Clay Amended Pine Bark Influences Irrigation Volume and Water Buffering Capacity

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Nature of Work: Pine bark substrates are the industry standard in the Southeastern United States for container-grown ornamental plants. Yet pine bark substrates do not offer nutrient retention or water buffering capacity provided by soil. Clay minerals are the dominant soil components that provide these beneficial attributes. With little nutrient or water buffering capacity, high water and nutrient inputs are required to yield a salable plant quickly.

The value of adding clay to pine bark substrates has been debated since 1964. Even though amending pine bark substrates with clay would appear to have many potential benefits, there was little empirical evidence to definitively answer this question (1, 2). To date the most detailed study for clay amended pine bark has been conducted with arcillite by Warren and Bilderback (3). They reported that container capacity, available water, and bulk density increased with increasing rate of arcillite, whereas arcillite did not affect total porosity and unavailable water.

Unfortunately, 'clay' is often used generically to describe soils that have high water and nutrient holding capacity. Clays, like soils, are not the same due to differences in physical and chemical properties as a result of handling, source, and packaging. The effectiveness of clay should differ with type (1 : 1 versus 2 : 1), handling (temperature pretreatment, particle size), and source or location mined (chemical composition). The type of clay and heat treatment (pasteurized or calcined) are important factors affecting water holding capacity and available water content, thus determining water buffering capacity. Therefore, it is misleading to simply talk about 'clays' since they differ in their ability to improve the water and nutrient capacity of a soilless substrate. Recent research with peat in the Netherlands has suggested that clay particle size and heat treatment (calcined or pasteurized) may affect how effective clay will be in increasing water and nutrient buffering of soilless substrates (Hans Verhagen, RHP Foundation, personal communication). In addition, results from our preliminary studies suggest that 2 : 1 clays are more effective than 1 : 1 layer clays (e.g. kaolinite) in increasing buffering capacity in pine bark substrates (data not presented). Therefore, the objective of this study was to determine the effect of particle size and temperature pretreatment of a 2 : 1 layer clay (e.g. montmorillonite) on physical properties of a pine bark substrate and subsequent plant growth.

The experiment was a randomized complete block design with three replications.

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The treatments were pine bark amended with attapulgite clay mineral with one of either two particle sizes (mesh sizes 5/20 or 24/48) that had been pretreated at one of two temperatures {calcined [389 C (700 F)] or pasteurized [140 C

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(250 F)]}. All clay was added as an 8% (by vol.) substrate amendment. An additional substrate was added to represent the industry standard [8 pine bark: 1 sand (by vol.)].

Cotoneaster dammeri 'Skogholm' cuttings were potted with each substrate into 14 liter (3.7 gal) containers amended with controlled-release fertilizer and dolomitic limestone. Plants were grown in a plant production area subdivided into 15 separate plots that allowed for collection of all leachate leaving each plot. Plots were 8 x 1 m (25 x 3 ft) with a 2% slope. Ten containers were placed in each plot. 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 (0.3 in/min)]}. Based on these values, an irrigation volume to maintain a 0.2 leaching fraction was applied to each treatment. After 112 days, tops from two randomly chosen containers per plot (total of six plants / treatment) were removed. Roots were placed over a screen and washed with a high pressure water stream to remove substrate. Shoots and roots were dried at 65 C (150 F) for 5 days and weighed.

To determine if the clay treatments increased the water buffering capacity of the substrate, irrigation of the remaining plants was shut off at the end of the study. During this time, measurements of net CO_2 assimilation and stomatal conductance were made on one plant from each replication from 1030 to 1130 HR and 1530 to 1630 HR using a portable photosynthesis system containing a LI-6200 computer and LI-6250 gas analyzer (LI-COR, Lincoln, Nebraska). All data were subjected to analysis of variance procedures (ANOVA). Treatments means were separated by protected LSD, $P = 0.05$.

