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Weeping Willow Growth Rates Compare with *Salix babylonica* Re-rooted Branch Cuttings

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Research Article

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ABSTRACT

Remarkable growth rates of Weeping Willow trees (*Salix babylonicae*) are reported, and their unique ability to regenerate from branch cuttings by re-rooting in the ground. This unusual type of reproduction is an active area of research, particularly with regard to other species, which are resistant to this technique. *Babylonica* growth rates are quantified in terms of tree height, base trunk diameter, leaf stem length, and root growth rate (N= 3). The old tree roots and new branch roots grow at the same rate, 6 cm/yr. Leaf stems from the full size tree and leaf stems from the rooted branch also grow at the same rate, 4 m/yr. In other words, like father like son. The success probability for "branch re-rooting" is low, only 25%, N= 8, a problem reported by others, which may depend on branch diameters in the range 0.6 cm to 1.6 cm.

INTRODUCTION

According to folk lore, all of the Weeping Willow trees in England were originally generated from a single "branch-rooting" procedure during the 1,600's, whereby severed branches are simply inserted into the ground. Herein, we report a similar modern experiment using local Weeping Willow trees (*Salix babylonicae*) which were not reproducing conventionally. Hershey discusses willow-shoot planting techniques and growth rates in terms of the overall weight of the tree [Kg/year] [1].

We observed that Weeping Willow trees grow at an incredible rate, in terms of height [m//yr.], trunk diameter [cm./yr.], leaf stem length [m./yr.], and root length [cm./yr.] compared with other local trees, i.e. walnut, maple, pine, locust, elm, chestnut, sycamore, oak, etc., so it is of practical interest to quantify these growth rates. The *Salix babylonica* has a particularly active cambium layer, and thus is unique in its ability to propagate via the technique of branch rooting. Under normal circumstances, Salix reproduction is a matter of pollen spreading from the male *babylonica* flowers to the female *babylonica* flowers, which then drop to the ground and germinate. Although this man-made type of propagation, i.e. "branch-rooting", is an old technology, the likelihood of success is low, so we still have a lot to learn in terms of the exact details of this procedure.

MATERIALS AND METHODS

During the 8-year period 1995–2004, 3 newly planted Weeping Willow trees were observed to grow from saplings 2.4 meters tall [8-feet in height, trunk diameter at base 7.5 cm (3 inches)] to 9 meters tall [30 feet tall, trunk diameter 20 cm (8 inches)], a remarkable average growth rate of 0.75 to 1.0 meters/year (2.5 to 3 feet per year). Trunk diameter growth rate was 1.6 cm/year (0.63 inches per year). Initially, the root ball of these trees was 0.9 meter in diameter (3-feet in diameter) at the time of planting in 1995, planted in a 1.2 meter (4-foot) diameter hole. Szekely and Dagmar report overall physical dimensions, but not rates, of various types of Salix trees [2].

In an experiment to accelerate the reproduction rate of these trees, during the fall of 2014, 8 Weeping Willow branches were severed and re-planted in the ground. The recommended procedure is deeply planting the branch (i.e. "re-rooting") 0.3 to 0.4 meters (12-inches to 16-inches) into the ground, including the woody part of the branch (not just the leaf stems). The 8 branches were severed with a parrot-clipper, lopper, or hack saw, depending on height above the ground in the original tree and

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branch diameter. These branches were cut from underneath the canopy (crown) of the tree. Following this procedure, 2 each of 4 different diameters of severed branches were planted: 0.6 cm (1/4–inch diameter), 0.9 cm (3/8–inch diameter), 1.3 cm (1/2-inch diameter), and 1.6 cm (5/8-inch diameter).

RESULTS AND DISCUSSION

Yield Percentage

Of these 8 branch-routings, only 2 survived, as shown in **Figure 1**, still alive in May 2015 after a severe winter, one of the worst in the last 25 years here in the northeast U.S. What exactly was done correctly with these 2 branches, and what was done wrong with the other 6, is not known at this time? In this connection, Vesk discusses re-sprouting success as a function of plant size, including branch diameter. Zsuffa et al., discuss the difficulties of propagating willow branch cuttings, compared with those of Aspen and Poplars, which show some limited promise regenerating this way [3,4].

Figure 1. Now age 10 months, July 2015, 2 re-rooted branches start to generate characteristically long leaf stems each stem 0.3 to 0.4 meters long, as shown in the upper left.

Soil, Lighting, Hydration

Soil composition for the experiments was existing flowerbeds of ordinary topsoil. The lighting conditions, partial sunlight, were the same for all 8 rooted branches. Perhaps there were slight differences in the net captured rainfall, one location to the next. The fall months are likely the worst time to try such an experiment what with winter on the way. Above ground, the upper portions of the rooted branches, after the first frost in Nov. 2014, remain dormant for approximately 6 months until spring 2015.

Leaf Stem Growth Rate

As shown in **Figure 1**, during the last 2 months, 0.3 to 0.4 meter leaf stems (12 to 16-inches in length) have developed on both branches, initially growing at the remarkable rate of 3.7 to 4.9 meters/year (12 to 16 feet per year). Greene et al., discuss bending and buckling of Taraxacum stems and leaves [5]. Niklas et al., discuss the mechanical bending moment and hydraulics of such tree leaf stems, including the Eucalyptus and the *Salix babylonica* (Weeping Willow) [6]. In terms of bending, for a mature *babylonica*, these leaf stems grow upwards for several feet, then arc over, heading for and reaching the ground if left un-pruned. Beismann et al., measure bending and yield stress for Salix branches. Leaf stems from the tree and leaf stems from the rooted branch grow at the same rate, 4 m/yr. In other words, “like father like son” [7].

