Fertilization of Container-Grown Baldcypress (*Taxodium distichum* (L.) Rich.)[1]

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Abstract

Two fertilization experiments were conducted with first-year seedlings of baldcypress [*Taxodium distichum* (L.) Rich.] in containers (substrate = composted pine bark). First, seedlings were subjected to factorial combinations of dolomitic lime, soluble fertilizer (SF), and incorporated controlled-release fertilizer (CRF) (19.0N–2.6P–8.8K; 8- to 9-month release). Lime decreased growth. Incorporated CRF [4.8 kg/m^3 (8 lbs/yd^3)] yielded more growth than a single weekly application of SF (N = 0.5 g/liter). In the second experiment, most of the potential height growth and total plant dry weight were realized with 2.4 kg/m^3 (4 lbs/yd^3) and 4.8 kg/m^3 (8 lbs/yd^3), respectively, of incorporated CRF. At optimal growth, foliar N concentrations were 3.0%.

Index words: forest regeneration, wetlands restoration, mineral nutrition, nursery stock, *Taxodium distichum*.

Significance to the Nursery Industry

Historically, bare-root planting stock (1-year-old) has been used in forest planting operations to regenerate baldcypress. Production of large containerized stock might provide a means to circumvent severe damage by deer and rabbits on some wetland regeneration sites. However, there is little published information concerning containerized baldcyress and its response to fertilization. Results herein quantify the response of cypress to lime, incorporated controlled-release fertilizer (CRF), and soluble fertilizer (SF). Plants can be grown in composted pine bark amended with 4.8 kg/m^3 (8 lbs/yd^3) of CRF (19.0N–2.6P–8.8K; 8- to 9-month release). Lime is not needed.

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Introduction

Baldcypress (*Taxodium distichum*) is an important swampland forest tree species in the southeastern United States. It occurs on soils ranging widely in texture, reaction, base saturation, and fertility (8), but is normally confined to swamps where there is abundant moisture throughout the year (19). It is not demanding nutritionally, but is so exacting in regard to moisture that the area adapted for best growth is extremely limited (22). Regeneration of baldcypress is usually accomplished with 1-year-old (1–0) bare-root seedlings. Seedlings produced by the North Carolina Forest Service are normally 0.60 to 0.75 m tall (24 to 30 in), sometimes 1 m (40 in). The root system, with its large taproot and fibrous laterals, is easy to bar plant. In addition, the shoot (stem) tends to be straight with few lateral branches.

Heavy browsing by deer and rabbits on forest regeneration sites often results in unacceptably high mortality and deformed trees as well as significant loss of height during the first few years (15). Although planting trees up to 1.2 m tall (4 ft) might circumvent this problem on some sites, growing 2-year-old bare-root seedlings would not be practical due

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to their large size and resulting transplant shock. Production in containers is an alternative, but there is little information on container culture of this species.

In earlier research, baldcypress nursery stock in fabric bags grew best at high levels of nitrogen (N) fertilization, compared to several other genera of forest trees (11). On restoration sites in Louisiana, early diameter growth doubled after applications of controlled-release fertilizer (CRF) (20). Cypress best utilizes N under saturated, aerated conditions, and ammonium is a better N source than nitrate (9). Given the possible need for containerized plants, our objective was to examine the response of containerized seedlings to lime, CRF, and soluble fertilizer (SF), and determine an optimum rate of incorporated CRF.

Materials and Methods

Recently germinated field-grown seedlings of baldcypress [7 to 8 cm (2.8 to 3.1 in) tall] were dug from standard outdoor nursery beds at Claridge Nursery (N.C. Forest Service, Goldsboro) during June 1999, taking care to ensure that each had a small root ball of soil. Seedlings were heeled into shallow nursery trays filled with soil, watered, transported to Raleigh, placed under 50% shade, and watered twice daily until initiation of experiments.

