Propagation protocol for

BAREROOT WILLOWS

| Tim Mathers

KEY WORDS
Salicaceae, vegetative propagation, cutting beds, riparian zones, bareroot nursery

NOMENCLATURE
Newsholme (1992);
Soper and Heimburber (1982)

Willows (*Salix* spp. [Salicaceae]) are a complex and wide-ranging group of woody plants with more than 20 native species are found throughout Ontario (Soper and Heimburger 1982). The species described in this article are grown in nurseries because they: 1) are indigenous to Ontario; 2) thrive in riparian areas found along stream banks, shorelines, and floodplains of local watersheds; 3) are easily and reliably propagated, producing marketable plants in 1 y (McCluskey and others 1984); and 4) are widely used in restoration work across southern Ontario (OMNR 1995). The method described here uses dormant hardwood cuttings as a quick and inexpensive way to produce relatively large numbers of bareroot plants in 1 growing season. While the protocol was developed for willow species native to southern Ontario, the approach is readily applicable to willow species native to other parts of North America.

PRODUCTION METHODS

To produce usable plants in the shortest time possible, I have developed several production steps. These steps are similar to those described by Morgenson (1991) but with less reliance on herbicides.

Figure 1. Stooling beds provide an annual source of propagation material.

Photo by Tim Mathers

IN ONTARIO

using Hardwood Cuttings

Establishment of Stock Plants

Stock plants are established in a clean-cultivated field and used as an annual source of propagating material (Figure 1). The advantages to this approach are many, including the fact that stock plants ultimately save time and money in producing propagating material because they:

- facilitate cost-effective and necessary pest control operations;
- can be cultivated, fertilized, and irrigated resulting in very high percentages of usable propagating material;
- maintain individual species identity and genetic diversity, an important consideration given the inherent difficulties in species identification and the genera's tendency to hybridize; and
- maintain genetic diversity in confirmed species, if propagating material is collected from both male and female plants (Landis and others 2003).

Harvesting of Propagating Material

Harvesting willow stems from stock plants is done annually and is essentially a coppicing system. In southern Ontario, cutting can be carried out anytime between early November and mid March but is usually carried out in late November and is conducted by manual (with pruning shears) or mechanical (with chain saws, brush cutters, or a tractor-mounted sickle bar mower) means.

Cuttings are made as clean and low to the ground as possible. This activitiy, in concert with stooling or burying of root crowns, stimulates growth from dormant buds on or near the root collar. Stooling also contributes to the longevity of production, which in the case of the current plants is going into the fifth season.

Processing of Propagating Material

After harvesting, plant material is processed in anticipation of either sticking (planting) or storage. Depending on the time between harvesting and sticking, the number of cuttings to be made, and the use to which the cuttings will be put, the processing of propagating material can take several forms.

Currently, 2 types of cuttings are produced: a 15 to 20 cm (6 to 8 in) cutting, approximately 15 to 25 mm (0.5 to1 in) in diameter; and a 1 m (40 in) cane, approximately 25 mm (1 in) in diameter. Care is taken to select healthy, vigorous material with plenty of vegetative buds. When making cuttings, the terminal 15 to 30 cm (6 to10 in) of stem is discarded because it usually contains the flowering portion of the stem, which grows poorly as energy will be directed to the production of flowers rather than roots (Hudak 1982).

Once cuttings have been made, the shorter cuttings are used for bareroot production, while canes may be processed further or used in bioengineering applications. In both cases, cuttings are bundled in units of 25 or 50, labeled as to species, and either stuck or placed in storage.

Storage of Propagating Material

Proper storage maintains cutting health and vigor and ensures that the material is viable when stuck. Cram and Lindquist (1982) outlined a method for storing hardwood cuttings using refrigerated cold storage. Where such facilities are unavailable, however, several other techniques can be used:

- burying processed cuttings in outdoor pits for the winter, which allows for callusing of cut tissues that assists in the development of root systems once the cuttings are stuck (MacDonald 1986);
- caching bundled and labeled stems (1 m canes) in an unheated building for the winter; materials are packed in snow and covered to reduce moisture loss and predation by rodents;
- delaying cutting of stems until late February or early March, so long-term storage is unnecessary.

Handling of Processed Propagating Material

After removing propagating material from storage and just prior to sticking, I soak cuttings in tepid water for 48 to 72 h. Edwards and Kissock (1975) showed that soaking cuttings in water increases their survival and growth by increasing the number, length, and weight of primordial roots. Although Hudak (1982) suggested that cuttings remain soaking in oxygenated and fertilized water until roots emerge, soaking need only occur until the root initials begin to swell. In fact, if roots are allowed to grow too far (> 4 to 5 mm [0.2 in]), they will be broken or damaged during sticking.

Sticking of Processed Propagating Material in Production Beds

Soil conditions (particularly tilth) are of paramount importance. Soil texture and structure are amended annually by deep plowing and incorporating ~13.5 m^3/ha (44 yd^3/ac) of peat moss. These amendments improve rooting depth and density. Where natural soil fertility is high, as determined by a soil test, no fertilizer amendments are made until cuttings have been stuck and have produced 10 to 15 cm (4 to 6 in) of top growth. If soil fertility is low, amendments should be made at this time.

