Influence of Liming Rate on Holly, Azalea, and Juniper Growth in Pine Bark

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Abstract. Rooted cuttings of Ilex crenata Thunb. 'Helleri', Rhododendron obtusum Planch. 'Rosebud', and Juniperus chinensis L. 'San Jose' were grown in a 100% pine-bark medium amended with dolomitic limestone at 0 to 8 kg m\(^{-3}\) with resulting pH from 3.4 to 7.2. Except for juniper at 2 kg m\(^{-3}\), growth was not increased by liming, and 8 kg m\(^{-3}\) tended to reduce shoot and root growth. This reduced growth was attributed in part to greater NH\(_4^+\) adsorption by the bark, reducing the amount available for plant uptake, and a higher nitrification rate, leading to an elevated NO\(_3^-\)/NH\(_4^+\) ratio in the medium. Liming pine bark to improve growth of these woody plants may be unnecessary.

Pine bark has become an important container medium due to its desirable physical properties and its availability as a by-product of pulp and lumber industries. However, little information is available on the physical and chemical properties of pine bark in relation to plant nutrition, especially in regard to the optimum pH for plant growth. Milled pine bark has a pH of about 4.5, and dolomitic limestone is usually added at 4–6 kg m\(^{-3}\) to adjust the pH to about 6.0. The advisability of this addition is unknown, since studies evaluating the effects of pine-bark pH on growth of woody nursery crops are lacking.

In organic soils, the pH levels for satisfactory growth have been reported to be 1–1.5 units lower than values established for mineral soils (9). Recent studies by Hipp and Morgan (7) indicated that growth of Nephrolepis exaltata 'Rooseveltii' in a peat-perlite medium was greatest when pH was adjusted to 4.0–5.0. Further, maximum dry weight of N. exaltata 'Compacta' was obtained in a peat-perlite medium unlimed (pH 3.6) or with low lime rates (pH 5.5), compared to higher lime rates (5). The purpose of the experiments reported herein was to evaluate growth of 3 nursery crops as influenced by liming rate in a pine bark medium.
Materials and Methods

Pine bark used in this study was primarily from *Pinus taeda* L. and had a particle size distribution of 38% less than 0.05 mm (U.S. Series sieve #35), 28% between 0.05 and 1.19 mm (U.S. Series sieve #16), 20% between 1.19 mm and 2.38 mm (U.S. Series sieve #8), and 14% between 2.38 and 6.35 mm (U.S. Series sieve #3), with a bulk density of 0.35 g cm⁻³.

*Expt. 1.* Based on the results of a preliminary experiment, pine bark was amended with dolomitic limestone at 0, 1, 2, 4, and 8 kg m⁻³ of dolomitic limestone. On September 3, 1981, 75 rooted cuttings of *Rhododendron obtusum* ‘Rosebud’ and *Ilex crenata* ‘Helleri’ were potted into one-liter plastic pots containing pine bark amended with the above lime rates. The plants were greenhouse-grown in a randomized complete block design with 5 replications and 3 plants per treatment per replication. Each plant was fertilized with 300 ml of a nutrient solution containing 100 ppm N as NH₄NO₃, 10 ppm P as H₃PO₄, 100 ppm K as K₂SO₄, 70 ppm Ca as CaSO₄·2H₂O, 25 ppm Mg as MgSO₄·7H₂O, 5 ppm Fe as NaFeEDTA, and micronutrients according to Hoagland and Arnon (8). For azalea, the N and K concentrations were changed to 35 ppm and 30 ppm, respectively. Both genera were fertilized every other day for 8 weeks.

Leachates were collected after surface application of 50 ml of distilled water on September 9, and weekly thereafter from one container per treatment per replication. The leachates were filtered through Whatman #1 filter paper, and the pH was determined. Leachates then were frozen for future NO₃-N and NH₄-N analysis by ion selective electrodes, P determination colorimetrically (14), and K determination by atomic absorption spectroscopy.

