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Preliminary Evidence of Genetic Variation in Winter Injury and Seedling Height of Paulownia Trees in New Jersey

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A progeny test of 9 paulownia trees (Paulownia tomentosa Sieb.) for height growth showed that the best open-pollinated family of seedlings averaged more than twice as tall as the poorest family after two growing seasons. Tree Planters' Notes 41(2) :31-33; 1990.

Paulownia tomentosa Sieb., a tree native to central China (2), was first brought to the eastern United States about 1834 (10) or 1845 (7) and has since become naturalized from Alabama to New Jersey (8). Known as *kiri* in Japan, it has been grown there for centuries to produce lightweight, check-resistant wood for *tansu* (bridal chests), *koto* (musical instruments), coffins, beams, ridgepoles, pillars, rice pots, sandals, spoons, and bowls. Its uses have become strongly linked to tradition. As the prosperity of the Japanese increased following World War II, demand for this resource soon outpaced the capacity of domestic sources. Plantation-grown wood from China, Korea, and Taiwan, able to satisfy some of this demand, was not considered to be of good-enough quality for use in the most expensive *tansu* (7).

In 1973, a Japanese importer discovered that paulownia had become common in the Eastern United States, and that trees here were larger than any he had seen before. Although widely dispersed, they could easily be found by helicopter search crews who spotted the lavender-blossomed crowns in spring. That year, 60 tons of logs were harvested and shipped to Japan. The Japanese determined that American-grown paulownia was of the highest quality, and exports climbed rapidly from 423,787 cubic feet in 1978 to 1,024,135 cubic feet in 1979, with prices as high as $1,500 per thousand board feet. By 1985, one Virginia tree farmer had sold 50 paulownia logs for $55,000 (5).

Winter injury and resulting crookedness are often seen in New Jersey, although the largest paulownia in the United States grows in nearby Philadelphia (1), and in that city huge paulownias flank the Museum of Art and surround Logan Circle.

In 1986, a small research project was initiated here to test the effects of varying fertilizer levels and spacing on the growth rate and stem form of paulownia. Different parent trees were included in the study, because New Jersey lies at the northern end of paulownia's naturalized range, and natural selection for greater winter hardiness may be occurring as a locally adapted land race develops.

Methods

In the summer of 1986, we enlisted the help of county agents and the New Jersey Bureau of Forest Management to search for the best timber-form paulownias. Selection criteria included size, straight trunks, and absence of winter dieback. Six trees were initially chosen (nos. 1, 2, 4, 5, 7, and 8 in table 1); later, three additional parents were added: the record tree in Philadelphia (no. 3) because of its size; a tree in Hainesburg, NJ (no. 6) representing the northern extreme of the land race; and a tree planted in 1925 at the New Jersey Botanical Garden, Ringwood, NJ, from a seed source in Ohio (no. 9). This latter tree had exceptionally large, dark green, glossy leaves, its trunk bore evidence of repeated dieback and winter injury, and we were curious to see if its progeny would be different. Seeds were collected from all 9 trees in November 1986.

In January 1987, seed of each lot was broadcast atop one full rack of Leach tubes (165 cm^3) filled with moistened 1:1 peatvermiculite mix. The soil mix

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contains vermiculite and sphagnum peat in equal proportions plus 589 g/m^3 5-10-5 fertilizer, 441 g/m^3 KNO_3, 441 g/m^3 $CaNO_3$, 589 g/m^3 triple super phosphate, 4,708 g/m^3 lime, 883 g/m^3 Micromax, 883 g/m^3 Aqua-gro, 589 g/m^3 $MgSO_4$, and 112 g/m^3 Oxamyl.

Because paulownia requires light in order to germinate (4), we covered the nine racks with clear plastic and placed them in a shaded area in the greenhouse. Kundt (6) outlines cultural practices for the germination and establishment of this species. When seeds had germinated, in 7 to 10 days, the plastic was removed and the racks were placed in the sun. No supplemental lighting was used. By March, seedlings were thinned to one per tube and in April, were transferred to 3.8 liter (1-gallon) containers.