Root Development

Figure 2 shows the newly developing root structure of 1 of these replanted cuttings, i.e. a re-rooted branch, recently pulled from the ground. Senthalir et al. present control data, (i.e. with no chemical additives) relevant to the normal growth rate of pruned branches [8]. **Table 1** presents data on growth rates of various segments of the tree, showing the surprising result that the old tree roots and new branch roots grow at the same rate, 2-3 inches/yr. (5-7 cm/yr).

DISCUSSION

Other Tree Varieties

This branch-rooting procedure is distinctly different from “coppicing”, which if done right, also generates multiple vertical branches of similar diameter from recently cut tree trunks. Paolillo and Bassuk discuss the root development dynamics of 17 different types of trees [9]. Waters et al., discuss the re-sprouting abilities of the Eucalyptus tree, after having suffered varying degrees of damage to the trunk [10].

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Figure 2. One of the two Weeping Willow branches is pulled from the ground, to reveal the newly developing root structure [9]. An estimated 8-9 new roots (each 1-2 mm in diameter, 1-2 cm long) were generated by the original plant over the Winter and Spring, but 4 are sheared away from friction during the removal process.

Table 1. *Salix babylonica* Growth Rates

Plant Segment	Rate of Growth
[1] Tree height [2] Trunk diameter	2.5 to 3.0 ft./yr. 0.75 to 1.0 m./yr. 0.6 in./yr. 1.6 cm/yr.
[3] Branch leaf stem [4] Tree leaf stems	0.75 to 1.0 m./yr. 2.5 to 3.0 ft./yr. 0.6 in./yr. 1.6 cm/yr.
[5] Tree roots [6] Branch roots	2.0-2.5 in./yr. 5-6 cm/yr. 2.5-3.0 in./yr 6-7 cm/yr

Coppicing

Because of impending danger cracking concrete basement walls, some of the 30-foot Weeping Willows were cut to the ground. However, this extreme level of "coppicing", (i.e. cutting the stump so as to promote new vertical branch development), does not produce new vertical branches if the trunk is cut too low, flush to the ground. Routinely, other types of trees (undoubtedly the Weeping Willows also), when cut within 1-foot to 3-feet above the ground, do "coppice" successfully (for instance, pre-cut commercial Teak trees are discussed by Bailey and Harjanto as we have observed locally with maple trees, each generating 4-8 new vertical branches (saplings) [11].

Frost Line

The recommended procedure is to plant the branch cutting quite deep into the ground, 0.3 to 0.4 meters [12-inches to 16-inches]. This places the lower portion of the branch below the frost line. Consequently, the observed root growth, **(Figure 2)**, occurs on a part of the branch that remains relatively warm and un-frozen throughout the winter, whereas the upper dormant portions are continually cycled, almost daily, to freezing and thawing, here in the northeast U.S. This sub-surface temperature effect may be critically important to the success of this type of branch-rooting. Usually, laboratory experiments on branch-rooting [10-12] are done under controlled circumstances, in a greenhouse at elevated temperature and humidity.

Thermal Effects

Von Fricks reports that various Salix species can withstand -40°C. (25°F) During October, as cold as -550°C. (-67°F.) in March. Kristiansen et al. measure optimal root growth temperatures in the range 21°C. to 25°C. (70°F to 77°F.) for the Schlumbergera plant (Russian Dancer) [12]. We estimate that below the frost line, the babylonica roots are at 350 F. to 450 F. (2°C. to 70°C.) throughout most of the winter.

Pre-Soaking

Since almost all varieties of trees (except the *Salix*) are highly resistant to branch-rooting, for experimental purposes [1,7,10,12], it is standard procedure to "pre-soak" the cutting in aqueous solutions with various biochemical additives, for maximum hydration, sometimes as long as 30-days prior to rooting, to encourage and promote new root development. Even so, these procedures have limited success. The branches described herein were not pre-soaked, simply planted (re-rooted) within 15-minutes after cutting. Our many various attempts at re-rooting leaf stem cuttings from *babylonica* all failed, regardless of pre-soaking conditions, potting soil, and lighting conditions. Evidently, rooting is only feasible with the *Salix babylonica* branches.

Commercial Applications

In terms of commercial applications, Weeping Willows and Poplars are well known for being remarkably flexible types of

wood for construction purposes, resistant to cracking, perhaps because of their hydration level. Following forest fires, it is of great practical interest to perfect techniques for reforestation which reliably and consistently accelerate the reproduction rate of these valuable trees, and other varieties as well. Pounders et al., Vahdata et al., and Arrillaga et al., discuss the difficulties in rooting Hemlock, Walnut, and Ash, respectively [13-15].

Growth "Stop Signal"

Whether from the original tree, or the re-rooted branch cutting, the Weeping Willow leaf branches continue to grow at a rapid rate, until they hit the ground, at which point it is observed that they stop growing. This suggests that gravity or wind loads may play a role in stimulating branch growth. Evidently, once settled on the ground, somehow the plant senses this, and stops growing. "Mechanosensing" is discussed by Greene et al. [5].

CONCLUSION

Like the Bamboo tree, the Weeping Willow is well known to thrive in marshy soil, having powerful and fast growing roots, powerful enough to crack a 15-20 cm (6-8 inch thick) concrete foundation wall. Remarkably, the observed growth rates reported here for *babylonica* leaf stems (~12 ft/yr) and roots (~2.5 in/yr), whether from the tree or a transplanted branch, are essentially the same, as shown in **Table 1.** In other words, like father like son. The Weeping Willow has a very active cambium layer in the trunk and branches, which may explain this unique root-generating ability of *Salix babylonica*, (Aspen and Poplar trees are less so, but hopefully may prove similar in this regard, Zsuffa et al. [4].

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