Research Reports:

Arcillite: Effect on Chemical and Physical Properties of Pine Bark Substrate and Plant Growth[1]

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Abstract

The objective of this study was to determine the effect of arcillite, a calcined montmorillonite and illite clay, on the physical and chemical properties of a pine bark growth substrate and plant growth. To accomplish this, *Cotoneaster dammeri* 'Skogholm' and *Rhododendron* sp. 'Sunglow' were potted into pine bark substrate amended with 0, 27, 54, 67 or 81 kg/m^3 (0, 45, 90, 112 or 136 lbs/yd^3) arcillite. Plants were irrigated every 1, 2, or 4 days. Container capacity, available water, and bulk density increased with increasing arcillite rate. Air space decreased with increasing arcillite rate. Total porosity and unavailable water were not affected by arcillite. Substrate NH_4, NO_3, P, K, Ca, and Mg concentrations increased with decreasing irrigation frequency. Substrate NH_4, P, and K concentrations increased with increasing arcillite rate suggesting that arcillite improved retention within the container substrate. Azalea 'Sunglow' shoot dry weight decreased linearly with decreasing irrigation frequency and increased curvilinearly with increasing arcillite with maximum dry weight occurring at 67 kg/m^3 (112 lbs/yd^2). Cotoneaster 'Skogholm' shoot dry weight increased linearly with increasing arcillite rate at 2 and 4 day irrigations and curvilinearly at 1 day irrigation with maximum weight at 67 kg/m^3 (112 lbs/yd^2).

Index words: calcined clay, substrate amendment, water usage, nutrient efficacy

Species used in this study: *Cotoneaster* 'Skogholm' (*Cotoneaster dammeri* 'Skogholm'); azalea 'Sunglow' (*Rhododendron* sp. 'Sunglow')

Significance to the Nursery Industry

Arcillite has the potential to reduce water usage and improve fertilizer efficacy in container production. A grower could irrigate cotoneaster 'Skogholm' every 2 days in pine bark amended with 27 kg/m^3 (45 lbs/yd^3) of arcillite and produce a plant equivalent in size that was grown in unamended pine bark irrigated daily. More research is needed to refine the amendment rate and irrigation frequency for differing species.

Introduction

Nursery container production is unique among agricultural production systems. Porous container substrate combined with frequent irrigation and high fertility levels produces

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rapid plant growth. However, environmental concerns are forcing growers to rethink production practices, particularly, in regards to water and fertilizer usage (21). Growers cannot simply reduce water usage with porous, pine bark-based substrate without sacrificing plant growth and quality (19). Modifying a container substrate to increase container water-holding capacity while maintaining adequate air space would allow growers to reduce irrigation frequency, thereby, reducing water usage. Various products (hydrogels, clay) have been evaluated, however, none of these products have been widely adopted due to inconsistent results (3, 8, 10, 20). In addition, any changes in water management will affect nutrient retention and losses, thus impacting fertilizer efficacy (19, 25). For example, Stewart et al. (19) reported that a redwood:sand (2:1 v/v) substrate irrigated daily lost twice as much of its applied N in the leachate compared to every other day irrigation.

Nutrient losses from a container substrate could also be lessened by increasing the substrate cation exchange capacity (CEC). Clays have a high CEC. Whether amending pine bark with clay would improve nutrient retention is not known. However, pressure on agriculture requires maximization of nutrient use efficiency to prevent leachate induced environmental problems. Thus, any improvement in container substrate or production practices that would improve fertilizer efficiency would be advantageous.

Arcillite, a calcined montmorillite and illite clay, improved growth of container-grown nursery crops when mixed with loam soil or peat compared to loam soil or peat alone (23). The authors speculated that arcillite created a "superior environment in the root zone," however, neither physical or chemical properties of the substrate were measured. Arcillite has been used successfully as a container substrate for research purposes (1, 6). Still, there is little information on the use of arcillite as a container amendment (7, 12). Thus, the objective of this study was to determine the effect of arcillite on the physical and chemical properties of pine bark substrate and plant growth.

Materials and Methods

The experiment, a 2 × 3 × 5 factorial in a split-plot design with six single plant replications, was conducted on a gravel pad at North Carolina State University, Horticultural Research Unit 4, Raleigh. The three main factors were: 2 arcillite materials with differing particle size distributions (Table 1); 3 irrigation frequencies (1, 2 or 4 days); and 5 arcillite rates: 0, 27, 54, 67 or 81 kg/m^3 (0, 45, 90, 112 or 136 lbs/yd^3). The main plots were irrigation frequency. Arcillite materials and rates were subplots.