Seedlings were outplanted in six randomized blocks at the Rutgers Horticulture Farm, New Brunswick, NJ, in June 1987. Each block contained 6 seedlings from each of the 9 parent trees. Three blocks were planted at 2.4 x 2.4 m spacing, and 3 at 1.2 x 1.2 m spacing. One wide-spaced and one close-spaced block received no fertilizer, one of each received a spot-treatment of 488 kg/ha of 10-10-10 (3.3 g/tree), and the balance received 977 kg/ha of 10-10-10 (6.6 g/tree). Application rates were derived from a previous study by Beckjord and McIntosh (3). Woodchip mulch was applied in a 0.6-m-diameter circle around each seedling to suppress weeds, and the plantation was irrigated as necessary through the first summer.

Table 1—*Number of paulownia seedlings in each seedlot ($N = 36$) killed to the ground after first winter and mean two-year heights of seedlots ($N = 12$) in two continuing plots*

Parent	No. of seedlings with winterkill	Height (m)
1. Salem, NJ	3	3.19 a
2. Kingston, NJ	3	2.86 ab
3. Philadelphia, PA	4	2.84 ab
4. Campbelton Drive, Princeton, NJ	6	2.83 ab
5. Faculty Drive, Princeton, NJ	1	2.59 abc
6. Hainesburg, NJ	3	2.44 abc
7. Wawa Lot, Princeton, NJ	9	2.05 bcd
8. University Place, Princeton, NJ	9	1.79 cd
9. Ringwood, NJ	12	1.26 d

Means bearing the same letter do not differ significantly, Duncan's multiple range test, $P < 0.0001$.

In May 1988, surviving seedlings were tallied, and stems were lightly pruned by removing large branches. Unacceptably crooked or leaning stems were cut to the ground. Occasional girdled stems and clipped roots that appeared to be damage from mice were observed. Because extreme variation in site quality (later found to be due to difference in soil moisture, with the poor plots excessively dry and gravelly) had become apparent following the first summer (trees in one closed-spaced and one wide-spaced plot grew tall, while those in the remaining plots grew very poorly), we abandoned the poor plots and fertilized 3 trees of each seedlot in the remaining wide-spaced plot on a randomized basis. Each fertilized tree received 90 g of 10-10-10 (977 kg/ha), broadcast in a 1.25-m-diameter circle around the stem. The remaining 3 trees of each seedlot in the same plot received no fertilizer. The 1.2 x 1.2 m block was not fertilized.

In November 1988, tree heights were measured in the two continuing plots. An analysis of variance was conducted to test the significance of height differences among seedlots and between fertilization levels. Duncan's multiple range test ($P = 0.05$) was used to identify significantly different levels of seedling growth when F values proved significant (9); the Pearson product-moment correlation was run between family mean heights and numbers of seedlings of each family that were killed to the ground during the first winter.

Results

Stem survival through the first winter varied among seedlots, with 12 of 36 seedlings of the most tender lot killed to the ground, and only 1 of 36 of the hardiest lot killed (table 1). Stem survival (not killed to the ground) was 85%. No dieback other than winterkill to the ground was apparent as the trees began their 1988 growth. Mean height at the end of the second season was 2.20 m, with the tallest tree in the plantation measuring 4.87 m. Differences among the 9 seedlots were highly significant ($P < 0.0001$). Winterkill was inversely correlated with second-season height ($r = -0.84$, $P < 0.005$).

Mean height of fertilized trees in the wide-spaced plot was 2.15 m, and unfertilized trees in the same plot 1.94 m; the difference was not significant (perhaps because of the low power of the test). Trees in the 1.2 x 1.2 m block averaged 2.71 m, while those in the 2.4 x 2.4 m block averaged 2.05 m, but because of lack of replication of these blocks, we cannot state whether the difference was due to spacing or to site variation.

Discussion

The inverse correlation between first-year winterkill and second-year height in trees growing at the north end of paulownia's naturalized range in North America is not surprising. The poor showing in both winter hardiness and second-year height of progeny of the Ringwood tree (no. 9) shows that phenotypic selection for winter hardiness might be worthwhile with paulownia, and should result in faster growing trees. It could also result in straighter trees, because the poor tree form so common in this area appears to be due at least in part to winterkill.

In view of the differences in height and winter injury found among open-pollinated families of paulownia in this small study, it appears that hardier, faster growing strains could be developed for the northern portion of this species' naturalized range in North America.

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