Fertilizer Rate and Pot-In-Pot Production Influence Growth of River Birch

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A study was conducted to compare the effects of three fertilizer rates [High N-Southern Formula, 23N-1.7P-6.6K at 1.3, 1.7, and 2.0 kg N m-3 (2.2, 2.8, and 3.4 lb N yd-3)] and the pot-in-pot (PIP) system of production compared with a conventional above-ground (CAG) system on the growth of *Betula nigra* 'Cully' Heritage™ river birch. Plants grown PIP had greater shoot and root growth, total biomass, and increased root : shoot ratios. Fertilizer rate increased shoot dry weights, but decreased root : shoot ratios. Rate of fertilizer application influenced foliar Mg, Zn, and Fe, while the production system had no effect. Nutrient concentrations in the leachate were greater for plants grown CAG. Fertilizer longevity was increased when the PIP system was used, presumably due to lower substrate temperatures during the experimental period.

INTRODUCTION

Pot-in-pot production is increasing in popularity in the southeastern United States (Haydu, 1997; Montgomery et al., 1995; Ruter, 1997). This new production method is being adopted by in-field nurseries and producers of larger container-grown trees. Recent studies have shown that PIP production can be less costly than conventional above-ground (CAG) or in-field production methods (Haydu, 1997; Montgomery et al., 1995).

Fertilizer release from multicoated controlled-release fertilizers is regulated by substrate temperature. During the warmer production season, root-zone temperatures were consistently lower with plants grown PIP compared to CAG production systems (Parkerson, 1990; Ruter, 1993). To my knowledge, 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.

MATERIALS AND METHODS

The experiment was conducted outdoors under full sun conditions at the University of Georgia Coastal Plain Experiment Station, Tifton. Uniform liners of *Betula nigra* 'Cully' Heritage™ river birch were transplanted from 2.8 L (#1) containers to 26 L (#7) containers in May, 1996. Potting substrate consisted of milled pine bark and sand (8 : 1, v/v) amended with micronutrients 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}). Substrates were surface-incorporated to a depth of 2.5 cm (1.0 in) with 23N-1.7P-6.6K (23-4-8, High N - Southern Formula; The Scotts Company, Marysville, OH) 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 31 May, 1996. Holder pots (sleeve pots into which the containers are inserted) were placed in the ground with 2.5 cm (1 inch) at the top of the pot remaining above grade.

The experiment was a randomized complete block with two container production systems (PIP and CAG), three fertilizer rates, and six replications. Additional plants were grown at the 1.7 kg N m^{-3} (2.8 lb N yd^{-3}) fertilizer rate to collect fertilizer prill samples. Cyclic irrigation [~1033 ml (35 oz)] was applied three times per day at 8:00, 12:00, and 16:00. Irrigation was applied using 160° low-volume spray emitters (Roberts Irrigation, San Marcos, CA). All containers (PIP and CAG) had SpinOut™-treated landscape fabric placed beneath the bottom of the planted container to eliminate any problems with rooting-out into the surrounding soil.

On 29 Oct. 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 h at 65.5 C (150 F). Substrate 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 20 mesh, 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. Soluble salts (dS/m) and pH of leachate samples were determined using a conductivity meter and pH meter, respectively. Nitrate-N concentrations were determined with an ion-specific electrode. Nutrient charge remaining in the fertilizer prills was determined 180 and 300 DAA by crushing 2.5 g of oven-dried fertilizer prills in a mortar and pestle and adding the pulverized fertilizer to 250 ml of deionized water (n=4). Remaining nutrient charge was then determined by measuring the soluble salt concentration of the solution. Data analysis for all parameters were evaluated by analysis of variance and regression analysis where appropriate.

RESULTS

Growth indices of plants grown PIP were 7% larger compared to plants produced CAG, but production system had no effect on plant height. 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 effect on growth indices, root dry weight or total biomass. Shoot dry weight increased linearly as fertilizer rate increased. At the highest rate of application 2.0 kg N m^{-3} (3.4 lb N yd^{-3}), 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 at the lowest rate to 1.6 at the highest rate.

The production system had no influence on the concentration of foliar nutrients. Fertilizer rate influenced foliar Mg, Zn, and Fe. Both Mg and Zn decreased linearly as rate of fertilizer increased while Fe showed a curvilinear response to rate of application. Production system had no effect on soluble salts or nitrate-N until 60 DAA when both parameters were greater for CAG plants compared to PIP. At 120 DAA, nitrate-N in the leachate was higher for the CAG plants. Soluble salt and nitrate-N levels increased linearly as rate of fertilizer increased at 15 and 60 DAA. The rate of fertilizer application had no affect on soluble salts and nitrate-N at 30 DAA and there was a curvilinear response to fertilizer rate for both parameters at

120 DAA. At 180 DAA, the remaining nutrient charge for fertilizer prills in the PIP system (6.3 dS m^{-1}) was greater than for CAG (4.7 dS m^{-1}). The same held true at 300 DAA as the values for PIP were 4.6 dS m^{-1} compared to 3.5 dS m^{-1} for CAG.

DISCUSSION

Plants grown PIP produced more biomass in terms of shoot and root growth compared to a CAG production system. Fertilizer rate had no effect on growth indices but did increase shoot dry weights, indicating that a denser canopy was produced. The production system and rate of fertilizer application had no effect on tree height. 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.

Fertilizer rate had minimal affects on foliar nutrient concentrations. For both production system and fertilizer rate, soluble salt levels were below the recommended minimum of 0.2 dS/m at 30 and 120 DAA while nitrate-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 32.2 C (90 F). 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 and fertilizer longevity as well as decreasing the potential for nutrient leaching.

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