Experiment 1 (Lime, CRF, and SF). On June 10, 1999, a 2 × 2 × 2 factorial experiment was installed 1) with and without dolomitic lime [3.6 kg/m^3 (6 lbs/yd^3)], 2) with and without CRF (19.0N–2.6P–8.8K) (Coor Farm Supply, Smithfield, NC) [4.8 kg/m^3 (8 lbs/yd^3)], and 3) with and without SF (once weekly, N = 0.5 g/liter). The SF contained 15N–13.2P–11.0K (Scotts-Sierra Hort. Products, Marysville, OH). The CRF was a resin-coated material with an 8- to 9-month release at 20C (72F), and contained only ammoniacal N. Coated N was 15.2%—about 80% of the total N. Other mineral nutrients were as follows: 1.7% Ca, 1.2% Mg, 1.0% S, 1.0% Fe, 0.05% Zn, 0.25% Mn, 0.025% Cu, 0.0025% B, and 0.0003% Mo. Initial pH of the composted pinebark substrate was ≈4.5.

Containers were 7.3 × 7.3 × 20.3 cm (2.9 × 2.9 × 9 in) black plastic tree bands (Anderson Tool & Die, Portland, OR) held in trays with a capacity of 25 bands (5 rows × 5 containers per row). Each replication (block) consisted of three trays, side by side (n = 15 rows), with the eight treatments randomized among alternate rows. Thus, the end trays (#1 and #3) each had three plots; the middle tray (#2) had two plots. Each container had one plant, and plots were separated by blank rows of empty containers. The experimental design was a randomized complete block (RCB) with six blocks and eight treatments. Plants were kept under 50% shade, and watered twice daily (2 × 30 min) by overhead impact sprinklers.

The experiment was terminated after 3 months (September 10–14, 1999), and data recorded. Measurements on each plant included 1) total height, 2) stem diameter in opposing directions, 1 cm (0.4 in) above the cotyledons, 3) length of the longest leaf, and 4) dry weight of foliage, stems, and roots after drying to constant weight at 65C.

Experiment 2 (Fertilizer rate). On June 22, 1999, seedlings (same origin as those in Experiment 1) were lifted, and planted the following day in tree bands (same as Experiment 1) containing one of the following rates of CRF [0, 2.4, 4.8, 7.1, or 9.5 kg/m^3 (0, 4, 8, 12, or 16 lbs/yd^3)] (19.0N–2.6P–8.8K). The experiment was a RCB with six blocks, five treatments, five plants per plot, and one plant per container. Plots were randomized, as in Experiment 1, with two contiguous trays (n = 10 rows) in each block, and open rows of containers separating plots. Plants were watered and maintained as in Experiment 1.

The experiment was terminated on September 8, 1999, and data recorded. Measurements on each plant included 1) height, 2) stem diameter in opposing directions 1 cm (0.4 in) above the cotyledons, and 3) weight of shoot, roots, and fo-

Table 1. Response of containerized baldcypress seedlings to factorial combinations of lime, controlled-release fertilizer, and soluble fertilizer (*Expt. 1*).

Treatment[z]				Dry weight				
L	CRF	SF	Height (cm)	Shoot (g)	Roots (g)	Total (g)	Stem area (mm^2)	Leaf length (cm)
—	—	—	8	0.24	0.24	0.48	3.1	3.3
—	—	+	69	5.2	2.9	7.2	33.2	14.3
—	+	—	74	6.7	2.7	9.3	42.2	15.8
—	+	+	76	7.8	2.8	10.6	44.9	17.2
+	—	—	14	0.25	0.21	0.46	2.9	2.6
+	—	+	56	2.8	1.4	4.1	22.1	9.2
+	+	—	72	6.2	2.3	8.5	36.7	14.4
+	+	+	78	7.6	2.7	10.3	44.8	16.4
	L		**[y]	**	**	**	**	**
	CRF		**	**	**	**	**	**
	SF		**	**	**	**	**	**
	L × CRF		**	NS	NS	*	NS	**
	L × SF		**	*	NS	**	NS	**
	CRF × SF		**	**	**	**	**	**
	L × CRF × SF		**	**	**	**	**	**
	R^2		0.95	0.82	0.76	0.83	0.84	0.82

[z]L = 3.6 kg/m^3 (6 lbs/yd^3) of dolomitic lime, CRF = 4.8 kg/m^3 (8 lbs/yd^3) of controlled-release fertilizer; SF = soluble fertilizer, once weekly (N = 0.5 g/liter).
[y]NS, *, **; Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

liage after drying to constant weight at 65C. Within each treatment, dried foliage was composited into two samples (blocks 1–3 and blocks 4–6) for chemical analysis by the N.C. Dept. of Agriculture & Consumer Protection—Agronomic Division, using standard procedures (4, 5).

