Improvement of Rhododendron and Forsythia Growth with Buffered-Phosphorus Fertilizer[1]

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Abstract

Rhododendron and forsythia plants were grown in a soilless medium containing one of four phosphorus treatments: soluble P, slow-release P, or 0.5% or 1% solid-phase alumina-buffered P (Al-P). Soluble phosphorus concentrations in the leachate were highest for soluble-P treatment and lowest for the Al-P treatments. Al-P supplied adequate P for plant growth throughout the season while substantially reducing P leaching. Forsythia plants produced more shoot dry mass when grown with 0.5% Al-P than with the other treatments, and larger rhododendron plants were produced when fertilized with 1% Al-P.

Index words: nutrition, fertilizer, phosphorus, *Forsythia, Rhododendron.*

Species used in this study: forsythia (*Forsythia intermedia* Zab.) and rhododendron (*Rhododendron catawbiense* Michx.).

Significance to the Nursery Industry

Soilless media used for production of containerized woody landscape plants lack the ability to retain phosphorus. Consequently, any phosphorus added to the container or released from slow-release fertilizers that is not quickly used by the plant is leached from the pot during irrigation. We describe the use of a solid-phase alumina-buffered phosphorus fertilizer that keeps phosphorus in a bound but available form so that leaching is minimized. Use of this fertilizer resulted in better growth of rhododendron and forsythia plants. Adoption of this technology by the industry would reduce pollution of groundwater with phosphorus leached from the growing medium, simplify nutrient management for growers and retailers, and improve the growth of plants by optimizing nutrient availability.

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Introduction

Container-grown woody plants are grown in soilless media. While such media have many advantages compared with natural soil, they lack the ability to hold and release phosphorus (P). As a result, P must be continuously supplied through a fertilization program. When P is supplied in soluble form, much of it is leached from the containers upon irrigation and becomes an environmental pollutant (5). Since production cycles for woody plants are long when compared to bedding plants and other container-grown crops, slow-release fertilizers are generally used. Slow-release fertilizers release P and other nutrients slowly as a function of coating thickness, water content of the medium, and temperature (6), but this release may not be synchronized with the nutrient demand of the plant, resulting in suboptimal nutrition and nutrient leaching.

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Table 1. **Source of nutrients supplied to rhododendron and forsythia plants. Fertilization with Osmocote 17–6–10 (Osmocote) represents typical current commercial practice. In the soluble P treatment, N and K are supplied with the same Osmocote preparation as the Al-P plants, but phosphorus is supplied with Micromax Plus rather than with Al-P.**

	Sources of nutrients (kg/100 liters)					
Fertilizer treatment	**Osmocote 36–0–0**	**Osmocote 0–0–44**	**Osmocote 17–6–10**	**Micromax**	**Micromax Plus 0–4–0**	**Al–P**
Osmocote	0	0	0.8	0.1	0	0
Soluble P	0.38	0.18	0	0	0.9[z]	0
Al-P 0.5%	0.38	0.18	0	0.1	0	0.5
Al-P 1%	0.38	0.18	0	0.1	0	1.0

[z]150% of recommended rate, contains 24% dolomite

In our previous research, we demonstrated that P leaching was reduced by using a solid-phase alumina-buffered P fertilizer (Al-P) (1, 2). Al-P acts as a P buffer, i.e. P is released from Al-P as a function of its concentration in the medium, therefore concentrations are kept nearly constant and leaching is minimized (1, 2). In addition, the quality of bedding plants grown with Al-P had superior postproduction quality and greater drought resistance than conventionally fertilized plants (1). This suggests that the Al-P fertilizer can provide optimal levels of P for plant growth, and that its use might improve the growth and quality of other container-grown plants as well.

The objectives of this study were to determine whether Al-P fertilizer could provide adequate phosphorus throughout the growing season for two woody landscape species and to compare growth of plants fertilized with Al-P or conventional fertilizer.