Milled pine bark [(<13 mm) (0.5 in)] was amended on a m^3 (yd^3) basis with 3 kg (5 lbs) dolomitic limestone, 1.8 kg (3.0 lbs) Perk micronutrient fertilizer, and arcillite. Fifteen grams (0.5 oz) of Woodace 20-1.7-9.1 (20-4-11) was surface applied on May 26, 1989 (Day 0). An additional 15 containers of each of the pine bark × arcillite substrate combinations were filled at initiation of the study. These fallow containers were irrigated daily and received similar cultural practices as those with plants, except no Woodace fertilizer was added.

Plant growth. Uniform rooted cuttings of cotoneaster 'Skogholm' and azalea 'Sunglow' were potted into 3.8 l (#1) containers on May 8, 1989. All plants received 1400 ml (47 oz) of water daily via spray stakes until May 26, 1989, thereafter plants received 1400 ml (47 oz) per specified irrigation frequency. On November 11, 1989, the shoots (aerial tissue) of both species were removed and dried at 70°C (158°F) for 96 hr. Because the roots could not be physically separated from the substrate with any reasonable accuracy, dry weight was not obtained for roots.

Table 1. Particle size distribution of pine bark and arcillite.

Particle size range (mm)	Pine bark	Arcillite material 1	Arcillite material 2
		(% wt)	
>6.3	7.1	0	0
6.3–4.0	10.6	0	0
4.0–2.8	10.4	0	0
2.8–2.0	11.2	0	0
2.0–1.4	10.3	0	0.8
1.4–1.0	9.4	0.1	0.2
1.0–0.7	10.4	10.5	0.5
0.7–0.5	9.2	48.2	7.6
0.5–0.4	7.3	30.8	41.4
0.4–0.3	5.3	9.4	23.9
0.3–0.2	3.2	0.8	12.1
0.2–0.1	2.5	0.1	6.9
<0.1	3.1	0.1	7.4

After drying, azalea 'Sunglow' leaves were removed and ground in a Wiley mill to pass a 40 mesh (0.425 mm) screen. Each tissue sample (1.25 g) was combusted at 490°C for 6 hr. The resulting ash was dissolved in 10 ml of 6 N HCl and diluted to 50 ml with distilled deionized water. Phosphorus, K, Ca, and Mg concentrations were determined by inductively coupled plasma emission spectroscopy. Nitrogen was determined using 10 mg samples in a Perkin Elmer 2400 CHN elemental analyzer. All tissue analyses were conducted at the Analytical Service Laboratory, Dept. of Soil Science, North Carolina State Univ., Raleigh.

Physical properties. Cylindrical aluminum rings, 347.5 cm^3 (21.2 in^3) in volume (7.6 cm dia, 7.6 cm ht) (3 in dia, 3 in ht), were inserted into 8 fallow containers at potting. After 9 weeks, the cylinders with intact, naturally compacted substrate were extracted. Data were collected for moisture retained at 10 moisture tensions from 0 to 30 kPa (0 to 300 cm) using a pressure plate apparatus and procedures of Fonteno et al. (4), Karlovich and Fonteno (9), and Milks et al. (15). After measurement at 30 kPa, each sample was removed and bulk density determined by calculating its volume, drying 24 hr at 105°C and weighing (11). A nonlinear, five-parameter function developed for soils by Van Genuchten and Nielsen (22) and adapted to horticultural substrate by Milks et al. (15) was used to describe the moisture retention data.

Cylindrical aluminum rings, 115.8 cm^3 (7.1 in^3) in volume (7.6 cm dia, 2.5 cm ht) (3 in dia, 1 in ht), were inserted into 5 fallow containers at potting. After 9 weeks, the cylinders were extracted. Data for moisture retained on a measured volume basis were collected at a moisture tension of 1500 kPa, according to Klute (11) and Milks et al. (16).

Total porosity (TP) and unavailable water (UW) were equal to volume wetness at saturation and 1500 kPa, respectively. Container capacity (CC) was predicted using the equilibrium capacity variables model developed by Bilderback and Fonteno (2) and refined by Milks et al. (16). Air space (AS) was calculated as the difference between TP and CC. Available water (AW) was calculated as the difference between CC and UW (16).