Data analysis. In Experiment 1, shoot dry weight was the sum of stem dry weight and foliage dry weight. In both experiments, stem cross-sectional area was calculated as the area of a circle with diameter equal to average stem diameter 1 cm above the cotyledons. Data were analyzed using GLM and REG procedures of SAS (23).

Results and Discussion

Experiment 1 (Lime, CRF, and SF). Most main effects and interactions were highly significant for all measured indices of growth (Table 1). With minor variations, response patterns to factorial combinations of lime, CRF, and SF were similar for shoot weight, root weight, stem cross-sectional area, and leaf length (Table 1). Graphs are included to illustrate the 2 × 2 treatment interactions for 1) total dry weight (Fig. 1), and 2) height (Fig. 2).

After 12 weeks, fertilized plants were 15 to 20 times heavier and 8 to 10 times taller than nonfertilized controls (Figs. 1 and 2). Incorporated CRF yielded greater plant dry weight than a single weekly application of SF (Fig. 1A and E). Maximum dry weight resulted from a combination of CRF and SF, with about 80% to 90% of the gain attributable to CRF (Fig. 1A, B, E, and F). Lime tended to decrease dry weight (Fig. 1A, B, C, and D).

Where no lime was added to the substrate, leaf length was 15.8 cm for plants that received CRF, compared to 3.3 cm in controls (Table 1). Without lime, 83% of maximum leaf length was realized with a weekly application of SF, compared to only 53% in the presence of lime (Table 1). Maximum leaf length (17. 2 cm) resulted from a combination of CRF and SF, without lime.

Height (Fig. 2), compared to dry weight (Fig. 1), was less responsive to fertilization method. For example, without lime and CRF, weekly applications of SF yielded 91% of the maxi-

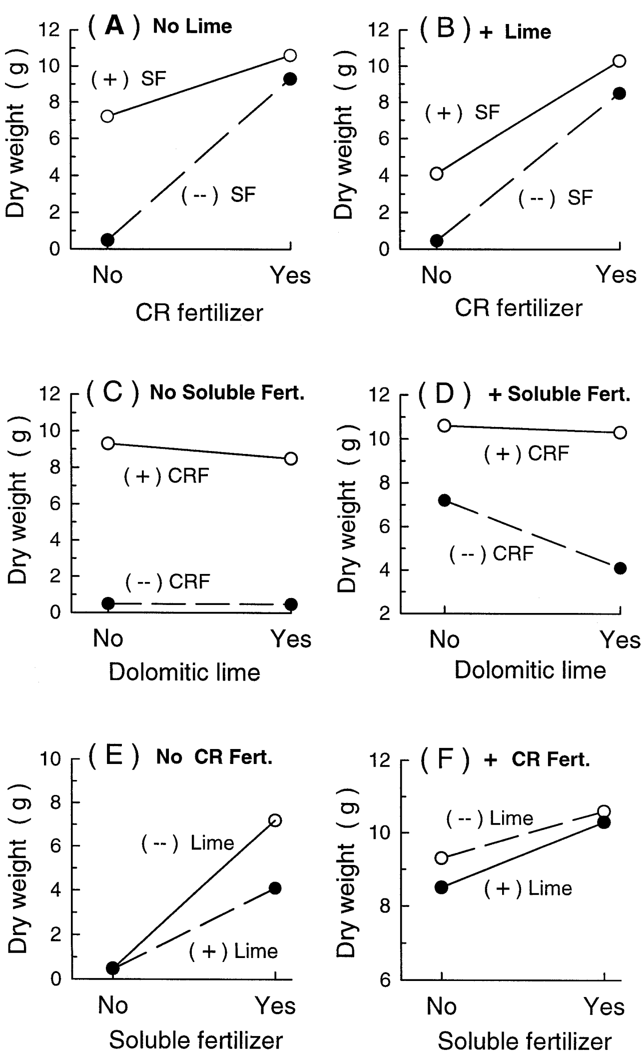

Fig. 1. **Total dry weight of 1-year-old containerized baldcypress seedlings: two-way interactions of lime, controlled-release fertilizer (CRF), and soluble fertilizer (SF) (Expt 1).**

