Pre-soaking Dormant Willow and Cottonwood Cuttings

Derek J. Tilley
Range Conservationist (Plants)
USDA-NRCS Plant Materials Center
Aberdeen, ID
February 24, 2006

Figure 1. *Cuttings of black cottonwood, coyote willow and peachleaf willow soaking in aerated water*.

Introduction

Dormant cuttings of willow species, cottonwood species and other riparian trees and shrubs are commonly used for restoring or repairing disturbed riparian areas, streambank and bioengineering projects (Schaff et al, 2002; Darris and Lambert, 1993; Hoag, 1993). In an effort to improve the establishment success of planted dormant cuttings, many people recommend pre-soaking the cuttings prior to planting. Some reasons given for soaking cuttings include 1) priming the cutting with water to reduce water stress during initial establishment and 2) initiating root and shoot development during soaking to allow roots and shoots to emerge more quickly following planting (Edwards and Kissock, 1975; Schaff et al, 2002). Schaff et al (2002) found pre-soaking for ten days significantly improved the number of live roots and shoots as well as overall survival rate in black willow (*Salix nigra* Marsh.) cuttings transplanted under greenhouse conditions. This paper is an overview of studies conducted at the Aberdeen Plant Materials Center during 2004 and 2005 to determine the effects of pre-soaking dormant cuttings of a number of western riparian willows and cottonwoods.

Greenhouse Trials, 2004

In 2004 several observational greenhouse studies were conducted involving the soaking of dormant cuttings from six species of western willows and cottonwoods: black cottonwood [*Populus balsamifera* ssp. *trichocarpa* (Torrey & Gray) Brayshaw], Drummond willow (*Salix drummondiana* Barratt), coyote willow (*S. exigua* Nuttall), Geyers willow (*S. geyeriana* Andersson), peachleaf willow (*S. amygdaloides* Anderson) and whiplash willow (*S. lucida* Muhlenberg). The purpose of these experiments was to compare the rate of production of root nodules between species, compare root nodule production rates under different temperatures, compare rate of root growth between species and to compare water uptake between species and different depths of water.

Nodule and root development/species

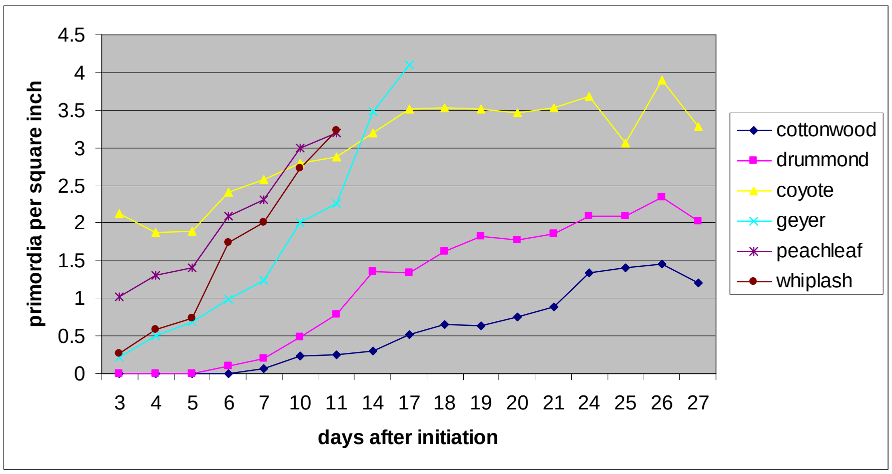
In this trial, root nodule development on soaked dormant cuttings was examined. Twenty-four, eighteen inch long cuttings, approximately 1 inch in diameter of each species were soaked in 12 inches of water in five gallon plastic buckets at the PMC greenhouse. Soaking began on April 9, 2004 and ran through May 8, 2004. At specific time intervals the cuttings were placed under a sheet of woven plastic with two, one inch sections cut out as windows through which to count root nodules. Cuttings were placed under the plastic sheet so the windows were over the fourth

Figure 2. *Cuttings of black cottonwood (left) and peachleaf willow (right) after 13 days of soaking.*

and eleventh inch of the cuttings. Cuttings were rotated and root nodules were counted for the entire circumference of the cutting under each window. The cutting diameter was then used to calculate an average number of nodules per square inch of cutting. Nodules were marked with colored push pins to monitor root growth over time. This trial was conducted both in the greenhouse with controlled temperatures and outdoors to mimic natural temperature conditions.

