in nursery production generally has low nutrient and water-holding capacity (Arreola et al., 2006; Beeson, 2006; Fare et al., 1994; Huett, 1997). Leaching from containers can be decreased by increasing irrigation frequency but not total volume. Less frequent irrigation may decrease plant growth as a result of nutrient shortage rather than water shortage, and more frequent irrigation may compensate for certain nutrient deficiencies (Buljovcic and Engels, 2001; Scheiber et al., 2008; Silber et al., 2003; Xu et al., 2004).

Many commercially important qualities of container-grown plants are a function of nutrients and water availability during production (Cameron et al., 2008; Sharp et al., 2008). Nitrogen is the primary nutrient that drives growth and therefore demand for other nutrients (Marschner, 1995). One of the largest challenges in container nursery nutrient management is that water availability may have unforeseen impacts on nutrient availability and vice versa. Maintaining a balance of water and nutrient availability to optimize growth and quality of container plants requires knowledge of how these factors interact. The influence of water and N management on uptake of other nutrients during production for many crops has not been evaluated fully. With some woody perennial plants, growth is enhanced more by minimizing water stress than by increasing fertility (Rose et al., 1999; Tan and Hogan, 1997).

Nitrogen availability influences growth and uptake and storage of N and other nutrients by evergreen and deciduous cultivars of *Rhododendron* spp. (Bi et al., 2007a; Harris et al., 2006; Scagel et al., 2007, 2008a, 2008b). Negative growth responses to excess N can occur from increased salinity, disruption of the balance between N and other nutrients, or increased water stress (Bi et al., 2007b; Cabrera, 2004). Certain N application rates can increase uptake of other nutrients; however, growth of plants with a high N status can be limited by availability of other nutrients if nutrient management strategies are not altered for high N rates. Irrigation scheduling can alter growth of *Rhododendron* (Keever and Cobb, 1985; Million et al., 2007). Improved knowledge of the combined influence of irrigation and nutrient management during nursery production is needed to develop integrated nursery production practices targeted at improving plant quality and decreasing production inputs.

Recently, we described how both N deficiency and high plant N status increase water stress in container-grown *Rhododendron* (Scagel et al., 2011). Watering plants more frequently decreased water stress of plants fertilized with the highest N rate and had little impact on alleviating water stress of N-deficient plants. Altering irrigation frequency changed N availability in the growing substrate or the ability of roots to absorb N. In addition, we found that transitory increases in plant water stress from different irrigation frequencies alters N uptake and use and plant form without detectable changes in total plant biomass. The influence of N rate on the uptake of other nutrients reported in our previous research (Scagel et al., 2008a, 2008b) may have been partially a function of differences in water stress.

The effects of cultural practices on nutrient content can be complicated to interpret in terms of drawing conclusions related to nutrient uptake when plant size is also influenced by the cultural practices and cultivars evaluated. Differences in nutrient uptake between cultivars and treatments can be partially attributable to scaling effects of plant growth on nutrient content (Righetti et al., 2007). For example, the increasing rate of N application can increase total biomass and N content of *Rhododendron* (Bi et al., 2007b; Scagel et al., 2007, 2008a). This indicates that plants absorbed more N at greater N rates (e.g., greater N uptake) but it is not clear whether greater N uptake is solely a function of plant size or a combination of plant size and increased capability to absorb N.

Previously, we used covariate analyses to account for differences attributable to plant

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