Materials and Methods

Rooted cuttings of rhododendron (*Rhododendron catawbiense* 'English Roseum') in 6.5 cm (2.5 in) peat pots and *Forsythia intermedia* 'Spring Glory' in 10 cm (4 in) plastic pots were obtained from Appalachian Nursery (Appalachian Nurseries, Inc., Waynesboro, PA). The plants had not been fertilized for 9 months. Rhododendrons were trimmed to 10 cm (4 in) height (about 8–14 leaves) and forsythias were selected for uniformity. Excess potting medium was removed from each plant before planting in #2 nursery pots in Ball Growing Mix 1 (a bark, vermiculite and perlite mix, George J. Ball Inc.). The medium was amended with 0.5% or 1% (w:v) alumina-buffered phosphorus (Al-P) desorbing P at 200 µM (6.2 ppm). Nutrients were supplied as described in Table 1 from single applications of Osmocote™ 17–6–10 Plus Minors (8-9 month formulation), Osmocote™ 0–0–44 and 36–0–0 (12 month formulations), Micromax Micronutrients™, and Micromax Plus™ 0–4–0 (all from The Scotts Co., Marysville, OH).

Plants were grown outdoors at two sites, the Rock Springs Horticultural Research Farm in Rock Springs, PA, and at a nursery in Potters Mills, PA. On July 8, 1997, plants were arranged in a randomized block design with four plants per block and four blocks per treatment at each of the two sites. Forsythia and rhododendron plants were grown in adjacent plots at each site. Border plants surrounded each plot. Plants were irrigated with an overhead sprinkler system as needed. The P content of the irrigation water was 1.029 µM (32 ppb) at Potters Mills and 0.071µM (2 ppb) at Rock Springs.

Every two weeks, leachate was collected from 1 pot per block using the Virginia Tech extraction method (7). Phosphorus content of leachate was analyzed using the phosphomolybdenum blue method (4). Dissolved solids and pH were analyzed in the same samples using a soluble salts meter (Oakton TDSTestr™, The Geiger Co., Harleysville, PA).

Forsythia plants were pruned twice, on August 26, 1997, and on October 24, 1997, to 30 cm (12 in) and 10 cm (4 in)

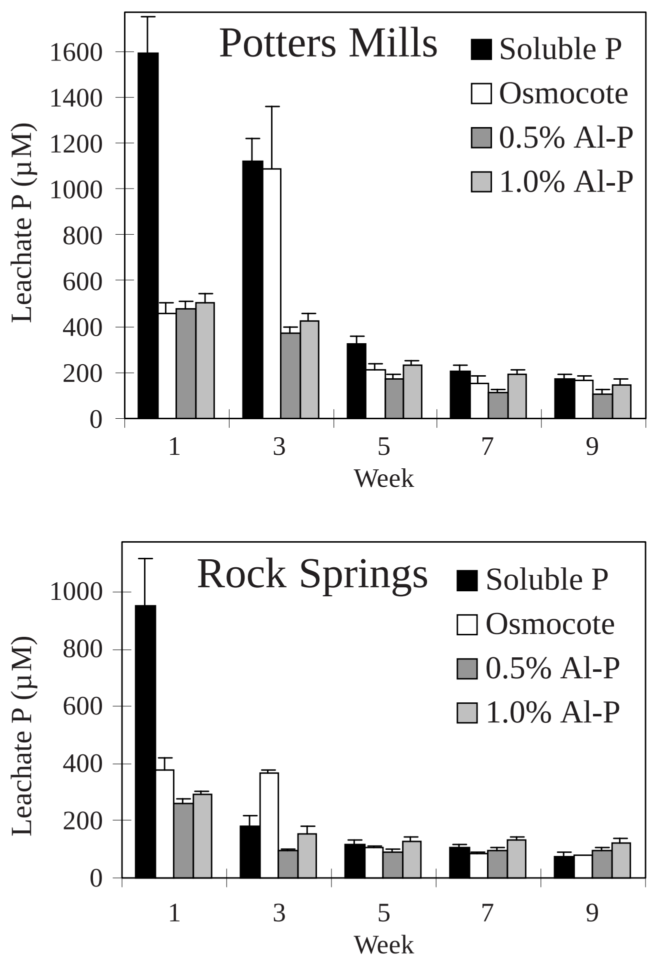

Fig. 1. **Phosphorus concentration of leachate from rhododendron and forsythia plants at two sites. Values shown are means of 4 samples ± SE.**