Chemical properties. The substrate solution was extracted from the azalea 'Sunglow' containers via the pour-through nutrient extraction method 12, 24, 36, 48, 60, 72, 84, 96 and 108 days after fertilizer application (24). The pour-through sample was obtained by pouring 150 ml (5 oz) of distilled water on the substrate surface 2 hr after irrigation and collecting the leachate. The samples were filtered through Whatman #1 paper and the pH was determined. Leachates then were frozen for future NO_3 and NH_4 analysis by Technicon Autoanalyzer II. Phosphorus, K, Ca, and Mg were determined by inductively coupled plasma emission spectroscopy. To quantify nutrients released from the container substrate, two fallow containers of each of the substrate were sampled at each collection time. All substrate solution analyses were conducted at the Analytical Service Laboratory, Dept. of Soil Science, North Carolina State Univ., Raleigh. Irrigation water, which was sampled at each collection time, averaged (ppm): 0.10 NO_3, 0 NH_4, 0.5 P, 4 K, 20 Ca, 2 Mg, and pH, 7.0.

All variables were tested for differences using analysis of variance and regression analysis. All reported correlations were significant at $P \leq 0.01$.

Results and Discussion

Physical properties. Arcillite materials did not affect any of the measured physical properties (data not shown). Furthermore, there were no significant interactions with arcillite materials; thus, the data for each parameter were pooled over arcillite material for statistical analysis.

Arcillite did not affect TP or UW (Table 2). Container capacity and AW increased curvilinearly with increasing arcillite rate with the maximum value occurring at 54 kg/m^3 (90 lbs/yd^3). Air space decreased linearly with increasing arcillite rate. Even though TP was not affected, addition of arcillite to pine bark apparently changed the pore size distribution within the substrate which increased water holding capacity and reduced air space. Bulk density increased linearly with increasing arcillite rate.

Chemical properties. Arcillite materials did not affect any of the measured substrate nutritional parameters (data not shown). Furthermore, there were no significant interactions with arcillite materials; thus, the data for each parameter were pooled over arcillite material for statistical analysis. Data collected at 12, 60, and 108 days after fertilizer application are representative of treatment effects and changes that occurred over time; therefore, the data from the remaining sample times (24, 36, 48, 72, 84, and 106 days after fertilizer application) are not presented. Irrigation frequency significantly affected every parameter although not at all sample times (Table 3). Arcillite rate affected all parameters except substrate NO_3, Ca, and Mg concentrations (Table 3).

In fallow containers, substrate nutrient concentrations in arcillite amended pine bark were similar to the nutrients concentrations in unamended pine bark (data not shown). Wildon and O'Rourke (23) reported that small quantities of various nutrients might be released by arcillite. However, it appears that within one growing season arcillite does not release measurable quantities of NO_3, NH_4, P, K, Ca or Mg.

Substrate pH decreased with decreasing irrigation frequencies from 0.1 to 0.6 units depending upon sample time (Table 4). In general, pH increased with increasing arcillite rate, from 0.2 to 0.3 units depending upon sample time. Arcillite has a pH of 5.9 to 6.1 (6). Changes in pH over time were 0.6 units or less.

Substrate NO_3 concentration increased with decreasing irrigation frequency at all sample times (Table 5). This is probably a reflection of reduced leaching with decreasing irrigation frequency. Similar results were reported by Stewart et al. (19). Arcillite rate did not affect NO_3 substrate concentration (Table 3, data not shown).

Similar to NO_3, substrate NH_4 concentration increased with decreasing irrigation frequency at all sample times (Table 5). Ammonium concentration in the substrate solution decreased with increasing arcillite rate at each sample time (Table 5). Wildon and O'Rourke (23) reported that arcillite reduced N leaching. Montmorillonite and illite clays have high CEC (14). Thus, the reduction in NH_4 measured

Table 2. Physical properties of pine bark and arcillite amended pine bark.

