Liming and Micronutrient Requirements for Containerized Landscape Tree Seedling Production©

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Nine species of landscape trees were grown from seed in two pine barks with a pH 4.7 and 5.1. Preplant amendment treatments to each pine bark were: with or without dolomitic limestone [3.6 kg m^{-3} (6 lb yd^{-3})] and with or without micronutrients [0.9 kg m^{-3} (1.5 lb yd^{-3}) Micromax™]. The experiment was repeated using two of the nine original species and pine barks with pH 5.1 and 5.8. In a second experiment, one of the species used in both above experiments was grown from seed in pine bark amended with 0, 1.2, 2.4, or 3.6 kg m^{-3} (0, 2, 4, or 6 lb yd^{-3})] dolomitic limestone and 0 or 0.9 kg m^{-3} (0 or 1.5 lb yd^{-3}) Micromax™ to determine the effect of micronutrient fertilization over a wide substrate pH range. Lime rates resulted in initial pine bark pH values of 4.0, 4.5, 5.0, and 5.5, respectively. In all experiments, micronutrient fertilization increased shoot dry weight and shoot height for all species, while lime amendments decreased shoot dry weight and shoot height for all species. Pine bark solution nutrient element concentrations increased when micronutrients were added, decreased when lime was added, and were higher in low pH bark than in high pH bark. In all experiments, adding micronutrients was necessary regardless of pine bark pH, while adding lime was not necessary.

INTRODUCTION

Container production of woody landscape trees using soilless substrates is rapidly increasing. The benefits of growing landscape trees from seed in the nursery are numerous and include ease of seed storage, decreased production costs, and plant vigor (Pinney, 1989). In an effort to improve production efficiency, there is an interest in the feasibility of sowing landscape tree seeds directly in a nursery container filled with soilless substrate. Pine bark, the most common container substrate in the Southeast, is often preplant amended with dolomitic limestone and fertilizer. Research shows that growth responses to lime additions to soilless substrates vary with species (Chrustic et al., 1983; Nash et al., 1983; Wright and Hinesley, 1991; Yeager and Ingram, 1983), yet there is no documentation on the benefits of dolomitic limestone additions for container production of a wide range of landscape tree seedlings.

Pine bark is also sometimes amended with micronutrients, but like lime, the growth of plants in response to micronutrients can be variable (Whitcomb, 1979; Wright and Hinesley, 1991). The picture is further complicated by the fact that lime additions or other factors that raise the pH of the substrate, such as high bicarbonate (alkalinity) irrigation water, usually cause existing micronutrients like Fe, Mn, Cu, Zn, etc. to be less available for plant uptake (Chrustic et al., 1983; Niemiera and Wright, 1984; Wiedenfeld and Cox, 1988). In response to the need for a recommendation for preplant amendments for landscape tree seedling production, the objectives of our research were (1) determine the effect of preplant lime and micronutrient amendments to pine bark on growth of containerized landscape tree seedlings and (2) determine the effect of these amendments over a wide range of pine bark pH.