Table 2. ANOVA results for leachate composition. The upper row is the F value and below is an indication of significance (ns P > 0.05, * P < 0.05, ** P < 0.01, *** P < 0.001).

Variable	Fertilizer treatment	Site	Species	Time	Site × treatment	Treatment × time
P content	33.5 ***	81.8 ***	1.03 ns	67.6 ***	7.2 ***	16.1 ***
pH	48.3 ***	1.31 ns	3.32 ns	74.1 ***	5.69 ***	5.35 **
Soluble salts	0.936 ns	16.3 ***	0.155 ns	4.28 *	3.50 *	0.67 ns

height respectively. Pruned branches were dried and weighed to evaluate growth. Rhododendron plants were evaluated on October 24, 1997, by measuring height, width (in 2 dimensions) and dry weight of the new growth on the shoot (i.e. above 10 cm). Volume was calculated by multiplying height by the two widths.

Fully expanded young leaves from both species were collected for tissue analysis. Six leaves per plant were collected from 1 plant per block. Samples were dried for 48 h at 60C (140F), ground, and analyzed by the Penn State Agricultural Analytical Laboratory for nutrient content.

Results and Discussion

Leachate analysis. In our previous research, we demonstrated that when greenhouse-grown bedding plants were produced in soilless medium amended with Al-P, leaching of phosphorus was reduced to less than 5% of that from conventionally fertilized plants (1). In those experiments, nutrients were expected to leach readily from the soilless medium of control plants because it was constantly irrigated with soluble fertilizers. In this project, the control plants fertilized once with soluble P (from Micromax Plus) also lost a great deal of P in the leachate during the first few weeks after planting (Fig. 1, Table 2).

Another group of control plants were fertilized according to the fertilizer manufacturer's recommendations with slow release fertilizer (Osmocote), which would be expected to result in less leaching of nutrients than fertilization with soluble fertilizers. Indeed, P concentrations in leachate from Osmocote plants were lower than from soluble P plants 1 week after planting, but there was little difference after that (Fig. 1, Table 2). The highest P concentration in leachate from Osmocote plants was 1089 µM P (33.7 ppm) (Potters Mills, week 3, Fig. 1), about the same as found in marigold plants fertilized with soluble fertilizer (1). In forsythia plants at both sites, P released from Osmocote increased at 3 weeks after planting and then declined, while rhododendron plants showed equal or less P release in leachate with each successive sampling (data not shown). This may have been a result of differences in root distribution within the pots. Since rhododendron roots are finer, they may have explored the medium more thoroughly than forsythia roots and scavenged more of the P. By 5 weeks after planting, P concentrations in leachate were low for all fertilizer treatments.

Osmocote-grown plants had lower concentrations of P in the leachate than plants grown with soluble P, but still higher than plants in medium amended with Al-P during the first three weeks (Fig. 1, Table 2). Plants grown with Al-P had the lowest rate of P leaching. Plants fertilized with 0.5% Al-P had an average of 60% less P release over the course of the season than soluble P-fertilized plants and 42% less than Osmocote-fertilized plants.