Arcillite rate	Total Porosity[z] (TP)	Air Space[y] (AS)	Container Capacity[x] (CC)	Available Water[w] (AW)	Unavailable Water[v] (UW)	Bulk Density
(kg/m^3)			(% Volume)			(g/cm^3)
0	79.9	29.2	50.7	20.4	30.3	0.19
27	76.3	24.2	52.2	23.6	28.6	0.22
54	80.4	25.1	55.2	24.9	30.4	0.24
67	78.2	23.4	54.8	24.6	30.2	0.25
81	74.0	20.8	53.2	24.1	29.1	0.27
Significance[u]						
L[t]	NS	**	*	*	NS	**
Q	NS	NS	*	*	NS	NS

[z]Percent volume at 0 kPa.

[y]TP − CC.

[x]Predicted as percent volume at drainage.

[w]CC − UW.

[v]Percent volume at 1500 kPa.

[u]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p < 0.01$, respectively.

[t]L = linear, Q = quadratic.

Table 3. Response of container substrate nutrient concentrations, NO_3:NH_4 ratio, and pH to irrigation frequency and arcillite rate: 12, 60, and 108 days after fertilizer application.

	Container substrate concentration (mg/liter)											
	NO_3			NH_4			K			P		
	Days after fertilizer application											
Source of variation	12	60	108	12	60	108	12	60	108	12	60	108
Irrigation (I)	*[z]	**	**	*	**	**	**	**	**	**	**	**
Arcillite (A)	NS	NS	NS	**	**	**	*	**	**	**	**	**
I × A	NS	NS	NS	NS	NS	NS	**	*	**	**	**	*
	Ca			Mg			NO_3:NH_4 ratio			pH		
Irrigation	**	**	**	**	**	**	*	**	**	**	NS	**
Arcillite	NS	NS	NS	NS	NS	NS	**	**	**	**	**	**
I × A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively.

in the leachate could be in response to an increase in CEC with increasing arcillite rate, however, there are no supporting data. In addition, pine bark has increased absorptive capacity with increasing pH (5), so the shifts in pH could alter NH_4 retention within the substrate.

Nitrate:ammonium ratio was significantly affected by irrigation frequency and arcillite (Table 3). Excluding 12 days after fertilizer application, NO_3:NH_4 ratio decreased with decreasing irrigation frequency (Table 5) which could be due to decreasing nitrifying bacteria with decreasing irrigation frequency (18) or decreased leaching of NO_3. The NO_3:NH_4 ratio increased with increasing arcillite. Amending pine bark with arcillite could have improved the environment for nitrifying bacteria resulting in higher rates of NO_3 (14). This change in NO_3:NH_4 ratio could affect plant growth. Though plants can utilize both NO_3 and NH_4, reports in the literature demonstrate that many plants have a preference for NO_3 or NH_4 (25).

Substrate K concentration was significantly affected by irrigation frequency and arcillite rate, and their interaction was significant although not at all sample times (Table 3). Twelve days after fertilizer application, K concentration increased linearly with increasing arcillite rate with daily irrigation, was not affected by arcillite rate with 2 day irrigation, and decreased linearly with increasing arcillite rate with 4 day irrigation (Fig. 1A). This illustrates how initial nutrient release and availability can vary with differing irrigation frequencies. At 60 days after fertilizer application, K concentration increased with decreasing irrigation frequencies and increasing arcillite rate (Fig. 1B). The response was similar at 108 days after fertilizer application (data not shown). The increase in K concentration from 0 to 81 kg/m^3 (136 lbs/yd^3) arcillite was 40, 53, and 35%, respectively, at 1, 2 or 4 day irrigation frequencies. Possible explanations for increasing K with increasing arcillite are reduced leaching through increased retention by some unidentified mechanism, arcillite acts as a K source, and increased adsorption with increasing pH. Levels of K in arcillite are quite high (6), however, our data suggests that K is not released from arcillite. However, adsorption of K by pine bark has been shown to increase as pH increases (5).

Substrate P concentration responded similarly to K at all sample times (Table 3, data not shown). Arcillite may be affecting P retention indirectly by affecting pH since P sol-

Table 4. Effect of irrigation frequency and arcillite rate on pH: 12, 60, and 108 days after fertilizer application.

	Days after fertilizer application						
Irrigation frequency (Days)	12	60	108	Arcillite rate (kg/m^3)	12	60	108
1	7.0	6.9	6.4	0	6.6	6.7	6.1
2	6.9	6.8	6.3	27	6.6	6.8	6.2
4	6.4	6.8	6.1	54	6.9	6.9	6.3
				67	6.8	6.8	6.3
				81	6.9	6.9	6.3
Significance[z]							
L[y]	**	NS	**		*	**	**
O					NS	**	NS

[z]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively.

