Reducing Water and Nutrient Inputs to Clay Amended Substrates: How Low Can We Go?

James S. Owen , Jr., Stuart L. Warren
Ted E. Bilderback and Joseph P. Albano[2]
NC State University, Dept. of Horticultural Science, Raleigh, NC 27695-7609
[2]USDA-ARS, U. S. Horticultural Research Laboratory, Fort Pierce, FL 34945
jim_owen@ncsu.edu

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Significance to the Industry: The objective of this study was to determine the affect of a 50% reduction in phosphorus application and leaching fraction on plant growth with a clay- or sand-amended pine bark substrate. Reduction of water volume to maintain a leaching fraction of 0.10 versus 0.20 did not significantly affect 'Skogholm' cotoneaster growth, but reduced daily and cumulative water use ≈ 30% across both clay- and sand-amended pine bark substrates. At the 0.5x P rate, however, dry weight of 'Skogholm' cotoneaster grown in the clay-amended substrate increased 45% compared to sand-amended pine bark. The clay-amended substrate also increased growth 15% at the 1.0x P rate compared to the sand-amended substrate. Dry weight of 'Skogholm' cotoneaster when grown in clay-amended pine bark was similar with the 1.0x or 0.5x rate of P. Therefore, clay-amended pine bark can maintain plant growth with only half the currently recommended leaching fraction and P rate compared to traditional sand-amended pine bark. With the clay-amended substrate this research demonstrated that environmental impact of containerized nursery crops can be reduced without affecting plant growth by decreasing water and phosphorus (P) inputs.

Nature of Work: The use of controlled release fertilizers, cyclic irrigation, and leaching fraction has allowed nurseries to increase nutrient and water use efficiency without sacrificing plant growth (9). Increasing environmental regulation and water use guidelines, however, have affected the nursery industry on both the east and west coasts. Currently, the United States Environmental Protection Agency has established maximum contaminant level (MCL) of 10 mg NO_3 L^- and set goals for P not to exceed 0.10 mg P L^- in streams that do not drain into lakes or reservoirs (8). Excess of these limits may result in a decline in water quality through eutrophication; loss of aquatic biota and hypoxia (1). New approaches to water and nutrient management for containerized nursery crop production are focused on both engineering soilless substrates that increase water and nutrient buffering capacity and reviewing the current recommended optimum substrate nutrient concentrations.

Recently, pine bark amended with mineral aggregates has been shown to

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dramatically decrease phosphorus leaching (4, 6), increase plant nutrient content (5), decrease water usage (4), and increase substrate water buffering capacity, without loss of plant growth. These studies were inspired by previous research conducted by Warren and Bilderback (10) who reported a curvilinear increase in

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nutrient and water efficiency with increasing arcillite amendment rate in a pine bark substrate. Concurrently, Lea-Cox and Ristvey (2) focused on optimizing fertility rate to provide maximum growth while minimizing environmental losses. They reported that 15 to 20 fold reduction in phosphorus application would still have adequate phosphorus for many nursery applications. Ruter (7) reported similar findings across containerized ornamental species stating that no significant affect on growth would occur with a 33% reduction in phosphorus from 15 mg P L^{-} to 10 mg P L^{-}. The objective of this study was to determine the affect of a 50% reduction in phosphorus application and leaching fraction on plant growth in containerized crop production.

The experiment was a 2 x 2 x 2 factorial in a randomized complete block design with four replications with 10 plants per replication. The treatments were two substrates: pine amended with a mineral aggregate or coarse sand at 11% (by vol), two leaching fractions: 0.10 and 0.20, and two rates of P: 1x and 0.5x rate. The mineral aggregate used was a 300 µm to 710 µm (24/48 mesh) calcined (LVM) palygorksite-bentonite mineral from Georgia (Oil-Dri Corporation of America, Chicago, IL) (3). Two of the four replications were randomly placed on the leachate collection plots described previously (5). The remaining two replications were randomly placed between the leachate collection plots. Rooted stem cuttings of *Cotoneaster dammeri* C.K. Schneid. 'Skogholm' were potted in 14 L containers (trade 5 gal). To determine leaching fraction, effluent was measured daily from irrigation water that was applied via pressure compensated spray stakes [Acu-Spray Stick; Wade Mfg. Co., Fresno, CA; (200 ml min^{-})]. Irrigation was applied in a cyclic manner with three applications daily (0100 HR, 0300 HR, and 0500 HR EST). An irrigation volume to maintain a leaching fraction of 0.10 or 0.20 was applied to each plot based on effluent values monitored daily and irrigation volumes that were monitored bi-weekly. All substrates were fertilized at the beginning of the study (DAI=0) with 54 g 19-2-8 or 19-4-8 (6 month controlled-release fertilizer, Harrell's, Lakeland, FL) for the 0.5x or 1.0x phosphorus application rate, respectively. All substrates were amended with 0.6 kg m^{-3} (2 lb yd^{-3}) blend of crushed and ground dolomitic limestone. After 112 days, one plant was randomly chosen from each plot (total of four plants/treatment). The top was removed and the roots were placed over a screen and washed with a high pressure water stream to remove substrate. Tops and roots were dried at 65 C(150 F) for 5 days and weighed. All data was subjected to ANOVA procedures. Treatments means were separated by Fisher's protected LSD at $P = 0.05$.

Results and Discussion: Reducing water volume to maintain a leaching fraction of 0.10 versus 0.20 did not significantly affect total dry weight of 'Skogholm' cotoneaster, whereas daily and cumulative water use was reduced ≈ 30% across both clay- and sand-amended pine bark substrates (Figure 1). Therefore at 112 days after treatment initiation, each container irrigated to maintain a 0.10 leaching fraction was using 0.7 L (1.5 pt) less water daily resulting in a water savings of 39 L (10 gal) over the growing season compared to a leaching fraction of 0.20 (Fig. 1). The clay-amended substrate significantly increased total dry weight of 'Skogholm' cotoneaster 15% when grown with the 1.0x rate and 45% at the 0.5x rate of P compared to dry weight produced in the sand-amended substrate (Data not presented). Dry weight of 'Skogholm' cotoneaster

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when grown in clay-amended pine bark was similar with the 1.0x or 0.5x rate of P. These data suggest that with the proper substrate it is possible to reduce leaching fraction and rate of P fertilization without sacrificing plant growth.

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Figure 1. Daily (A) and cumulative (B) water application of 'Skogholm' cotoneaster potted in a 14 L (5 gal.) container with a low(''' 0.10) or high (''' 0.20) leaching fraction (LF) maintained for 112 days.