P concentrations in leachate from Al-P grown woody plants were higher than previously reported for bedding plants, which were less than 50 µM (1). The reason for this difference is that the alumina used in this experiment was loaded with higher concentrations of P, giving an initial desorbing concentration of 200 µM (6.2 ppm) P. We chose to charge the alumina used in this experiment with higher concentrations of P to ensure that adequate P would be available during the longer production cycle of these woody plants. After 9 weeks we observed no decline in the ability of the Al-P to continue releasing P (Fig. 1). The fact that the P concentration in leachate was similar among the Al-P and conventional treatments after 7–9 weeks suggests that P concentrations released by this type of Al-P were adequate and similar to current commercial practice. Further research is needed to determine whether Al-P concentrations could be even lower.

Soluble salts and pH were tested in leachate after 5 and 7 weeks, when nutrient flushing had leveled off (see Fig. 1). The pH of the leachate was significantly affected by treatment and sampling time (Fig. 2, Table 2). The highest pH

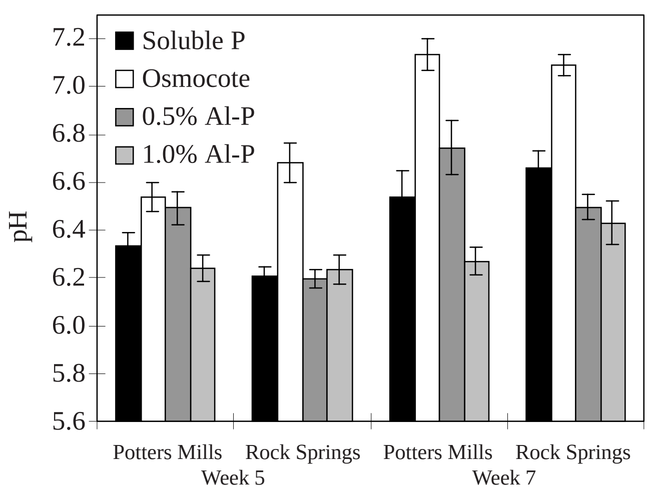

Fig. 2. The pH of leachate collected on two dates from woody plants grown at two sites. Species did not significantly affect pH, so values shown are the means of both species. Values shown are means of 8 samples ± SE.

Table 3. **ANOVA results for plant tissue analysis. The upper row is the F value and below is an indication of significance (ns P > 0.05, * P < 0.05, ** P < 0.01, *** P < 0.001).**

Variable	Treatment	Site	Species	Treatment × site × species
P content				
F-value	7.21	4.26	237.2	12.89
P-value	**	ns	***	***
Al content				
F-value	1.17	25.63	9.35	0.854
P-value	ns	***	***	ns

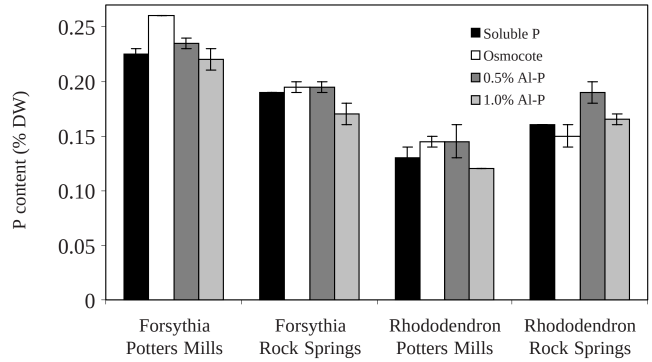

Fig. 3. Phosphorus content of leaves harvested at the end of the season. Values shown are means of 2 samples ± SE. When SE bars are not shown, the two values were identical.

values were recorded for Osmocote-grown plants sampled at 7 weeks. There were significant site by treatment interactions (Table 2), perhaps related to differences in irrigation rates and timing, water quality, and water pH, which was 7.7 at the Potters Mills site and 7.4 at the Rock Springs site. The pH of leachate was lower in 1% vs. 0.5% Al-P at Potters Mills, probably because Al-P acts as a weak acid and buffers the pH of the medium as well as the P content. Soluble salts were not significantly affected by treatment, except a small treatment by site interaction (Table 2). Soluble salt concentration in the water was 0.4 mmhos cm^{-1} at the Potters Mills site and undetectable at the Rock Springs site, and mean soluble salt concentration in leachate was 1.33 ± 0.07 mmhos cm^{-1} at the Potters Mills site and 1.08 ± 0.08 mmhos cm^{-1} at the Rock Springs site.