[y]L = linear, Q = quadratic.

Table 5. Effect of irrigation frequency and arcillite on NO_3 and NH_4 substrate concentration (mg/liter) and NO_3:NH_4 ratio: 12, 60, and 108 days after fertilizer application.

	Days after fertilizer application								
Irrigation frequency (Days)	NO_3			NH_4			NO_3:NH_4 ratio		
	12	60	108	12	60	108	12	60	108
1	0.4	5.6	6.0	3.1	0.6	0.8	0.1	9.3	7.5
2	0.6	6.7	7.6	3.6	0.8	1.0	0.2	8.4	7.6
4	1.4	9.4	11.1	5.1	1.4	2.7	0.3	6.7	4.1
Significance[z]									
L[y]	**	**	**	**	**	**	*	**	**

Arcillite rate (kg/m^3)	NH_4			NO_3:NH_4 ratio		
	12	60	108	12	60	108
0	6.4	1.3	2.6	0.2	5.4	3.6
27	3.8	1.1	1.7	0.4	6.3	6.1
54	3.2	0.9	1.3	0.6	8.8	8.4
67	3.1	0.6	1.1	1.6	12.2	11.6
81	3.0	0.5	1.0	2.0	13.5	12.7
Significance[z]						
L	**	**	**	*	**	**
Q	NS	NS	NS	NS	NS	NS

[z]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively.

[y]L = linear, Q = quadratic.

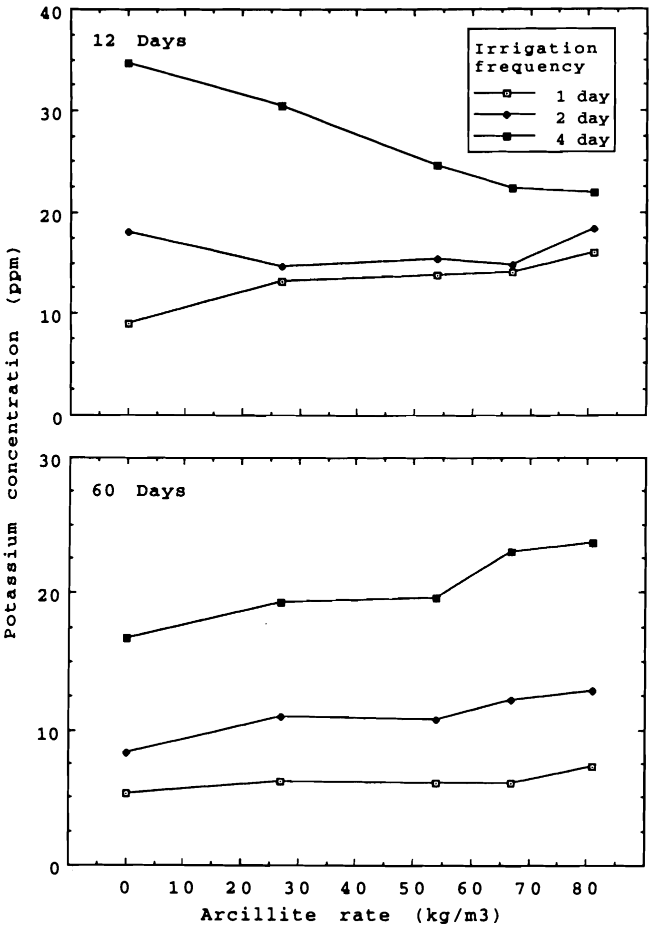

Fig. 1. Response of substrate K concentration to arcillite rate and irrigation frequency 12 days and 60 days after fertilizer application.

ubility decreases with increasing pH (13, 17) or arcillite could be increasing P fixation within the substrate (14) (data not shown).

Similar to the other elements, Ca and Mg concentrations in substrate solution increased with decreasing irrigation frequency (data not shown). Substrate Ca and Mg concentration were not affected by arcillite rate (Table 3, data not shown).

Plant growth. Arcillite materials did not affect any of the measured plant growth or foliar nutrient parameters (data not shown). Furthermore, there were no significant interactions with arcillite materials; thus, the data for each parameter were pooled over arcillite material for statistical analysis (Table 6). Irrigation frequency significantly affected every parameter except azalea 'Sunglow' foliar Mg concentration. Arcillite rate affected all parameters, except azalea 'Sunglow' foliar Ca concentration.

