Paulownia tomentosa Seedling Growth at Differing Levels of pH, Nitrogen, and Phosphorus[1]

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Abstract

This study examined the effects of various levels of acidity, nitrogen, and phosphorus on the survival and growth of *Paulownia tomentosa* seedlings. The seedlings grew within a pH range of 7.0 to 4.0, but little or no growth occurred at pH 3.0. The seedlings grew well with nitrogen at 50 to 200 ppm and phosphorus at 5 ppm, but growth was greatly reduced below 10 ppm nitrogen. Higher levels of phosphorus need to be investigated.

Index words: Nutrition, revegetation, disturbed sites

Significance to the Nursery Industry

Paulownia, or Empress Tree, has potential as an export commodity, as well as for various domestic uses. It may be suited for revegetation of surface mines since it can invade these disturbed sites naturally. Major difficulties in surface mine forestation are acidity and low available nutrients. This study demonstrates that *Paulownia* can grow satisfactory under high levels of acidity and poor fertility conditions.

Introduction

Paulownia tomentosa (Thumb.) Steud. (Scrophulariaceae) (7) is a fast growing tree that was introduced about 150 years ago into the United States. Called kiri, empress-tree, princess-tree, or one of several locally acquired names, it has become naturalized in southern and middle states east of the Mississippi River, but will also grow on sheltered sites in the northeastern states and along the California, Oregon, and Washington coast.

Historically, Paulownia wood has been used extensively in the far east for making wardrobe furniture, cabinets, small chests, packing crates, musical instruments, bowls, and footwear. Recently, it has been used as a landscape tree in shelterbelts, leaf fodder for animals, as a cash-crop for export, and in agroforestry operations in developing countries. *Paulownia* invades disturbed sites such as strip mines (6), road banks, construction sites, and burned out slate dumps (personal observations). Since *Paulownia* can invade these disturbed sites, it could be economically useful for reclamation, cash-crop tree production, and nurse tree plantings.

Surface mines with inherent high acidity and low plant nutrients offer less than desirable conditions for *Paulownia* growth; however, growth studies regarding these parameters in *Paulownia* have been limited. Turner, Lau, and Young (10) studied the effect of acidity on germination and seedling growth and determined it is not acidophidic; however, they terminated the experiment after three weeks. Several studies involving nursery production have addressed nutrients status but only generally and as amendments (1, 2, 3, and 4). The purpose of this study was to examine the growth effects of various levels of acidity, nitrogen, and phosphorus on the survival and growth of *Paulownia tomentosa* seedlings.

Materials and Methods

Paulownia capsules were collected from a single tree near Scaffold Cane Road in Rockcastle County, Kentucky in the fall of 1983. The seeds were separated, air dried, placed in paper bags, and stored in a cold room at 4°C (39°F).

Growth medium was prepared by sifting and retaining horticultural-grade perlite 2.0 mm (0.08 in) in diameter and greater. The perlite was placed in 13 cm (5 in) plastic pots after nylon screens had been placed in the bottom to contain the perlite. The pots were divided into groups of 8 and placed into plastic trays. Each plastic tray of 8 pots represented a single treatment. *Paulownia* seeds were germinated in fine sand for about 2 weeks and after germination 3 seedlings were transplanted to each pot. The seedlings received a complete nutrient solution for 2 weeks to overcome transplant shock. Thereafter, the pots were subirrigated twice a week with the treatment solution and flushed with distilled water from the top on all other days as described by Beslow, Hacskaylo, and Melhuish (5). The plants were grown in a greenhouse with an 18 hour photoperiod using 500 watt incandescent and 40 watt fluorescent lights.

The experiment on the effect of acidity consisted of 5 levels of pH with a fixed nutrient level of 100 ppm nitrogen (N) and 5 ppm phosphorus (P). The pH level was adjusted to 7.0, 6.0, 5.0, 4.0, and 3.0 with either HC1 or NaOH. Nitrogen treatments were supplied as ammonium nitrate (NH_4NO_3) at concentrations of 1, 10, 50, 100, or 200 ppm while holding P at 5 ppm. Phosphorus treatments were supplied as potassium phosphate (KH_2PO_4) at concentrations of 2 ppm and 5 ppm while holding N at 100 ppm. The pH in the N or P experiments was 5.0 and no adjustment was made. Nitrogen and phosphorus amendments were added to a base nutrient solution described by Fowells and Krauss (8).

