Fertilizer Rate and Pot-In-Pot Production Increase Growth of Heritage River Birch[1]

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Abstract

A study was conducted to compare the effects of three fertilizer rates [High N Southern Formula, 23N–1.7P–6.6K (23–4–8) at 1.3, 1.7, and 2.0 kg N/m^3 (2.2, 2.8, and 3.4 lb N/yd^3)] and two production systems [pot-in-pot (PIP) or conventional above-ground (CAG)] on the growth of Heritage river birch (*Betula nigra* L. 'Cully') in 26 liter (#7) containers. Plants grown PIP had greater shoot dry weight (20%), root dry weight (31%), total biomass (27%) and root:shoot ratios (12%). Increasing fertilizer rates increased shoot dry weights but decreased root:shoot ratios. Rate of fertilizer application influenced foliar Mg, Zn, and Fe while production system had no effect. The foliar P:Zn ratio increased linearly as rate of fertilizer increased. Soluble salts and NO_3-N in the leachate increased linearly as rate of fertilizer increased at 15 and 60 days after application (DAA), whereas the response was curvilinear at 120 DAA. When different, nutrient concentrations in the leachate were greater for plants grown CAG. Fertilizer longevity based on prill analysis was greater when the PIP system was used, presumably due to lower substrate temperatures during the experimental period.

Index words: controlled release fertilizer, foliar analysis, leachate, nitrate, phosphorus, prill analysis, soluble salts, zinc.

Species used in this study: river birch (*Betula nigra* L. 'Cully' Heritage).

Significance to the Nursery Industry

Research on the influence of controlled release fertilizers for pot-in-pot production is limited. In our study, pot-in-pot production increased shoot and root dry weights, total biomass, and the root:shoot ratio of Heritage river birch compared to a conventional above-ground production system. Increasing fertilizer rates from 1.3 to 2.0 kg N/m^3 (2.2 to 3.4 lb N/yd^3) increased shoot dry weight by 34% but decreased root:shoot ratios. Nitrate-N concentrations in the leachate were often lower for pot-in-pot grown plants compared to those above ground. Lower NO_3-N concentrations from pot-in-pot grown plants could be due to increased plant uptake or slower release rates since substrate temperatures are lower during the growing season. Analysis of total salts remaining in the fertilizer prills indicated that less fertilizer was released in pot-in-pot containers at six and 10 months after application compared to above-ground containers. Growers may be able to reduce the frequency of fertilizer application in pot-in-pot systems due to extended fertilizer longevity, thereby decreasing production costs.

Introduction

Pot-in-pot production is increasing in popularity in the southeastern United States (2, 4, 10). This new production method has been adopted by in-field nurseries and growers of larger container-grown trees. Recent studies have shown that PIP production can be less costly than conventional above-ground or in-field production methods for small acreages (2, 4).

Fertilizer release from multicoated controlled release fertilizers is regulated by substrate temperature. Root-zone temperatures are consistently lower when plants are grown PIP compared to CAG production systems (5, 9, 10, 15). Improved root growth of plants grown PIP may influence nutrient uptake efficiency, and lower substrate temperatures may extend fertilizer longevity. Little research has been conducted on the effects of fertilizer rates on plants grown PIP. Therefore, the objectives of this study were to compare the growth of plants produced PIP and CAG with three rates of a controlled-release fertilizer and to evaluate the rate of fertilizer release.

Materials and Methods

The experiment was conducted under full sun at the University of Georgia Coastal Plain Experiment Station, Tifton. Uniform liners of *Betula nigra* 'Cully' Heritage were transplanted from 2.8 liter (#1) containers to 26 liter (#7) containers in May 1996. Potting substrate consisted of milled pine bark and sand (8:1 by vol) amended with micronutrients (Micromax, The Scotts Company, Marysville, OH) at 0.6 kg/m^3 (1.0 lb/yd^3) and dolomitic limestone at 3.0 kg/m^3 (5.0 lb/yd^3). The fertilizer [23N–1.7P–6.6K (23–4–8, High N Southern Formula; The Scotts Company)] was surface-incorporated to a depth of 2.5 cm (1.0 in) at the rates of 1.3, 1.7, and 2.0 kg N/m^3 (2.2, 2.8, and 3.4 lb N/yd^3) on May 31, 1996. Holder (socket) pots were placed in the ground with 2.5 cm (1 in) at the top of the pot remaining above grade. Spacing was 1.5 m (5 ft) within rows and 3.0 m (10 ft) between rows.