Indoor greenhouse water temperatures were about 20º C for the entire study, while outdoor water temperatures ranged from 3º C at night at the beginning of the experiment to 25º C during the day toward the end of the trial.

Observations indicate that root nodule development varies dramatically by species (figure 2). The indoor trial of coyote willow quickly produced root nodules and maintained a steady development until reaching a density of approximately 3.5 nodules/in². Very few roots were produced from coyote willow cuttings. Roots were first observed between 7 and 12 days after nodule formation. Peachleaf and whiplash willow both had rapid nodule production followed by fast root production. Roots were first seen about seven days after the first nodules appeared and had grown to an average length of 30 to 60 mm by the thirteenth day following nodule development. Geyer willow showed similar root nodule development trends as peachleaf and whiplash willow but had very little root development or growth. Drummond willow showed slow development of root nodules coupled with little to no root development. Black cottonwood cuttings had the slowest development of root nodules of the species tested. This concurs with findings obtained by the USDA-NRCS Plant Materials Center in Pullman, WA (Stannard and Guenther, ?). Cuttings produced few roots up to 12 days after the nodule formation, but roots developed fairly rapidly after four additional days, averaging 20 mm in length. Similar trends were observed in both the indoor and outdoor trial except the outdoor cuttings did not start producing root nodule until water temperatures had increased to a temperature warm enough to initiate root formation.



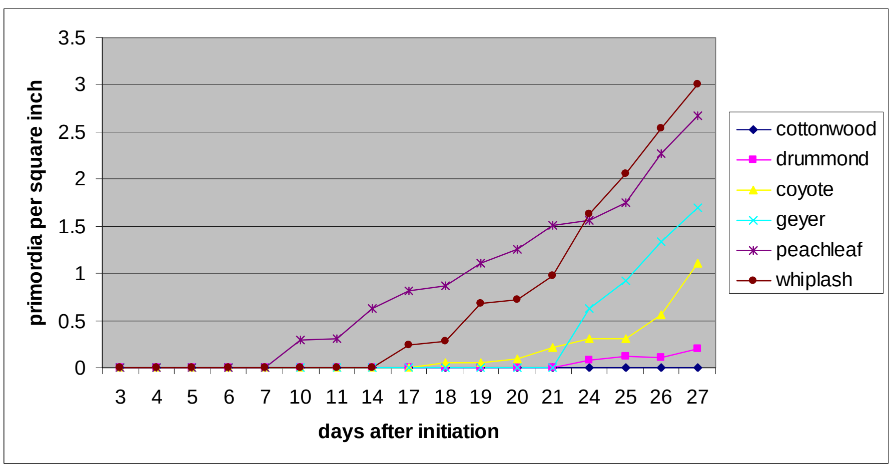


Figure 3. *Root nodule formation over time while soaking in warm greenhouse (above) and natural conditions (below).*

Root nodule formation temperature
Because of the differences observed between temperatures in the nodule and root development trial, we decided to attempt to determine the minimum temperature required for root nodule development. Sixteen 18 inch cuttings of peachleaf willow were soaked in 12 inches of water in five gallon buckets inside a germination chamber with constant temperatures of 3, 10, 15, 20 and 25º C. Cuttings were examined periodically to see when root nodule production began.