The experiment was concluded 12 weeks after transplanting. Shoot heights, shoot and root dry weights, and shoot/

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root ratios were determined. Analysis of variance was conducted to determine any significant differences among these parameters between treatments. The factors with statistical significant main effects were analyzed with Duncan's multiple range test.

Results and Discussion

Shoot heights, shoot and root weights, and shoot/root ratios were not significantly different ($P \leq .05$) between pH 7.0 and 6.0 (Table 1). There was no significant difference in the seedling heights between pH 6.0, 5.0, and 4.0, but the heights at pH 5.0 and 4.0 treatments were significantly less than pH 7.0. Shoot and root weights were not significantly different between pH 7.0, 5.0, and 4.0, but the weights at pH 5.0 and 4.0 were significantly less than pH 6.0. Virtually all the trees treated with nutrients at pH 3.0 died.

Paulownia growth was inhibited with N concentrations of 10 ppm and below. There was no significant difference in height, shoot and root weights, and shoot/root ratios between 200 ppm N and 50 ppm N (Table 2). Enlarged stems and dark green leaves were observed on seedlings treated with 200 ppm N. Seedlings treated with 50 ppm N had yellow tinted leaves. The data from the 3 lowest nitrogen concentrations (0, 1, and 10 ppm) are not included because most of the seedlings died and the few that lived were very small (Table 2).

Seedling height, shoot and root weights, and shoot/root ratios were not significantly different between 5 ppm and 2 ppm of phosphorus. Data for 0 ppm of phosphorus treatment level were not included in the analysis because most of the seedlings died (Table 3).

Paulownia seedlings grew within the pH range of 7.0 to 4.0. Unpublished studies indicate that this also is the case in soils and mine spoils. There was no statistical differences in height and shoot and root weights between pH 7.0 and 4.0 (Table 1, Fig. 1). Growth of *Paulownia* at pH 4.0 suggests that *Paulownia* may be suitable for disturbed sites with moderate acidity. Turner et al. (10) reported that they were not able to get seed germination below pH 4.0 and poor primary root growth was observed at pH 4.0 and 5.0. In this study, the seeds were germinated at a higher pH and were transplanted when they were two to three weeks old. The primary root of a newly germinated seed is small and delicate and would probably be more susceptible to acidity *in situ* than older plants. Beckjord (1) reported that seedlings tend to develop more root system than top growth for the first 35 to 40 days. In this study, the seedlings were grown beyond this period at a higher pH so the effect of acidity on root growth as reported by Turner et al. may have been circumvented. Artificial revegetation by direct seeding of surface mine sites may be an option where the pH is 5.0 and above, but transplanting older seedlings may be required where the pH is below 5.0.

Nitrogen and phosphorus are important macro-nutrients for forest tree growth. Even though it has been reported that *Paulownia* will grow on the poorest of soils, knowledge of the N and P requirements should yield important silvicultural

Table 1. Effect of pH on height, shoot and root weight, and shoot/root ratios of *Paulownia* seedlings.[z]

Acidity -pH-	Height -cm-	Dry Weight Shoot	Dry Weight Root -gm-	Shoot/root ratio
7.0	11.12 a	1.42 ab	0.42 abc	3.41 a
6.0	9.19 abc	1.97 a	0.63 a	3.06 a
5.0	8.12 bc	0.93 b	0.35 bc	2.82 a
4.0	7.48 c	0.92 b	0.31 c	3.22 a
3.0	—	—	—	—

[z]Means within a column followed by the same letter are not significantly different at the 5% level of probability based on Duncan's multiple range test.