Fields are then rototilled and formed into raised production beds, approximately 60 m (200 ft) long by 1.2 m (4 ft) wide. The timing of these activities in southern Ontario is usually around the first or second week of April. Cuttings are manually stuck on 10 cm (4 in) spacings, set out in 5 rows per bed. Beds of this size and spacing are capable of growing approximately 3200 plants. Table 1 gives the production targets and rooting success for 9 species of native willow.

It is interesting to note that several authors (MacDonald 1986; Dirr and Heuser 1987) recommend the use of rooting hormone to assist in root establishment and growth. Because willows have preformed root initials, however, healthy and vigorous propagating material should yield high rooting rates (+90%) without any rooting hormone (see Table 1).

Tending of Production Beds

Adverse weather conditions, weeds, insects, and/or diseases must be con-

TABLE 1

Production information for 9 species of native willows grown in Ontario.

Common Name	Species	Production Number	Target Size (m)	Rooting Success (%)	Processing	Sticking	Tending	Harvesting	Total	Unit Cost [a]
					(Worker hours)					(Can $)
peach-leaved willow	*Salix amygdaloides* Anderss.	1000	1.0	90+	20	5	4	6	35	0.53
Bebb's or beaked willow	*S. bebbiana* Sarg.	1500	1.5	90+	24	10	9	7	50	0.50
pussy willow	*S. discolor* Muhl.	3000	1.5	90+	42	16	13	10	81	0.41
heart-leaved or river willow	*S. eriocephala* Michx.	3000	2.0	90+	42	16	13	10	81	0.41
sandbar willow	*S. exigua* Nutt.	3000	2.0	90+	42	16	13	10	81	0.41
upland pussy or prairie willow	*S. humilis* Marsh.	1500	1.5	90+	24	9	9	7	49	0.49
shining willow	*S. lucida* Muhl.	3000	1.5	90+	42	16	13	10	81	0.41
slender willow	*S. petiolaris* J.E. Sm	3000	1.5	90+	42	16	13	10	81	0.41
autumn willow	*S. serissima* (Bailey) Fern.	3000	1.5	90+	42	16	13	10	81	0.41
Total		22000			320	120	100	80	620	

[a] Note: The per unit species cost can be calculated by taking the total worker hours per species, and multiplying by an hourly wage rate of Can$ 15. This value can then be divided by the number of plants produced per species to get the per unit cost.

trolled. As a result, several cultural practices are necessary.

Irrigation

Willows are water-loving plants and in Ontario, significant soil water deficits occur by July. Depending on weather conditions, 25 to 50 mm (1 to 2 in) of water are supplied by a fixed, overhead irrigation system every 7 to 10 d throughout the growing season.

Fertilization

In southern Ontario, most soils require fertilization. The amounts of fertilizer to apply are based on results of a soil test. In the nursery, a balanced fertilizer ($16N:16P_2O_5:16K_2O$) is applied twice per season. Granular band applications at 25 to 30 kg/ha of nitrogen (22 to 27 lb/ac N) have proved to be effective in achieving the target values described in Table 1.

Weed control

Weeds are controlled in a variety of ways, including chemical (herbicides), mechanical, and manual. It is particularly important that weeds be controlled early in the growing season, otherwise weeds can completely overwhelm emerging production beds. Experience has shown that if production beds start out clean at the time of sticking, they can be kept clean by 4 to 5 manual weedings per season. Because of the high density and survival of plants within production beds, weeds should not be a problem much past the end of July (Figure 2).

Insect and disease control

Given the large array of insects and diseases that prey upon willow, pests must be controlled. Failure to do so can threaten the success of the planting. Monitoring for pests, particularly various willow leaf beetles and sawflies, should begin as soon as leaves begin to emerge. Damage thresholds should be established so that control operations can be implemented promptly and effectively. Typically, 2 to 3 insecticide sprayings per season are required, depending on the nature and severity of the infestations.

Harvesting of Production Beds

If all of the previous steps have been successfully implemented, by mid November the plants will be ready for harvesting. Figure 3 illustrates the quality of plant that can be produced using this method. The main reasons for using production beds as described above are that they increase the quality and number of plants produced per unit area, and perhaps more important, beds facilitate the use of a mechanical seedbed harvester. This implement undercuts the entire production bed, shakes off the soil and essentially, drops the bareroot plants on top of the ground. This device not only has huge labor-saving benefits but also produces a better plant because it maintains the integrity and condition of the entire root system. Once lifted in this manner, plants are simply loaded on a wagon and transported to the grading site. From there, plants can either be shipped, put into refrigerated cold storage, or placed in outdoor heeling-in (holding) beds for shipment in the spring.

CONCLUSIONS

The production protocol outlined here demonstrates that a variety of willow species can be produced efficiently and economically (about Can$ 0.50 each). Moreover, while the species used in this protocol are native to southern Ontario, it is believed that the methodology is readily transferable to native willow species in other geographic locations.

Photo by Tim Mathers

Figure 2. Rapid growth of the cuttings shade out weeds by the middle of July.

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Figure 3. A typical 1-y-old *S. exigua* nearing the end of the growing season.