MATERIALS AND METHODS

Experiment 1. In the first experiment, nine species of landscape trees [*Acer palmatum* (Japanese maple), *Acer saccharum* (sugar maple), *Cercis canadensis* (eastern redbud), *Cornus florida* (flowering dogwood), *Cornus kousa* (kousa dogwood), *Koelreuteria paniculata* (golden-rain tree), *Magnolia* ×*soulangiana* (saucer magnolia), *Nyssa sylvatica* (blackgum), and *Quercus palustris* (pin oak)] were grown from seed in pine bark substrate. Pine bark substrates with two different pH levels were used (4.7 and 5.1) and were preplant amended as follows: (1) lime only [3.6 kg m^{-3} (6 lb yd^{-3})], (2) micronutrients only [0.9 kg m^{-3} (1.5 lb yd^{-3}) Micromax™], (3) lime and micronutrients (previously mentioned rates), or (4) no amendments. Stratified seeds were sown directly into 11-liter (3-gal) containers filled with amended or unamended pine bark. Treatments were thus assigned in a 2 (lime) × 2 (micronutrients) × 2 (bark pH) factorial arrangement for a total of eight treatments. Experimental design was a completely randomized design with three single-container replications per treatment. Approximately 30 seeds per container were sown just below the substrate surface in Jan. 1997. Seeds of all species germinated in 1 to 2 weeks and were thinned 6 weeks after planting to approximately 10 to 15 seedlings per container. After 12 weeks all seedlings except one per container were harvested, and shoot dry weight and shoot height were determined. The remaining seedling in each container was allowed to grow for 7 more weeks to monitor persistence of growth response to pine bark amendments. All seedlings were greenhouse grown and received liquid-feed fertilization [300 mg N $liter^{-1}$ (ppm), 45 mg P $liter^{-1}$ (ppm), 100 mg K $liter^{-1}$ (ppm)] throughout the experiment. To determine the amount of plant-available nutrients, pine bark solutions (liquid portion of the substrate that bathes the roots) were periodically extracted using the Virginia Tech Extraction Method (pour through) and analyzed for pH and Ca, Mg, Fe, Mn, Cu, and Zn.

Experiment 1 was repeated in July 1997 using golden-rain tree and pin oak. Seeds were sown, and seedlings were grown for 11 weeks in the manner described previously using two pine barks with higher initial pH values (5.1 and 5.8) than that of the first experiment. Pine bark solution was extracted as described previously, and shoot dry mass and shoot height were determined at harvest. All data were subjected to analysis of variance.

Experiment 2. A second experiment was conducted in March 1998, to determine if the benefit of micronutrient fertilization was consistent for pine bark with a lower pH range than our previous experiments. To obtain this wider pH range, pine bark with a low initial pH was used and was preplant amended with four rates of dolomitic limestone [0, 1.2, 2.4, 3.6 kg m^{-3} (0, 2, 4, 6 lb yd^{-3})] to obtain initial pine bark pH values of 4.0, 4.5, 5.0, and 5.5, respectively. At each level of lime, pine bark was

Table 1. Pine bark solution pH and nutrient concentrations for the four treatments in our first experiment (data pooled over bark type). Results shown here were representative of other experiments.

Treatment	pH	Ca	Mg	Fe	Mn	Cu	Zn
		mg liter^{-1} (ppm)					
Unamended	5.0	32	7	0.06	0.25	0.01	0.10
Lime	5.5	31	15	0.04	0.05	0.005	0.08
Micros	4 .8	83	20	0.10	2.70	0.02	0.50
Lime+Micros	5.4	65	34	0.05	0.88	0.01	0.10

Table 2. Effect of initial pine bark pH on growth of pin oak seedlings and bark solution pH and nutrient concentrations from our first experiment (data pooled over all treatments). Results shown here were representative of all other experiments.

Bark type	Dry weight (g)	pH	Ca	Mg	Fe	Mn	Cu	Zn
			mg liter^{-1} (ppm)					
Low pH	6.5	4.7	61	25	0.08	1.8	0.015	0.3
High pH	5.4	5.1	45	13	0.05	0.1	0.008	0.1

also amended with or without micronutrients [0.9 kg m^{-3} (1.5 lb yd^{-3}) Micromax™]. Seeds were sown and seedlings were grown in the same manner as the previous experiments. Pine bark solutions were extracted as described previously. All seedlings were harvested after 10 weeks and shoot dry weight and shoot height determined. All data were subjected to analysis of variance.

RESULTS

Experiment 1. At all harvests, shoot dry weight and height of all species were highest when pine bark was amended with micronutrients only and lowest when amended with lime only (Fig. 1). Seedlings grown in pine bark amended with just micronutrients appeared green and healthy, while those grown with just lime appeared chlorotic and stunted (visual observation). Reasonably good growth occurred when both lime and micronutrients were included; however, foliage color was less green compared to micronutrients alone. Adding lime resulted in decreased concentrations of micronutrients in pine bark solution (compared to unamended bark), while adding micronutrients increased these concentrations (Table 1). For some elements this increase was greater than 100%. There was also the expected increase in pine bark solution pH associated with lime additions. We observed that micronutrient additions, however, resulted in lower pine bark solution pH, perhaps due to hydrolysis of water by the metal cations present in Micromax™. Seedling growth and pour-through differences were also evident for the two bark pH levels (4.7 and 5.1). Both seedling growth and nutrient concentrations of the substrate solution were higher in the lower pH bark (Table 2).