Table 2. Effect of nitrogen concentrations on height, shoot and root weight, and shoot/root ratios of *Paulownia* seedlings.[z]

Nitrogen concentration -ppm-	Height -cm-	Dry Weight Shoot	Dry Weight Root -gm-	Shoot/root ratio
200	12.75 a	1.56 a	0.54 a	2.91 a
100 (complete)	12.20 a	1.49 a	0.48 a	3.11 a
50	10.21 a	1.15 a	0.45 a	2.54 a
10	—	—	—	—
1	—	—	—	—
0	—	—	—	—

[z]Means within a column followed by the same letter are not significantly different at the 5% level of probability based on Duncan's multiple range test.

Table 3. Effect of phosphorus concentrations on height, shoot and root weight, and shoot/root rations of *Paulownia* seedlings.[z]

Phosphorus conc. -ppm-	Height -cm-	Dry weight Shoot	Dry weight Root -gm-	Shoot/root ratio
5	12.20 a	1.49 a	0.48 a	3.12 a
2	11.13 a	1.54 a	0.47 a	3.25 a
0	—	—	—	—

[z]Means within a column followed by the same letter are not significantly different at the 5% level of probability based on Duncan's multiple range test.

Fig. 1. Growth of *Paulownia* seedlings at pH 7.0, 6.0, 5.0, 4.0, and 3.0 after three months.

information. The best growth for *Paulownia* seedlings in this study was at 100 ppm N. The very dark green leaves at 200 ppm N may have indicated the upper limit for N (9). The chlorosis of leaves at 50 ppm N may have indicated reduced chlorophyll production because of insufficient nutrients. It appeared that 5 ppm P was sufficient for seedling growth although higher levels such as 10 ppm P or 20 ppm P should be investigated since these concentrations of N and P are about one half that required by red maple (5). This possibly makes *Paulownia* more competitive than red maple in soils low in N and P. Knowing the limits of these major growth restricting or enhancing parameters will provide knowledge in the silvics of *Paulownia*.

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Anthracnose of Piggyback Plant Caused by *Colletotrichum gloeosporioides* (Penz.) Sacc.[1]

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Abstract

A leaf spotting disease of *Tolmiea menziesii* Torr. & Gray (piggyback plant) caused by *Colletotrichum gloeosporioides* (Penz.) Sacc. was investigated. The disease requires a moisture period of at least 12 hours for symptoms to occur. The disease is severe at 15.5, 21, and 27°C, (60, 70, 80°F), but does not occur at 32°C (90°F). Daconil and Fore are effective fungicidal controls.

Index words: *Tolmiea menziesii*, piggyback plant, *Colletotrichum gloeosporioides*
Fungicides used in this study: Benlate; (benomyl); *Methyl-1-butylcarbamoyl-2-benzimidazolecarbamate*; Daconil 2787, (chlorothalonil), *Tetrachloroisophthalonitrile*; Fore, (mancozeb), a coordination product of zinc ion and manganese ethylene bisdithiocarbamate.

Significance to the Nursery Industry

Anthracnose disease of piggyback plant is best managed in the greenhouse by the development of pathogen-free stock plants watered by drip or mat irrigation. A fungicide should be useful in developing and maintaining clean stock plants. Although piggyback plant is not mentioned on the Fore label, instructions allow its use if other label requirements are met. Reduction in frequency and period of watering also should help control the disease in production areas of the greenhouse.

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Introduction

Piggyback plant (*Tolmiea menziesii*) is a popular foliage house plant, especially for hanging baskets. It also is a good ground cover for shaded areas. The plant is native to the western coastal ranges from northern California to Alaska. Its chief attraction is its large, shallowly lobed leaves that produce new plantlets at the junction of the leaf blade with the petiole, hence the name "piggyback" (2).

In the spring of 1988 our laboratory received specimens of piggyback leaves covered with small 1–2 mm (0.06 to 0.125 in) dark brown necrotic spots and larger necrotic areas. The fungus *Colletotrichum gloeosporioides* was isolated from the necrotic tissues (Fig. 1). A *Colletotrichum* sp. which may or may not be the same species has been reported, but