Plant tissue analysis. Plant tissue P content was higher in forsythia than in rhododendron and there was a significant interaction among treatment, species, and site (Fig. 3, Table 3). Differences among treatments within a species and site were relatively small. Site differences may have resulted from differences in water quality.

Tissue concentrations of aluminum were unaffected by treatment, but there were significant differences between species and sites (Table 3). Rhododendrons had >50% more Al than forsythia (35.6 vs. 21.1 µg g^{-1} (ppm)), probably because they acidify the rhizosphere, which solubilizes aluminum. Al concentrations were more than twice as high in plants grown at Rock Springs as at Potters Mills (40.3 vs. 16.3 µg g^{-1} (ppm)), perhaps because the pH of the water was lower. Other nutrient concentrations were in the normal ranges. Na concentrations were about 10 times higher in rhododendron leaves from plants grown at Potters Mills than at Rock Springs because of the water source.

Plant growth. Forsythia shoot dry weights at the mid-season and end-of-season harvests as well as total harvested dry weight were significantly affected by fertilizer treatment and site (Table 4). Plants grown with 0.5% Al-P had the highest total dry weight production of all the treatments (Fig. 4).

Table 4. **ANOVA results for plant growth data. The upper row is the F value and below is an indication of significance (ns P > 0.05, * P < 0.05, ** P < 0.01, *** P < 0.001).**

Variable	Site	Fertilizer treatment	Site × fertilizer treatment
Forsythia			
Mid-season harvest dry weight	7.36 **	6.06 ***	3.81 *
End of season harvest dry weight	45.6 ***	2.32 ns	0.36 ns
Total dry weight	18.2 ***	2.95 *	0.49 ns
Rhododendron			
Dry weight	4.02 *	11.2 ***	0.88 ns
Height	54.6 ***	2.78 *	0.36 ns
Width	0.18 ns	12.1 ***	1.30 ns
Volume	14.4 ***	10.8 ***	1.1 ns

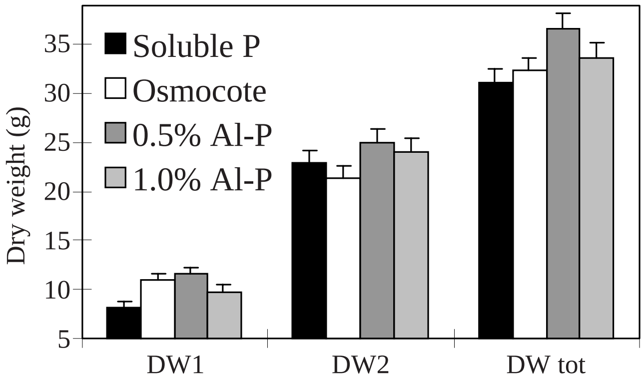

Fig. 4. Dry weight at mid-season (DW1), at the end of the season (DW2), and the total dry weight for forsythia plants grown in Al-P or control fertilizers at two sites. Values shown are means of 16 plants ± SE.