Experiment 2. Again, lime did not increase seedling growth. Additionally, all seedlings grown in pine bark amended with micronutrients had higher shoot dry weight and shoot height than seedlings grown without micronutrients, regardless of pH. As before, pine bark solution micronutrient concentrations were lower when lime was added and higher when micronutrients were added (data not shown for this experiment).

DISCUSSION

The negative seedling growth response to lime is likely due to the decrease in solution micronutrient concentrations resulting from the increase in pH. As pH increases, adsorption of nutrient cations to the substrate increases, thus decreasing the amount in solution (amount available for seedling uptake) (Brady, 1990). This pH effect was reinforced by the fact that nutrient concentrations and seedling growth in unamended bark were always higher in the bark that had lower pH (Table 2). The increase in seedling growth and improved seedling quality associated with micronutrient additions likely resulted from the increase in solution concentrations of Fe, Mn, Cu, and Zn. Increases in solution concentration of these elements was due not only to the fact that we were adding these elements, but also to the decrease in pH associated with these additions. A decrease in pH results in increased solubility of nutrient cations inherently present in the bark (Brady, 1990). Increased micronutrient concentrations in solution appear to be the key to improved seedling growth and quality since macronutrient fertility was not limiting.

Based on the results of our experiments, preplant lime amendments are not necessary for the container production of most landscape tree seedlings in pine bark. In our experiment, there was apparently sufficient Ca and Mg present in the irrigation water [10 and 4 mg liter^{-1} (ppm), respectively] and supplied by the pine bark to give initial unamended pine bark solution concentrations for Ca and Mg that were well above the critical values given by Starr and Wright (1984) of 5 to 10 mg liter^{-1} (ppm)

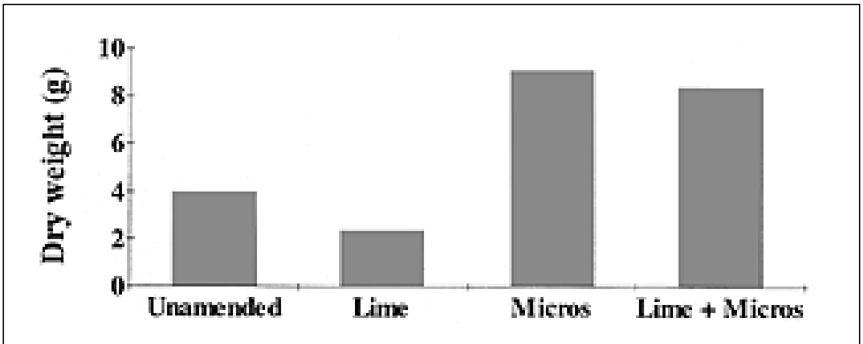

Figure 1. Growth response of pin oak seedlings after 19 weeks for the four treatments in our first experiment (data pooled over bark type). This response was representative of all other species used in our experiments. Response was similar for shoot height.

(Table 1). By eliminating lime incorporation in the production of landscape trees, growers can save money and improve seedling growth and quality.

Despite the wide range in pH in our experiments, micronutrient fertilization consistently improved seedling growth and quality. Even at low pH there was not sufficient micronutrient availability from the pine bark to optimize growth. Growth data for the lime plus micronutrient treatment (Fig. 1) indicates that micronutrient fertilization can even help overcome the decrease in growth associated with lime additions and higher pH. Additionally, the benefits of micronutrient fertilization remained quite evident at the end of all experiments, indicating that this practice can significantly improve first year landscape tree seedling growth in containers.

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