On November 6, 1981, stems were cut just above the upper roots, after which shoots and roots of ‘Helleri’ holly and shoots of ‘Rosebud’ azalea were rinsed in distilled water, dried at 70° C, and weighed. Root-ball diameter of azalea was measured and used as the parameter of root growth, since the medium could not be completely separated from the roots. Nitrogen was determined by micro-Kjeldahl technique (12), P colorimetrically (14), and K by atomic absorption spectroscopy.

*Expt. 2.* Expt. 2 was similar to Expt. 1 with the following changes. Sixty-four, 10-cm rooted cuttings of ‘Helleri’ holly and *Juniperus chinesis* ‘San Jose’ liners were potted on February 18, 1982 in pine bark amended with dolomitic limestone at 0, 2, 4, or 8 kg m⁻³. Both genera received 300 ml of the previously described nutrient solution for ‘Helleri’ holly, with the exception that Ca and Mg were omitted. The plants were greenhouse-grown for 12 weeks in a randomized complete block design with 4 replications and 4 plants per treatment per replication.

On February 25, and every 2 weeks thereafter, initial leachates were taken by pouring 75 ml of distilled water onto the surface of 4 containers from each of the 4 treatments (one from each replication). Leachate and tissue samples were treated as in Expt. 1 nutrient analysis.

Results

Mean pH over time for both holly and azalea at 0, 1, 2, 4, and 8 kg m⁻³ ranged from 3.4 to 7.2, respectively (Table 1). In Expt. 2, for both holly and juniper, treatments of 0, 2, 4, and 8 kg m⁻³ resulted in mean medium pH values ranging from 4.4 to 6.9 (Table 1). Changes in pH over time were 0.5 pH units or less.

Holly shoot weight in Expt. 1 decreased as limestone additions increased (Table 1). Shoot dry weight of azalea also decreased at 4 and 8 kg m⁻³ of limestone. Holly root dry weight decreased with increasing lime additions, and azalea root-ball diameter was reduced at 2 kg m⁻³ (Table 1).

Results of a preliminary experiment, with the exception that azalea NO₃-N levels were higher at lower lime rates (Table 3). P (Fig. 1c) and K (Fig. 1d) leachate levels for weeks 1-5 and 1-4, respectively, were higher at the lower lime rates, whereas by week 8 the reverse was true for P. Similar trends in nutrient leachate levels occurred for azalea in Expt. 1 and for holly and juniper in Expt. 2, with the exceptions that azalea NO₃-N levels were higher at lower pH levels throughout the experimental period and P levels did not demonstrate a reverse response by week 8 (data not shown).

Discussion

Increasing the lime rate of a pine-bark medium generally decreased dry weight, shoot tissue N, P, and K content, and medium leachate levels of NO₃, NH₄, P, and K. This effect of liming on growth concurs with the results of Hipp and Morgan (7) and Gilliam et al. (5) for *Nephrolepis*, where maximum growth was obtained from either nonlimed or low lime rates.

Differences in growth among the treatments may be attributed to the variance in the medium leachate nutrient levels, in particular, NO₃-N and NH₄-N. Holly leachate NO₃-N (for the first 5 weeks) and the NH₄-N concentrations throughout (Figures 1a and 1b) were of greater magnitude at the lower lime rates.
Fig. 1. Influence of liming rate on leachate nutrient levels over time from 'Helleri' holly (Expt. 1). Mean separation at each date by Duncan's multiple range test, 5% level.

The leachate N levels were reflected in the sequential decrease in shoot tissue N levels as the lime rate increased (Table 2). Niemiera and Wright (11), employing a sand culture, demonstrated that differences in substrate N levels in the range of those occurring in this particular study can influence ‘Helleri’ holly tissue N levels and shoot growth. Other investigators have reported that percentage of N in the leaves of 3 species of holly was related to amount of N in the nutrient solution (2).