Root nodules were observed on cuttings in both the 25º and 20º C temperature treatments shortly after initiation of study (within 7 days). Under the 15º C treatment, root nodules were observed after approximately 10 days. In the 10º C treatment nodule were not observed until 20 days after initiation. In the coldest treatment (3º C) no nodules had formed after 28 days of soaking.

Although no minimum temperature was conclusively found for root nodule development our data show that under colder temperatures, cuttings require more time to develop nodules and thus roots and shoots. This information should be considered when using dormant willow cuttings in early spring or in mountain areas where water temperatures are low. Cuttings may require more soaking time under these conditions to see all the benefits of pre-soaking.

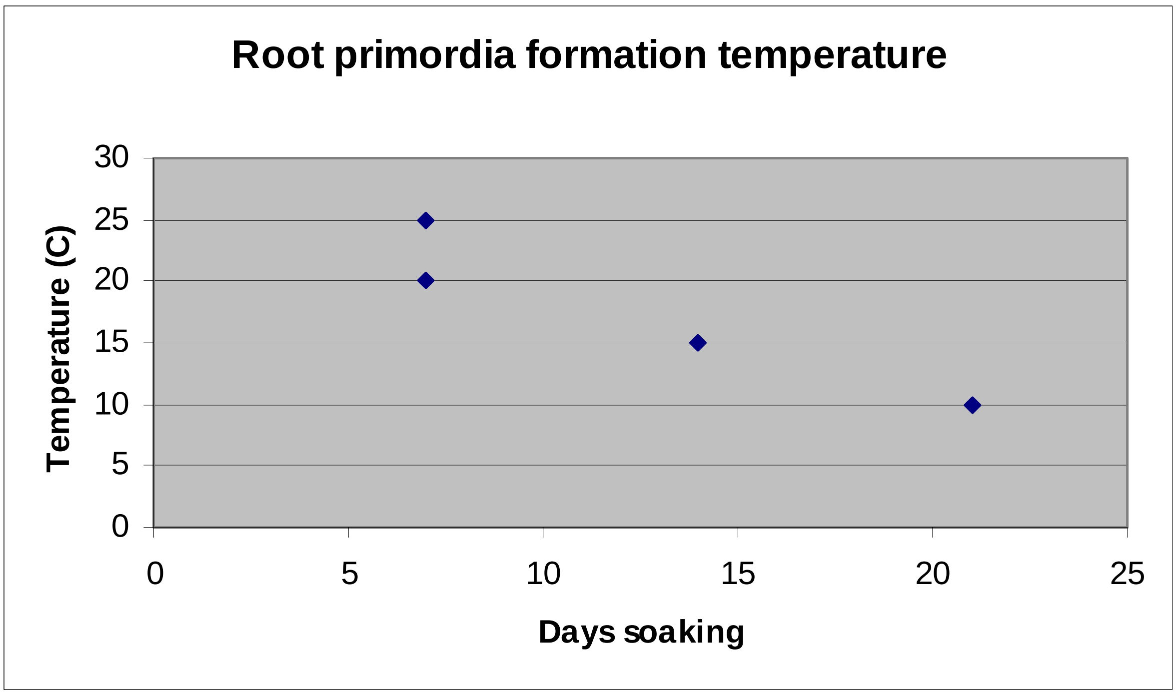


Figure 4. *Days until root nodule formation on peachleaf willow at constant temperatures.*

Figure 5. Bannock Creek study site prior to planting.

Field Trial, 2005

Abstract
In the 2005 study we examined the survival rate of three western riparian tree species, peachleaf willow, coyote willow and black cottonwood following five pre-planting treatments: 1) full soak- completely submerged in water with the cuttings laid horizontally in a 1.0’ deep metal water tank for seven days, 2) full soak for 14 days, 3) partial soak- cuttings placed vertically in 18” of water in a plastic garbage can for seven days, 4) partial soak for 14 days, and 5) no pre-soaking. Our results indicate that different species require different pre-soaking treatments for best results. Peachleaf willow showed good survival and no significant difference between treatments; however trends indicated that partial soaking performed better than full soaking or no treatment. Coyote willow had better short-term survival from 7 day soaking treatments over 14 day soaking or no treatment. Black cottonwood showed significantly better survival from partial soaking treatments and no treatment versus fully soaking the cuttings. No significant differences were found for long term survival between treatments. This is most likely due to external factors such as weed competition, lack of cutting to soil contact and cutting placement in relation to the water table.