Plant performance remains the most meaningful method of evaluating physical and chemical properties of container substrate. Azalea 'Sunglow' shoot dry weight decreased linearly with decreasing irrigation frequency and increased curvilinearly with increasing arcillite rate, with maximum dry weight occurring at 57 kg/m^3 (112 lbs/yd^3) (Table 7).

Azalea 'Sunglow' foliar %N, %P, and %K increased linearly with decreasing irrigation frequency (Table 8). This occurs when tissue weight increases at a rate greater than

Table 6. Response of azalea 'Sunglow' and cotoneaster 'Skogholm' shoot dry weight, and azalea 'Sunglow' foliar nutrient concentration to irrigation frequency and arcillite rate.

Source of variation	Shoot dry weight (g)		Azalea 'Sunglow' nutrient concentration (% dry weight)				
	azalea	cotoneaster	N	P	K	Ca	Mg
Irrigation	*[z]	**	**	**	*	**	NS
Arcillite	**	**	**	**	**	NS	*
I × A	NS	**	NS	NS	NS	NS	NS

[z]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively.

Table 7. Effect of arcillite rate and irrigation frequency on shoot dry weight of azalea 'Sunglow'.

Irrigation frequency (Days)	Dry weight (g)	Arcillite rate (kg/m^3)	Dry weight (g)
1	37.6	0	33.1
2	35.5	27	32.4
4	32.3	54	33.1
		67	39.5
		81	37.6
Significance[z]			
L[y]	*		**
Q			NS

[z]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively.

[y]L = linear, Q = quadratic.

nutrient absorption, decreasing the nutrient percentage expressed on a dry weight basis with time. In contrast, %Ca decreased with decreasing irrigation frequency. Foliar %Mg was not affected by irrigation frequency (Table 6, data not shown).

Foliar %N decreased linearly with increasing arcillite rate. Similar to the foliar %N response to irrigation frequency, this trend probably reflects dilution due to increased growth. In contrast, foliar %P, %K, and %Mg increased linearly with increasing arcillite rate. An increase in the elemental percentage along with an increase in weight indicates that nutrients are being absorbed in increasing quantity to maintain equivalent percentage of dry weight. This suggests that the plants were able to absorb more P, K, and Mg with increasing arcillite rate. This is supported by positive correlations between substrate P concentration and foliar %P ($0.38 < r < 0.60$), and substrate K concentration and foliar %K ($0.38 < r < 0.62$), depending upon sample time. The pour-through technique did not detect any significant effect of arcillite on substrate Mg concentration, however, azalea 'Sunglow' detected a difference as reflected in the foliar %Mg concentration. However, neither foliar %Ca or substrate Ca concentration were affected by arcillite rate. This may have been due to the 20 ppm Ca contained in the irrigation water.

Cotoneaster 'Skogholm' shoot dry weight increased linearly with increasing arcillite rate at irrigation frequencies of 2 and 4 day (Fig. 2). However, when irrigated daily, shoot dry weight increased curvilinearly with increasing

Table 8. Effect of arcillite rate and irrigation frequency on azalea 'Sunglow' foliar nutrient concentration.

Irrigation frequency (Days)	N	P	K	Ca	Arcillite rate (kg/m³)	N	P	K	Mg
		(% dry weight)					(% dry weight)		
1	1.24	0.09	0.64	1.50	0	1.41	0.08	0.59	0.34
2	1.31	0.10	0.63	1.31	27	1.40	0.09	0.64	0.35
4	1.56	0.12	0.71	1.02	54	1.37	0.09	0.65	0.36
					67	1.35	0.10	0.66	0.37
					81	1.31	0.11	0.73	0.37
Significance[z]									
L[y]	**	**	**	**		**	**	**	**
Q						NS	NS	NS	NS

[z]NS, *, **Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively.
[y]L = linear, Q = quadratic.