The experiment was a factorial arrangement of two container production systems (PIP and CAG), three fertilizer rates, and six replications. An irrigation volume of ~1033 ml (35 oz) was applied three times per day at 08:00, 12:00, and 16:00 using 160° low volume spray emitters (Roberts Irrigation, San Marcos, CA) and a 24 hr clock. All containers (PIP and CAG) had SpinOut-treated landscape fabric (Griffin Corp., Valdosta, GA) placed beneath the bottom of the planted container to prevent rooting-out into the surrounding soil.

On October 29, 1996, final plant height and width measurements were taken. Growth indices were calculated as: [(height + width 1 + width 2 (perpendicular to width 1)) / 3]. Shoot dry weight and root dry weight were determined after drying in a forced-air oven for 72 hr at 66C (150F). Sub-

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Table 1. **Effects of conventional above-ground production and pot-in-pot on the growth of Heritage river birch produced in 26 liter (#7) containers.**

Production system	Growth index[z] (cm)	Shoot dry weight (g)	Root dry weight (g)	Total biomass[y]	Root: shoot ratio
Conventional	121	500	853	1353	1.7
Pot-in-pot	130	599	1121	1720	1.9
(% increase)	(7)	(20)	(31)	(27)	(12)
Significance	**	**	**	**	*

[z]Growth index: [(height + width 1 + width 2) / 3].
[y]Total biomass: shoot dry weight + root dry weight.
**,* Significant at $P \leq 0.01$ or 0.05.

Table 2. **Effects of fertilizer rate (High N Southern Formula, 23–4–8) on the growth of Heritage river birch produced in 26 liter (#7) containers.**

Fertilizer rate (kg N/m^3)	Growth index[z] (cm)	Shoot dry weight (g)	Root dry weight (g)	Total biomass[y]	Root: shoot ratio
1.3	120	467	966	1433	2.1
1.7	128	558	976	1534	1.7
2.0	129	623	1020	1643	1.6
Significance					
Linear	NS	**	NS	NS	**

[z]Growth index: [(height + width 1 + width 2) / 3].
[y]Total biomass: shoot dry weight + root dry weight.
**,NSSignificant at $P \leq 0.01$ or nonsignificant.

strate was removed from the root system before drying. Total biomass was calculated as the sum of shoot and root dry weights.

Foliage was removed after dry weight was determined, ground to pass through a 20 mesh screen, and duplicate 1 g samples were analyzed for N by macro-Kjeldal. Phosphorous was determined using a molybdovandate method while leaf K, Ca, Mg, Zn, Mn, Fe, and Cu were determined by atomic absorption spectrophotometry. At 15, 30, 60, and 120 days after fertilizer application (DAA), the pour-through method was used to collect container substrate leachate (14). Soluble salts (dS/m) and pH of leachate samples were measured using a conductivity meter and pH meter, respectively. Nitrate-N concentrations were determined with an ion specific electrode. Additional plants grown at the medium rate of fertilizer were used to supply fertilizer for prill analysis at 180 and 300 DAA. Nutrient charge in the fertilizer prills was determined at 0, 180 and 300 DAA by crushing 2.5 g of oven-dried fertilizer prills in a mortar and pestle. The pulverized fertilizer was diluted with 250 ml of deionized water (n = 4). Remaining nutrient charge was determined by measuring the soluble salt concentration of the solution. Percentage of fertilizer remaining in the prills was determined by dividing the soluble salt reading at 300 DAA by the initial value. Data analysis for all parameters were evaluated by analysis of variance and regression analysis where appropriate (12). Production system by fertilizer rate interactions were not significant for all measured variables.

Results and Discussion

Growth indices of plants grown PIP were 7% larger compared to plants produced CAG (Table 1), but production system had no effect on plant height (data not shown). Trees in this study were allowed to grow with multiple trunks, and results may have been different if they had been trained to a single leader. For PIP plants, shoot dry weight and root dry weight were 20% and 31% greater, respectively, than plants grown CAG. The increase in shoot and root dry weight resulted in a 27% increase in total biomass. The root:shoot ratio increased 12% when plants were grown PIP.

Fertilizer rate had no influence on growth indices, root dry weight or total biomass (Table 2). Shoot dry weight increased linearly as fertilizer rate increased, indicating that a denser canopy was produced by putting more dry weight into the same volume of space. At the highest rate of application, shoot dry weight increased 34% compared to the lowest rate. The root:shoot ratio decreased linearly as rate of fertilizer application increased, ranging from 2.1 to 1.6.