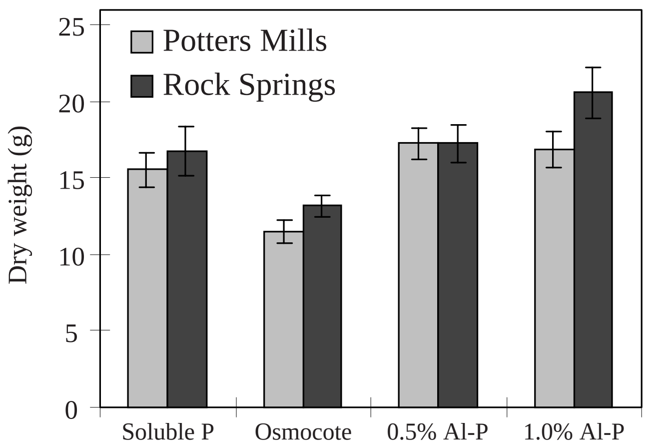

Fig. 5. Dry weight at the end of the season for rhododendron plants grown in Al-P or control fertilizers at two sites. Values shown are means of 16 plants ± SE.

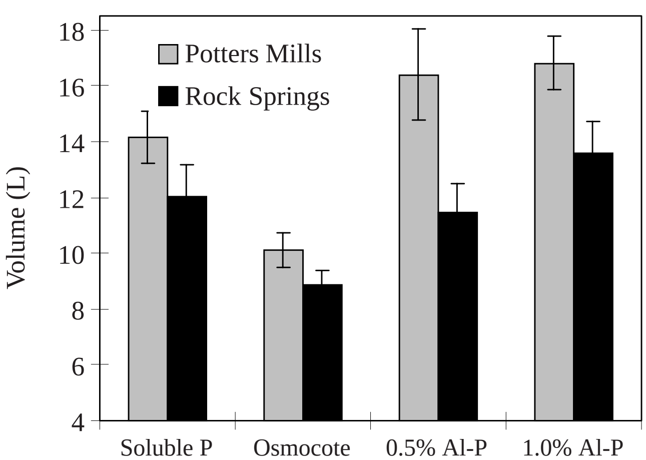

Fig. 6. Plant volume at the end of one season for rhododendron plants grown with Al-P or conventional fertilization. Values shown are means of 16 plants ± SE.

Despite a faster start early in the season, forsythia plants produced at the Potters Mills site completed the season with about 15% less total dry weight than plants grown at Rock Springs (data not shown).

Rhododendron plants grown with Al-P produced more dry matter after one season's growth than conventionally fertilized (Osmocote) plants, particularly at the Rock Springs site (Fig. 5). Plants grown with soluble P had intermediate dry matter production. Fertilizer treatment had a more significant effect on plant width than on height (Table 4). Plant volume was greater for Al-P plants than for Osmocote plants at both sites (Fig. 6). Volume of plants at the Potters Mills site was greater than that of plants grown at Rock Springs, even though the dry weights were equal or less (Figs. 5 and 6). This resulted from the fact that plants from the Potters Mills site were taller (data not shown). At both sites, the conventionally fertilized (Osmocote) plants were the smallest (Figs. 5 and 6).

For forsythia plants, 0.5% Al-P resulted in greater dry matter accumulation in the shoot than 1% Al-P or either of the controls (Fig. 4). However, rhododendron plants grew more with 1% Al-P than with 0.5% Al-P. One possible cause of increased rhododendron growth at 1% Al-P may have been the lower pH compared with other treatments, though the dry weight difference was greater at the Rock Springs site, where pH differences were smaller (Figs. 2 and 5).

The increase in dry matter accumulation when rhododendron and forsythia plants were grown with buffered Al-P fertilizer suggests that the conventional fertilization program based on Osmocote failed to provide optimum nutrition for plant growth. Excess P may have been supplied by slow-release and soluble fertilizers during the early weeks after planting (weeks 1–3, Fig. 1). Excess P can inhibit root growth and interfere with Zn, Fe, and Ca nutrition in the soil and in the plant (3). Reducing the application rates of slow-release and soluble fertilizers is not an option, since this would result in inadequate fertilization later in the season, when release by the fertilizer declines and uptake by the plant increases as the plant grows. Al-P, on the other hand, only releases P in proportion to its concentration in the medium, so that if the plant takes up more P, more P is released. Thus, P concentrations in the medium are less variable and better able to continuously supply the plant requirements.

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