Finding the Balance: Calcined Clay Rate Effects in Pine Bark Substrates

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Significance to Industry: The addition of a 710 µm to 300 µm (24/48 mesh) calcined (LVM) Georgia palygorksite-bentonite mineral at ≈ 11% (by vol.) to pine bark increased 'Skogholm' cotoneaster dry weight 39% when compared to a pine bark substrate. When clay was used to amend pine bark at rates greater than 12% (by vol.) plant dry weight decreased. A clay amended substrate engineered to retain water and fertilizers while improving or not affecting growth, allows BMPs to become more attainable without costly infrastructural changes. This, in turn, could reduce watershed impact and water use.

Nature of Work: The nursery industry is the largest crop producing sector in the United States, with 9.4 billion cash sales in 2003 in which ≈ $86 was spent per household. However, the nursery industry is coming under greater environmental scrutiny for the consumption of large amounts of water and fertilizer used to maximize plant growth to quickly produce salable plants. Nurseries have begun to implement Best Management Practices (BMP's) to increase fertilizer and water efficiency (4). In containerized crop production a substrate composed of pine bark and sand, both relatively inert, are commonly used to grow nursery crops in the southeastern United States. These substrate components offer little water or nutrient retention (2), contributing to a water and nutrient use efficiency ≤ 50%. Therefore, half of the water and nutrients applied are not used by the plant being produced. These nutrients are leached from the production system and contribute to water quality concerns. The use of BMP's alone still has not proven to increase water and fertilizer efficiency to an acceptable level for local, state, and federal proposed regulation without implementing costly infrastructural changes. Past research has focused on inputs, but has neglected to focus on substrate retention of these inputs to improve water and nutrient efficiency (4).

Our research has focused on the addition of industrial clay aggregate products in soilless substrates to increase water and nutrient efficiency in containerized nursery crop production. The clay component of soil is primarily responsible for water and nutrient retention. However, all "clay" is not created equally. In 2002, we found that amending pine bark with industrial clay aggregates

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increased water and nutrient efficiency without sacrificing plant growth. Water savings were equivalent to 370,309 liters growing hectare^{-1} year^{-1} (100,000 gallons growing acre^{-1} year^{-1}) whereas, phosphorus and ammonium leaching was reduced ≈ 50% (3). Our past research has shown clay used to amend pine

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bark based substrates are an effective method of improving nutrient and water efficiency. The objective of this study was to determine at what rate an industrial clay aggregate used to amend pine bark would result in maximum growth.

The experiment was a randomized complete block design with three replications. The clay used was a 710 µm to 300 µm (24/48 mesh) calcined (LVM) palygorksite-bentonite mineral from Georgia (Oil-Dri Corporation of America, Chicago, IL) (1). The palygorksite-bentonite mineral was added to a pine bark substrate at a rate of 0, 8, 12, 16, or 20% (by vol.). Rates were determined with a preliminary experiment that examined the effect of clay amendment rate on substrate physical properties (data not presented). In the preliminary experiment the calcined clay was used to amend pine bark at 0, 4, 8, 12, 16, 20, and 24% (by vol.). These data suggested an optimum rate occurred between 12% and 16% (by vol.).

Two hundred and forty rooted stem cuttings of *Cotoneaster dammeri* C.K. Schneid. 'Skogholm' were potted in a clay amended pine bark substrate at one of the previously mentioned rates in 14 L containers (trade 5 gal). There were 15 plants per replication. 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^{-1})]. Irrigation was applied in a cyclic manner, with three applications daily (1100 HR, 1400 HR, and 1700 HR EST). An irrigation volume to maintain a 0.2 leaching fraction was applied to each plot based on effluent values monitored daily and irrigation volumes that were monitored bi-weekly. All substrate was fertilized with 60 g 17-5-10 6 month controlled-release fertilizer (Harrell's, Lakeland, FL), at the beginning of the study. Substrate was also amended with 0.6 kg m^{-3} (2 lb cu yd^{-3}) blend of crushed and ground dolomitic limestone. To determine substrate water buffering capacity, stomatal conductance and net CO_2 assimilation were measured periodically under normal irrigation. Measurements were conducted from 1130 HR to 1330 HR EST with a LI-6200 computer and LI-6250 gas analyzer (LI-COR, Lincoln, Nebraska) after approximately 50 days of plant establishment. After 122 days, tops from two randomly chosen containers per plot (total of six plants $treatment^{-1}$) 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. All data was regressed using PROC REG (SAS Institute, Cary, NC) to determine best-fit, linear and quadratic models. Terms of the model were evaluated for significance based on a comparison of F values at $\alpha = 0.05$.

Results and Discussion: Plant weight and net photosynthesis both fit curvilinear models when plotted as a function of clay amendment rate (Figs.1 and 2). A 39% increase occurred in total dry weight when the clay amendment rate increased from 0% to 12% (Fig. 1). However, as the clay rate increased from 12% to 20% top dry weight decreased 20% (Fig.1). Clay amendment rates produced a quadratic relationship with maximum net photosynthesis and plant

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growth at clay rates of 12% and 11%, respectively (Figs.1 and 2).

When combining past and current results we have shown that a 710 µm – 300 µm (24/48 mesh) calcined (LVM) palygorksite-bentonite mineral from

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Georgia can reduce phosphorus leaching, reduce water application volumes, and maximize growth when used to amend pine bark at ≈ 11% (by vol.) versus pine bark only substrates.

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Figure 1. Effect of clay amendment rate on total plant dry weight (g) of 'Skogholm' cotoneaster after 122 days.

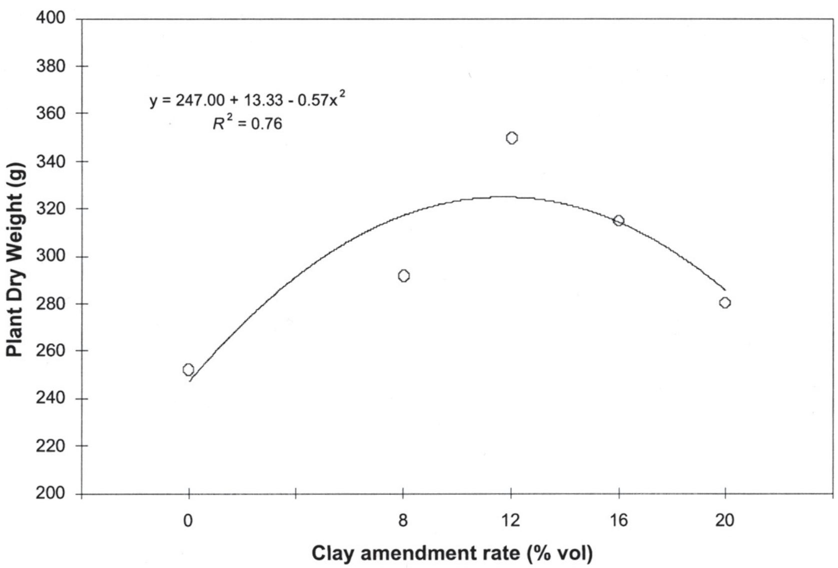

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Figure 2. Effect of clay amendment rate on net photosynthesis of 'Skogholm' cotoneaster. Measurements were taken on August 26, 2003, ;;;; 24 hr after irrigation was applied.