Concentrations of foliar nutrients were unaffected by production system (data not shown). Fertilizer rate influenced foliar Mg, Zn, and Fe (Table 3) whereas N, P, K, Ca, Mn, and Cu were unaffected by fertilizer rate (data not shown). Both Mg and Zn decreased linearly as rate of fertilizer increased, while Fe showed a curvilinear response to rate of application. While significant, the differences in foliar Mg and Fe due to rate of fertilizer application probably had little influence on plant growth. The ratio of P to Zn increased linearly as fertilizer rate increased, though no signs of Zn deficiency were present. Foliar Zn concentrations in this study were within acceptable limits for woody ornamentals (6). Phosphorus has been shown to induce Zn deficiency (1, 3). Deficiency symptoms often occur when high P:Zn ratios exist. Substrate P concentrations increased with increasing rates of fertilizer application, whereas Zn was only available from the initial incorporation of micronutrients. The solubility of Zn decreases in the presence of high concentrations of the phosphate ion (13). High substrate pH can also influence P:Zn interactions by limiting the availability of Zn. However, rate of fertilizer application had no effect on pH (data not shown) and the range of pH during the study (5.2 to 6.2) probably would not cause drastic decreases in substrate Zn concentrations.

Production system had no affect on soluble salts or NO_3-N until 60 DAA when both were greater for CAG plants

Table 3. **Influence of fertilizer rate (High N Southern Formula, 23–4–8) on foliar nutrient concentrations of Heritage river birch.**

Fertilizer rate (kg N/m^3)	Mg (%)	Zn (mg/kg)	Fe (mg/kg)	P:Zn
1.3	0.41	87	79	19.5
1.7	0.41	53	86	35.8
2.0	0.38	43	72	39.5
Significance				
Linear	*	**	NS	**
Quadratic	NS	NS	*	NS

**,*,NSSignificant at $P \leq 0.01$, 0.05, or nonsignificant.

Table 4. **Influence of time and production systems on leachate soluble salts and NO_3-N concentrations for Heritage river birch produced in 26 liter (#7) containers.**

Days after application	Production system[z]	Soluble salts (dS/m)	Nitrate-N (mg/l)
15	CAG	0.55	29
	PIP	0.46	28
Significance		NS	NS
30	CAG	0.18	17
	PIP	0.13	10
Significance		NS	NS
60	CAG	0.45	49
	PIP	0.23	16
Significance		*	*
120	CAG	0.14	26
	PIP	0.16	18
Significance		NS	*

[z]CAG = conventional above-ground, PIP = pot-in-pot.

[*,NS] Significant at $P \leq 0.05$ or nonsignificant.

Table 5. **Influence of time and rate of fertilizer application (High N Southern Formula, 23–4–8) on leachate soluble salts and NO_3-N concentrations for Heritage river birch produced in #7 (26 liter) containers.**

Days after application	Fertilizer rate (kg N/m³)	Soluble salts (dS/m)	Nitrate-N (mg/l)
15	1.3	0.38	21
	1.7	0.57	31
	2.0	0.55	33
Significance		L*	L*
30	1.3	0.13	11
	1.7	0.14	12
	2.0	0.19	17
Significance		NS	NS
60	1.3	0.21	18
	1.7	0.30	25
	2.0	0.52	54
Significance		L*	L*
120	1.3	0.14	23
	1.7	0.12	17
	2.0	0.19	25
Significance		Q*	Q*

[L*,Q*,NS] Significant linear, quadratic, or nonsignificant at $P \leq 0.05$.

compared to PIP (Table 4). At 120 DAA, NO_3-N in the leachate was higher for CAG plants. Soluble salt and NO_3-N levels increased linearly as rate of fertilizer increased at 15 and 60 DAA (Table 5). Rate of fertilizer application had no affect on soluble salts and NO_3-N at 30 DAA and there was a curvilinear response to fertilizer rate for both at 120 DAA. Higher concentrations of soluble salts and NO_3-N were found 15 DAA compared to 30 DAA for both production system (Table 4) and fertilizer rate (Table 5). A small percentage of the fertilizer prills in this formulation are not coated, thus a portion of the fertilizer was soluble and could provide an initial nutrient release.

At 180 DAA, the remaining nutrient charge for fertilizer prills in the PIP system (6.3 ± 0.2 dS/m) was greater than for CAG (4.7 ± 0.2 dS/m). The same held true at 300 DAA as the values for PIP were 4.6 ± 0.2 dS/m compared to 3.5 ± 0.5 dS/m for CAG. With the fertilizer prills having an initial value of 8.8 dS/m, the percentage of fertilizer remaining in the prills 300 DAA was 52% for PIP compared to 40% for CAG. A similar procedure used in Ireland determined that most of the N in controlled release fertilizers rated as 12 to 14 month formulations was released in 8 to 10 months (7). In the southeastern United States, some 12- to 14-month formulations may only provide sufficient nutrients for three to four months (8), indicating the need for procedures to evaluate fertilizer longevity. New formulations of controlled-release fertilizers may provide sufficient nutrients for a 10-month period in the southeast (11).