Materials and Methods
Dormant cuttings of peachleaf willow, coyote willow and black cottonwood were harvested between February 10 and March 14, 2005 at the Aberdeen Plant Materials Center Fish and Game Farm. Cuttings were 36” long and ranged from 1” to 2” in diameter for peachleaf willow and black cottonwood, and 0.5” to 1” for coyote willow at the base. All side and terminal branches were trimmed and the cuttings were stored in a cooler at 38º F until treatment.

Cuttings were divided into five treatments with an equal distribution of various sized cuttings to each treatment. Peachleaf willow and black cottonwood received 24 cuttings per treatment, and coyote willow received 22 cuttings per treatment. The five treatments were as follows: 1) full soak- completely submerged in water with the cuttings laid horizontally in a 1.0’ deep metal water tank for seven days, 2) full soak for 14 days, 3) partial soak- cuttings placed vertically in 18” of water in a plastic garbage can for seven days, 4) partial soak for 14 days, and 5) no soak- left in the cooler until planting. All soaking treatments were aerated using a Profile 1500 Aquarium Air-pump in an attempt to increase oxygen levels. Martin et al (2004) found that higher levels of oxygen (>95%) increased shoot and root growth in black willows over low oxygen levels (<15%). Soaking treatments were all timed to end on the day of planting.

On May 18, 2005 cuttings were planted at Bannock Creek approximately 1.0 mile east of Arbon, ID (figure 5). This is a small stream with rocky to sandy soil. The streambanks are dominated by creeping foxtail (*Alopecurus arundinaceus* Poir) and have moderate rates of channel erosion. Prior to planting, weeds were cut to ground level using a gas powered weed trimmer. Cuttings were arranged at three foot intervals with coyote willow in one series closest to the stream and peachleaf willow and black cottonwood in a separate series approximately 18 inches higher up the bank. All cuttings were completely randomized within their series. Cuttings were planted using a water-jet stinger planting tool (Hoag et al, 2001) to a depth of approximately 24 inches with effort being made to reach the water table. A five person crew running two stinger nozzles off of one pump completed the entire planting in less than seven hours.

During planting, a shallow rocky layer was encountered in the soil profile. This layer proved difficult to penetrate with the water-jet stinger. As a result, it was necessary to work the stinger for longer periods of time in one space than is normally recommended. This resulted in washing much of the finer soil material from the hole. We noticed during the evaluation on June 15, 2005, that many of the holes had little to no sediment and entire cuttings were left exposed to the air. Very few, if any, of the cuttings found in this condition survived to the second evaluation.

Cuttings were evaluated on June 15, 2005 (28 days following planting) and September 22, 2005 (4 months after planting). Survival was determined by healthy green leaves or buds present on the cutting. Data were then analyzed using the chi-squared goodness of fit test with an alpha of 0.05 (Zar, 1999). The authors realize that the data obtained here will not represent the long-term survival for the planting. Future evaluations are scheduled for 2006 through 2010.