Results and Discussion: Top and root dry weights were unaffected by any of the treatments (data not presented). However, mean daily irrigation volume applied per container was decreased 9 % to 18 % by the clay treatments compared to 8 pine bark: 1 sand substrate (Table 1). The smallest particle size (24/48) decreased mean daily water application by ≈ 0.4 L day^{-1} compared to the industry standard. Thus, the clay treatments produced similar sized plants with less water. When extrapolated over a growing season [May through September (153 days)] this is equivalent to approximately 370,309 liters per growing hectare (≈ 100,000 gal per growing acre) of water savings. In addition, the smaller particle size (24/48) had a significantly lower mean daily irrigation volume compared to 5/20. Mean daily irrigation volume was unaffected by heat treatment.

Substrate water buffering capacity determined as a function of stomatal conductance showed that clay temperature pretreatment had more influence than clay particle size (Fig. 1). Nineteen hours after the irrigation had been shut off, pasteurized clay had higher stomatal conductance compare to calcined clay. The response due to the temperature treatments of clay were further separated by particle size, with the smaller particle size (24/48) having greater stomatal

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conductance compared to 5/20 after 19 hours without water. After 47 hrs all treatments had similar levels of stomatal conductance.

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Significance to Industry: From this study, a 2 : 1 calcined clay with 24/48 mesh size decreased water usage and increased water buffering capacity of a pine bark substrate compared to a 8 : 1 pine bark: sand substrate. Given the right type of clay, particle size, and heat treatment, clay can be a valuable amendment in a pine bark substrate. This study amended pine bark with 8% (by vol) of various clay particle sizes and heat treatments. The remaining question is how much clay should be added for maximum effectiveness?

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Literature Cited:

1. Ingram, D.L. and J.N. Joiner. 1980. Fired clay as a container medium component. Southern Nursery Assoc. Proc. 35:11-12.
2. Laiche, A.J., Jr. and V.E. Nash. 1990. Evaluation of composted rice hulls and a lightweight clay aggregate as components of container-plant growth media. J. Environ. Hort. 8:14-18.
3. Warren, S.L. and T.E. Bilderback. 1992. Arcillite: Effect on chemical and physical properties of pine bark substrate and plant growth. J. Environ. Hort. 10:63-69.

Table 1. Mean daily and total irrigation volume applied container^{-1} over 112 days to maintain a 0.2 leaching fraction.

	Amount of water applied (L)	
Substrate treatment	Daily	Total
8 pine bark : 1 sand	2.09 a[z]	171.44 a
Calcined 5/20	1.90 b	156.03 b
Pasteurized 5/20	1.85 b	151.56 c
Calcined 24/48	1.72 c	141.07 e
Pasteurized 24/48	1.73 c	141.82 d

[z]means separated using Fischer's protected LSD

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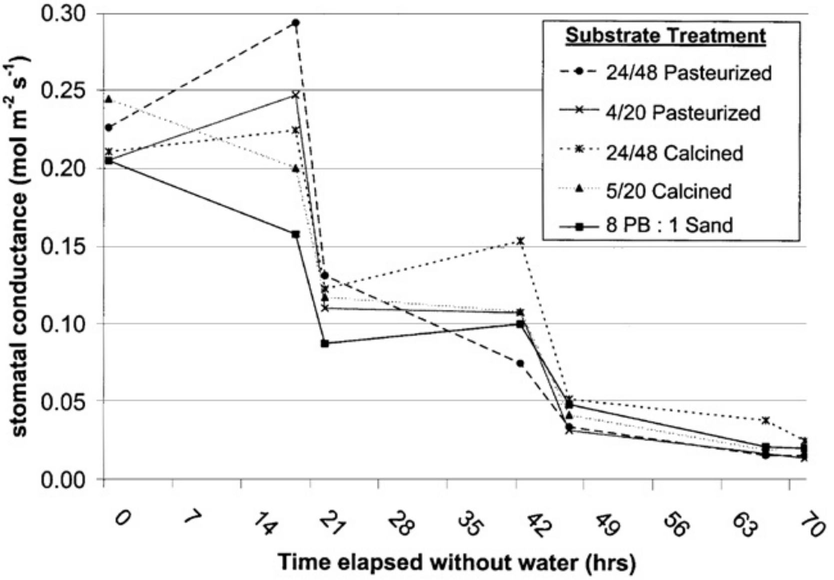

Figure 1. Stomatal conductance of 'Skogholm' cotoneaster as an indicator of substrate water buffering capacity during an 70 hour substrate drydown period.

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