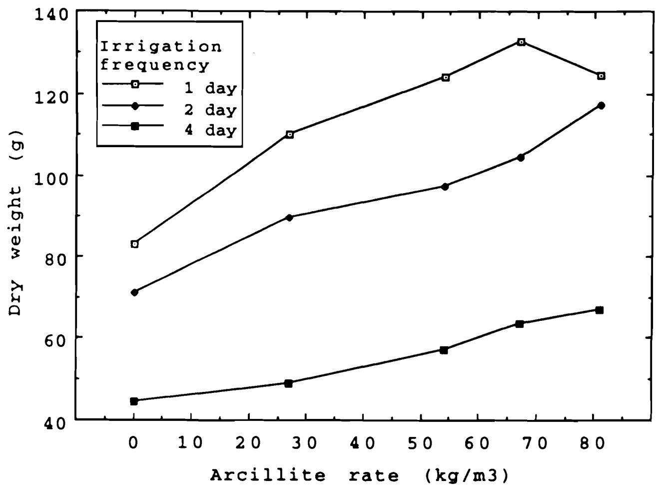

Fig. 2. Shoot dry weight response of cotoneaster 'Skogholm' to arcillite rate and irrigation frequency.

arcillite rate, with maximum dry weight occurring at 67 kg/m³ (112 lbs/yd³). This suggests that there is an upper limit to the addition of arcillite when irrigated daily. The 81 kg/m³ (136 lbs/yd³) arcillite rate had the lowest percent air space (20.8) which may not be adequate with daily irrigation. The addition of arcillite increased shoot growth 59, 65, and 51%, for irrigation frequencies of 1, 2, and 4 days, respectively, compared to plants grown without arcillite. Arcillite improved the physical and chemical properties of a pine bark substrate as evidenced by the improved plant performance. Data herein suggest that arcillite has excellent potential as an amendment for pine bark substrates.

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Landscape Architects as Related to the Landscape/Nursery Industry: I. Impact on Demand for Plant Material[1]

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Abstract

A survey of landscape architects in Georgia was conducted to help growers and landscape contractors work more closely with this group. We received 62 completed surveys for a 37% response. About 66% of the Georgia firms are located in the metro Atlanta area. We established three size classes of firms based on the 1990 wholesale value of plants specified, small (<$200 K), medium ($200–999 K), and large (≥$1 M). Comparisons are made among size classes and data are presented for each size class. Approximately 21% of the firms accounted for 67% of the plants specified in 1990. It is estimated that Georgia landscape architects specified about $85 M of plants in 1990. About 90% of the firms conduct a majority of their business in Georgia and indicated that 85% of all projects are in-state. However, 47% of the plant material specified by these firms is obtained from outside the state of Georgia. This implies that $34 M worth of plant material used in Georgia is sourced out-of-state.

Index words: nursery growers, landscape contractors, market research

Significance to the Nursery Industry

The survey results provide the first quantitative estimate of the important role that landscape architects play in the demand for plant material. The value of plant material specified by Georgia landscape architects is equivalent to 42.5% of the value of plants grown in Georgia. This suggests that growers develop a close working relationship with landscape architects. Follow-up market research to determine the type of plants imported to Georgia and the reasons for imports can help nurserymen with their marketing plans.

Introduction

The landscape industry is in a transition phase as nurseries change from production-oriented to market-driven businesses. This is necessitated by periods of over-supply, cost-conscious customers, and more rapidly changing trends. The smaller profit margins require that producers reduce waste. These factors, and the long production times, require growers to be more involved in development of marketing programs. Most marketing programs have two components, market research (what to produce) and merchandising (how to sell what you have) (6, 8).

The long production cycles in the survey industry necessitates that growers understand who determines demand for their product (3, 4, 5). A useful tool to describe the flow of product and customers is the distribution channel map (1). A simplified channel map for landscape plants is presented in Fig. 1. The channel map highlights the influential role of landscape architects in creating demand for plant materials. The decision on plant material used in many of the commercial, government, and private developments is made by the landscape architect (3, 4). In addition to determining specific plant varieties for landscape projects, landscape architects are the first to know about future demand, since they develop projects several months in advance of the time plants are requested. Landscape architects also influence demand at retail garden centers. This occurs when consumers observe plants in highly visible commercial projects and subsequently request the same plants from their local garden center.

A literature search revealed no information on the relationship between landscape architects, landscape contractors, and growers. Also unavailable is information on the value of plant material specified, information sources on what plants to specify, and where plants are sourced.

This paper is the first in a series covering the results of recent market research with Georgia landscape architects. The goal of the market research is to gather information and recommend strategies that will help landscape architects, growers, and landscape contractors exchange information and work together

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