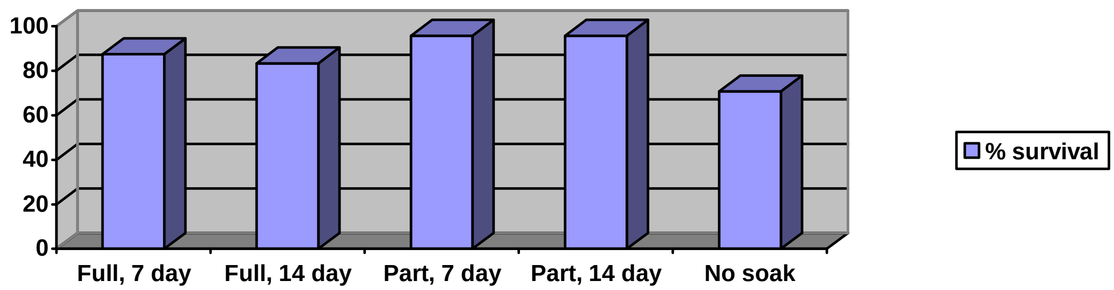
Results
Although the success rates for all treatments of peachleaf willow were extremely high (70.8 to 95.8 %), no significant difference was detected between survival rates for the five treatments ($0.75<p<0.90$). Partial soaking treatments for both seven days and 14 days had excellent survival (95.8%), while full soaking treatments had slightly lower percentages (87.5% from the seven day

treatment and 83.3% for the fourteen day soak). The no soak treatment resulted in the lowest survival rate of 70.8%.

Table 1. Peachleaf willow

Treatment	Full, 7 day	Full, 14 day	Partial, 7 day	Partial, 14 day	No soak		
# samples	24	24	24	24	24	Total survived	Expected (total/5)
# survived	21 (87.5%)	20 (83.3%)	23 (95.8%)	23 (95.8%)	17 (70.8%)	104 (86.7%)	20.8

Peachleaf willow

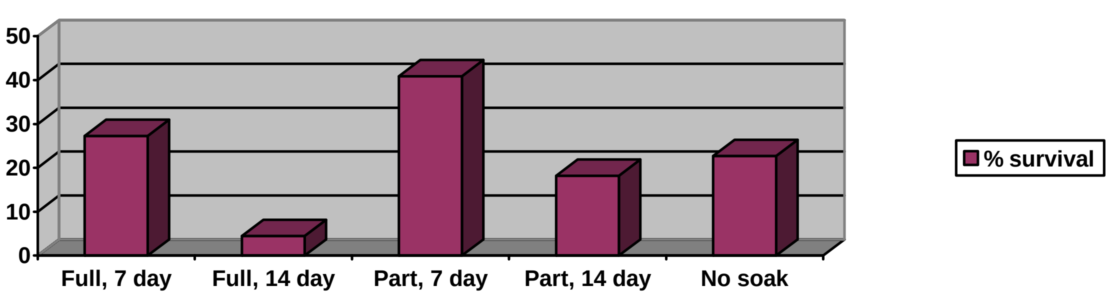


Coyote willow showed a much lower survival rate than peachleaf willow among all treatments (table 2). Both seven day soaking treatments performed better than all others, with a seven day partial soak having the best overall success (40.9%). The 14 day treatments had poorer survival rates than even the control. Despite the range of success, chi-squared analysis detected no significant difference between actual and expected results for any treatment ($0.10<p<0.25$).

Table 2. Coyote willow

Treatment	Full, 7 day	Full, 14 day	Partial, 7 day	Partial, 14 day	No soak		
# samples	22	22	22	22	22	Total survived	Expected (total/5)
# survived	6 (27.3%)	1 (4.5%)	9 (40.9%)	4 (18.2%)	5 (22.7%)	25 (22.7%)	5