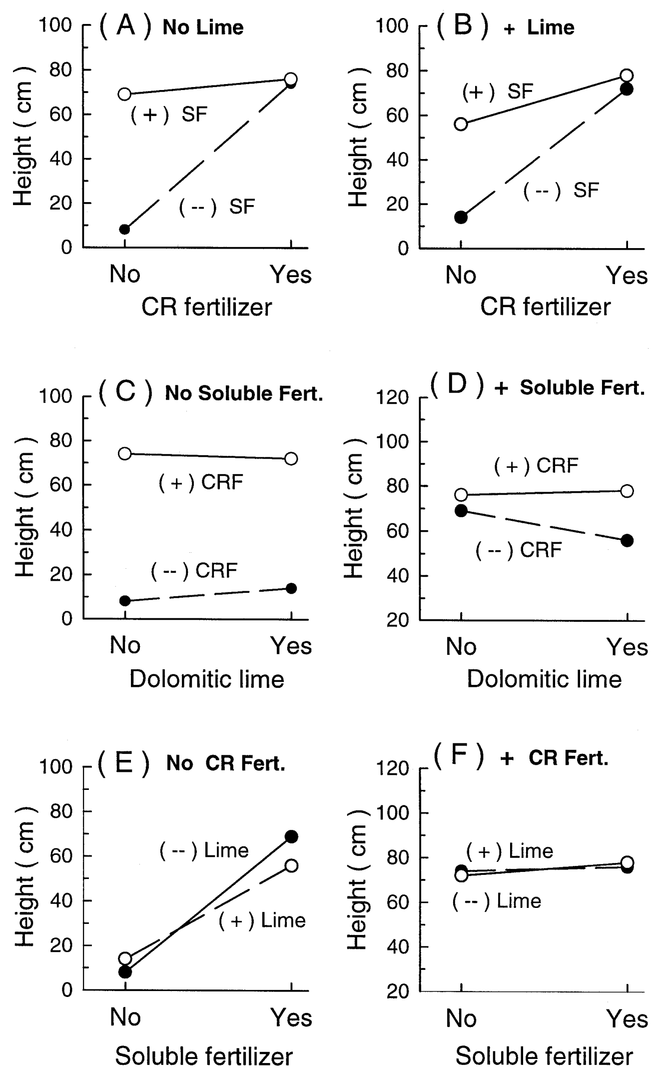

Fig. 2. **Height of 1-year-old containerized baldcypress seedlings: two-way interactions of lime, controlled-release fertilizer (CRF), and soluble fertilizer (SF) (Expt. 1).**

mum height growth (Fig. 2A) but only 68% of maximum total dry weight (Fig. 1A). About 95% of potential height was realized with CRF alone, and lime and SF had little additional effect (Fig. 2).

Experiment 2 (Fertilizer rate). The growth response to increasing levels of incorporated CRF was quadratic. Height was near maximum at 2.4 kg/m^3 (4 lbs/yd^3), with little change at higher rates (Fig. 3A). Dry weight (foliage, shoot, roots, and total) increased sharply up to a rate of 4.8 kg/m^3 (4 lbs/yd^3), and leveled off at higher rates (Fig. 3B, C, D, and E). The pattern for stem cross-sectional area closely followed that of total dry weight (Fig. 3F).

Foliar N , K, and S concentrations (Fig. 4) peaked at 4.8 to 7.1 kg/m^3 (8 to 12 lbs/yd^3); whereas P and Zn increased across the range of application rates (Fig. 4). The pattern of increase was quadratic for N, P, K, and S; linear for Zn. Concentrations of other mineral nutrients (data not presented) showed no clear relationship to treatment. Average foliar mineral nutrient concentrations (rate = 4.8 kg/m^3) were N (3.1%), P (0.25%), K (1.5%), Ca (0.83%), Mg (0.18%), S (0.18%), Fe (75 ppm), Mn (84 ppm), Zn (73 ppm), Cu (4.4 ppm), and B (38 ppm) (data not presented). Nutrient concentrations can vary, however, depending on leaf maturity (24).