Table 3. Influence of dolomitic limestone rate on ratio of NO$_3^-$-N to NH$_4^+$-N in leachates of holly and azalea at week 8 (Expt. 1) and holly and juniper at week 12 (Expt. 2).

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<thead>
<tr>
<th>Lime rate (kg m$^{-3}$)</th>
<th>Ratio NO$_3^-$-N:NH$_4^+$-N</th>
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<td>Expt. 1</td>
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<td></td>
<td>Holly</td>
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The greatest single benefit of liming acid mineral soils is the reduction of aluminum and manganese toxicity to plants (13). Pine bark is inherently low in aluminum and manganese, and therefore the toxicity potential is reduced. Further, the need to lime pine bark to supply Ca and Mg does not appear necessary, since leachates from pine bark receiving no lime and no Ca and Mg (Expt. 2) contained 34 ppm Ca and 15 ppm Mg. Presumably this was supplied from the bark and the water supply, which contained 13 ppm Ca and 5 ppm Mg. Further experimentation should be conducted to determine if applications of Ca or Mg over a 1- to 2-year period are necessary for plants grown in pine bark.

We conclude that there is no advantage to liming pine bark for growth of holly and azalea if all nutrients are supplied in sufficient quantities and if no element is present in toxic concentrations. More investigations are needed to determine if juniper requires additions of limestone at low rates (2 kg m$^{-3}$) for optimal growth.

Literature Cited

Inhibition of Shoot Growth in Greenhouse-grown Tomato by Periodic Gyratory Shaking
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Additional index words. seismomorphogenesis, Lycopersicon esculentum

Abstract. Seedlings of tomato (Lycopersicon esculentum Mill. cv. Rutgers) were agitated periodically on a gyratory shaker. Shaking plants at 175 rpm for 5 minutes once daily during the winter reduced leaf area, stem length, and water content and dry weight of both leaves and stems. This treatment was ineffective when applied during the summer. Five- to 20-minute treatments applied 2 or 3 times daily reduced growth during either season, but were more effective during winter. Responses were independent of the time of day at which treatment took place. Leaf area, stem length, water content of leaves and stems, leaf dry weight, and specific stem water content were reduced progressively relative to undisturbed controls as the shaking rate increased from 125 to 175 rpm during the winter. Leaf area, specific leaf water content, and specific stem water content were reduced by shaking at 44% of full summer sunlight, but not at 31% or 17%. Shaking enhanced specific stem weight only at 44% light, whereas stem length was reduced most by shaking at 17% light. Differences in relative plant response to shaking between summer and winter remained even when seasonal differences in solar flux density were minimized by use of shade cloth during the summer.

Plants subjected to wind action often have shorter stems, smaller leaves, and lower fresh and dry weights than wind-protected plants (2, 9, 10, 21). Wind-induced growth changes have been associated with increased respiration and transpiration, as well as with decreased photosynthesis and water content (1, 4, 5, 6, 13, 18, 19). The mechanical aspect of wind action on plant development has been investigated using a variety of mechanical treatments including air currents, shaking, flexing, rubbing, and water spray (5, 8, 11, 15, 17, 20). Periodic disturbance applied with a gyratory shaker affects plants in ways similar to those resulting from wind action (15). Time of day of treatment did not alter the response to shaking of tomato (15) or sweet gum (16), whereas chrysanthemum was dwarfed more by shaking at 0800 HR than at 1600 or 2400 HR (3). Threshold shaking duration for chrysanthemum was 30 sec at 200 rpm; and 2 or 3 daily treatments of 2- to 5-min duration each time were more effective than one daily treatment (3).

Tomato plants shaken for 30 sec once daily at 282 rpm were smaller than undisturbed controls after 2 weeks of treatment (15). Tomato appears to be more sensitive than chrysanthemum to periodic shaking. This investigation provides a systematic characterization of tomato response to shaking by varying the timing, duration, and intensity of treatment during the summer and winter seasons.

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