For both production system and fertilizer rate, soluble salt levels were below the recommended minimum of 0.2 dS/m at 120 DAA while NO_3-N concentrations were generally within or above the acceptable range of 15 to 25 mg/l for controlled release fertilizers. The formulation of fertilizer used in this study has been rated to last 8 to 9 months at substrate temperatures of 32.2C (90.0F). After 10 months there were still substantial nutrient reserves in the fertilizer prills. Nutrient charge remaining after 10 months was greater for the PIP system compared to CAG, probably due to lower substrate temperatures during the experimental period. With the PIP system, slower fertilizer release rates coupled with increased nutrient uptake due to a larger root system should increase plant growth. Fertilizer longevity should increase while decreasing the potential for nutrient leaching. Future research with different species, new fertilizer formulations, and use of fertilizer prill analysis is warranted.

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Greenhouse Conditioning Affects Landscape Performance of Bedding Plants[1]

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Abstract

Conditioning treatments were evaluated for effects on growth of bedding plants during greenhouse production and carryover effects on plant performance in the landscape. Treatments included two fertilization regimes using a complete water soluble fertilizer applied three times/week at 500 ppm N, designated 'high N', or at 50 ppm N, designated the 'low N' treatment. Other treatments included: ebb and flow irrigation, drought stress for up to 2 h wilt/day, 5000 ppm B-Nine (daminozide), 45 ppm Bonzi (paclobutrazol; 180 ppm on columbine), and brushing (40 strokes twice daily). Unless otherwise noted all plants, including controls, were maintained well-irrigated and fertilized with 250 ppm N three times/week. Marigolds and New Guinea impatiens grown under low N during greenhouse production exhibited reduced plant height and width relative to control plants at 4 weeks after planting (WAP) in the landscape. Plant quality ratings of all species conditioned with low N were lower than those of controls 2 and 4 WAP. Plant height of New Guinea impatiens conditioned with high N was greater than that of controls 4 WAP in the landscape. Marigolds subjected to drought in the greenhouse were still shorter than controls 2 and 4 WAP. Persistent height reductions in the landscape in response to B-Nine were observed in ageratum 2 and 4 WAP and to Bonzi in New Guinea impatiens through 8 WAP. Brushing reduced the height of all species except ageratum in the greenhouse, but had no carryover effect on plant growth in the landscape. At 4 weeks after treatment, plant height of columbine treated with low or high N, drought, brushing, or B-Nine was reduced relative to controls, but all plants were similar in size in the landscape.

Index words: growth regulators, stress, brushing, drought, Bonzi, B-Nine.

Species used in study: columbine (*Aquilegia* x *hybrida* Sims 'McKana Giants'); New Guinea impatiens (*Impatiens* x *hybrida* L. 'Agadoo'); marigold (*Tagetes erecta* L. 'Little Devil Mix'); ageratum (*Ageratum Houstonianum* L. Mill. 'Blue Puffs').

Chemicals used in this study: B-Nine (daminozide), butane-dioic acid mono(2,2-dimethylhydrazide); Bonzi (paclobutrazol), β-[(4-chlorophenyl)methyl]-α-(1,1-dimethylethyl)-1*H*-1,2,4-triazole-1-1-ethanol.

Significance to the Nursery Industry

Cultural practices and/or chemical growth regulators are commonly used during greenhouse production to control bedding plant height. However, the carryover effects of these practices on landscape performance are seldom examined. Landscape performance affects customer satisfaction and therefore, repeat business. This paper emphasizes the reduction in plant height and quality of ageratum and New Guinea impatiens in the landscape when the bedding plants were produced under a low N fertilization regime (50 ppm N, 3×/week). Landscape quality ratings of marigold bedding plants produced under low N levels also were reduced, with no reduction in plant height during greenhouse production. A high N fertilization regime (500 ppm N, 3×/wk) increased height of only one species, ageratum, in the greenhouse, but increased the height of New Guinea impatiens 4 WAP in the landscape, relative to their respective controls. Production of ageratum under ebb-and-flow conditions increased plant height in the greenhouse, but reduced plant quality ratings in the landscape. Rates of chemical plant growth regulators (PGRs) must be carefully selected to avoid persistent growth reduction in the landscape. Management of cultural conditions to produce healthy vigorous bedding plants in the greenhouse provides the best plants for optimum landscape performance.

Introduction

Management of plant growth during greenhouse production generally involves a combination of cultural and chemi-

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