Lime appeared to reduce the growth of containerized baldcypress (Expt. 1), but this conclusion is based on a single high rate [3.6 kg/m^3 (6 lbs/yd^3)]. Similar results have been reported for many other woody ornamentals (7, 25, 31), but not universally. For example, eastern redcedar (*Juniperus virginiana* L.) benefited from lime additions in pine bark substrate, with or without incorporated micronutrients (30). In our experiments, Ca and Mg content of irrigation water averaged 0.015 g/liter and 0.003 g/liter, respectively (personal communication, Dr. S. L. Warren).

Growth of containerized plants is affected by many factors, including type of fertilizer (12, 21, 28, 29), substrate (3), rate of fertilization (13, 14), container type and size (18, 26), method and frequency of fertilizer application (10), micronutrients (31), coatings on container walls (1), water re-

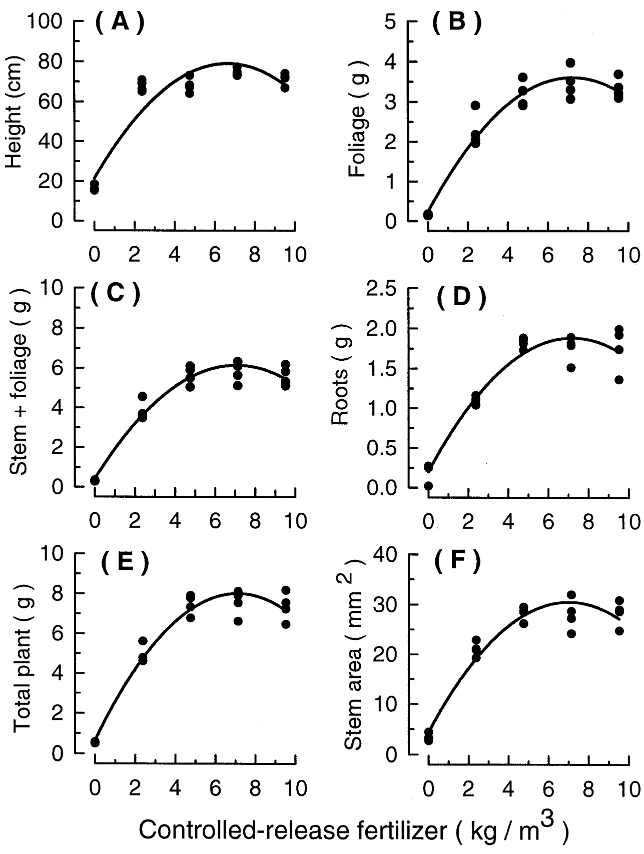

Fig. 3. Growth of containerized baldcypress seedlings in response to increasing rates of incorporated controlled-release fertilizer (Expt. 2). (A) height (cm) = 21.5 + 17.3(rate) – 1.30(rate)^2, R^2 = 0.87; (B) dry weight of foliage (g) = 0.24 + 0.93(rate) – 0.065(rate)^2, R^2 = 0.94; (C) dry weight of aboveground shoot (g) = 0.41 + 1.62(rate) – 0.115(rate)^2, R^2 = 0.95; (D) dry weight of roots (g) = 0.20 + 0.47(rate) – 0.032(rate)^2, R^2 = 0.93; (E) total plant dry weight (g) = 0.65 + 2.07(rate) – 0.15(rate)^2, R^2 = 0.96; and (F) stem cross-sectional area 1 cm above the cotyledons (mm^2) = 4.4 + 7.5(rate) – 0.53(rate)^2, R^2 = 0.93. Significance testing was at $P \leq 0.05$.

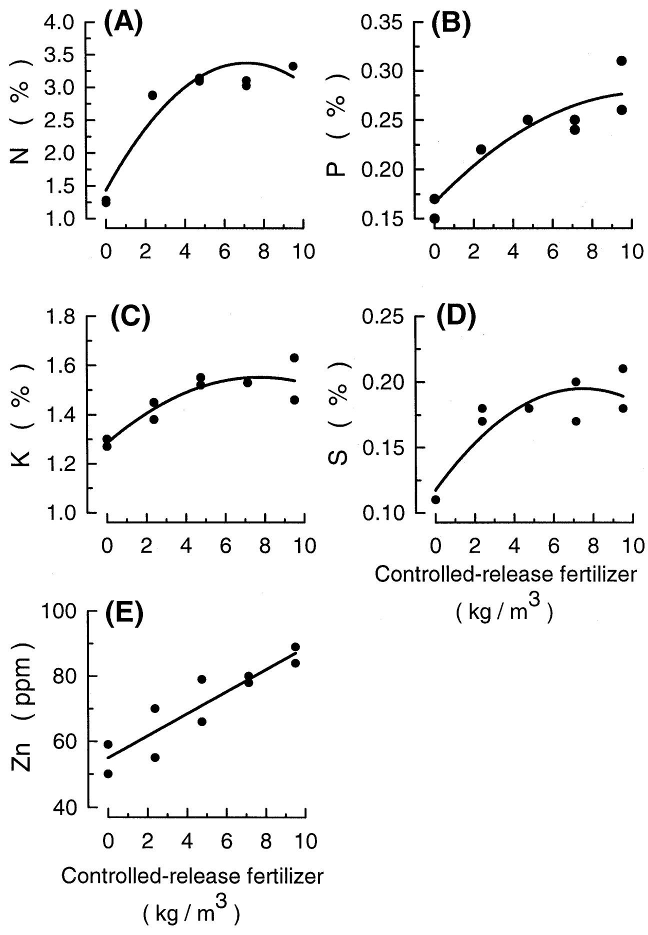

Fig. 4. Foliar mineral nutrient concentrations of containerized baldcypress seedlings grown with increasing rates of incorporated controlled-release fertilizer (Expt. 2). (A) nitrogen (%) = 1.44 + 0.54(rate) – 0.0379(rate)^2, R^2 = 0.86; (B) phosphorus (%) = 0.17 + 0.021(rate) – 0.0009(rate)^2, R^2 = 0.80; (C) potassium (%) = 1.28 + 0.069(rate) – 0.0045(rate)^2, R^2 = 0.78; (D) sulfur (%) = 0.12 + 0.021(rate) – 0.0014(rate)^2, R^2 = 0.76; and (E) zinc (ppm) = 55 + 3.4(rate), R^2 = 0.81. Significance testing was at $P \leq 0.05$. Concentrations of other nutrients (data not presented) were unaffected by fertilization rate.

gime (12, 27), supplements to the substrate (2, 17), pH and lime (7, 25, 31), mycorrhizae (6), interaction of fertilizers and micronutrients (30), source of N (9, 16), and temperature and release rates of fertilizer and compost materials (14). Many experiments would be required to reveal the interactions of these factors as they affect growth of a particular species, including baldcypress.

Our purpose was to develop preliminary suggestions for fertilization of containerized baldcypress. We used one container size—judged as large enough to accommodate 1 year of growth, yet small enough to yield a reasonable number of plants per square meter of production area. In addition, this container yielded a root ball about the maximum size that could be planted with ordinary forestry hand tools. Plants experienced only one irrigation schedule, so results (growth) could easily vary for other watering methods. One experiment compared the response to CRF, dolomitic lime, and SF. The second experiment determined the optimum rate of CRF, using a representative material. In both studies, the sole criterion for evaluating treatments was plant growth for this limited combination of container, CRF, SF, and irrigation regime. Additional research would be required to refine recommendations under different conditions.

In summary, containerized baldcypress grew well in composted pine bark amended with 4.8 kg/m^3 (8 lbs/yd^3) of CRF (19.0N–2.6P–8.8K; 8- to 9-month release). Lime was of no benefit, and supplemental SF (N = 0.4 g/liter, applied once weekly) yielded less growth than incorporated CRF, although more frequent applications of SF, or a different formulation, could have likely negated the difference. At optimal growth, foliar N concentrations were ≥3.0%.

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