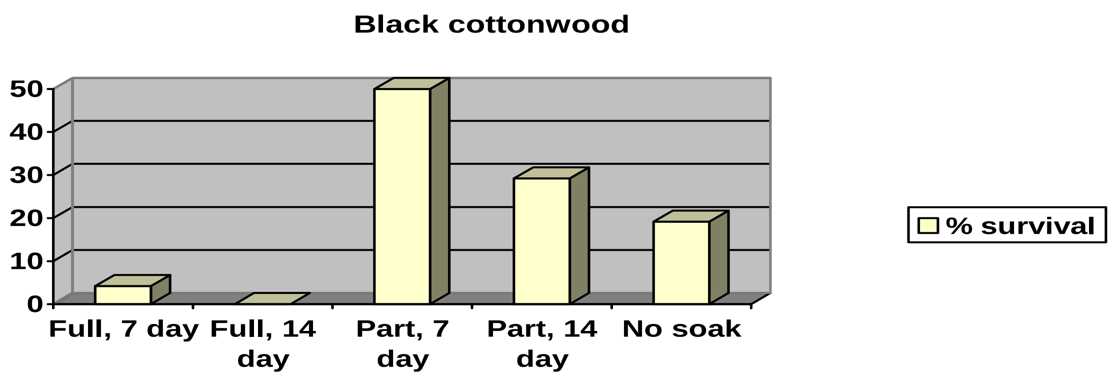
Coyote willow



Black cottonwood showed much better survival from the partial soaking versus fully soaking treatments (table 3). Best results came from the partial, 7 day soak with 50% survival followed by the partial 14 day soak with 29% survival. The poorest survival results came from both treatments of fully soaking. The seven day, full soak yielded 4% survival while the full, 14 day soak had no survival. Significance was high between the partial, 7 day soak and the full, 14 day soak ($p<0.05$).

Table 3. Black Cottonwood

Treatment	Full, 7 day	Full, 14 day	Partial, 7 day	Partial, 14 day	No soak		
# samples	24	24	24	24	24	Total survived	Expected (total/5)
# survived	1 (4.2%)	0 (0.0%)	12 (50.0%)	7 (29.2%)	3 (12.5%)	23 (19.2%)	4.6

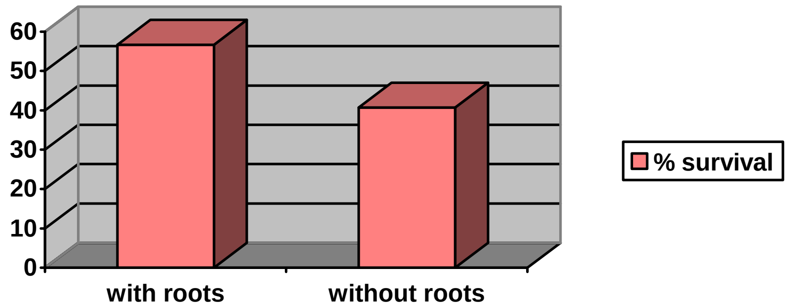


Roots versus no roots
Interestingly, roots were only produced in the partial soak treatments in all three species. It appears that the cuttings need to be at least somewhat exposed to the air in order for roots (or buds) to form. Of the 350 total cuttings used in the experiment, 60 had formed roots at least 0.25 inch long prior to planting. Of these 34 (56.7%) had survived to the first evaluation. In comparison, of the 290 cuttings without pre-formed roots, 118 (40.7%) survived.

Table 4. Roots versus without

	Cuttings with roots	Cuttings without roots	Total Cuttings
	60	290	350
Survived	34 (56.7%)	118 (40.7%)	152 (43.0%)
Expected	25.8	124.7	

Survival with pre-formed roots v. without



The second evaluation took place on September 22, 2005 (4 months after planting). No significant differences between the treatments were found. Total survival per species is shown in table 5. Several factors may have affected the long term survival of the cuttings. Coarse gravelly soil forced planters to keep the water-jet stinger in the ground for longer periods of time than normal, which washed soil out of the holes. During the evaluations, many cuttings were found sitting loose in holes with very poor soil to stem contact. None of the cuttings found in this condition survived to the second evaluation. Also, several cuttings were planted too shallow in the soil because of rocks, resulting in the cutting not being deep enough in the water table. Additionally, heavy competition from perennial grasses (creeping foxtail, reed canarygrass, and quackgrass) may have shaded out cuttings and/or out-competed the cuttings for root space. The high survival rate of peachleaf willow in every treatment, however, suggests this species has very high cutting establishment vigor and it can survive competition better than other species in this study.

Table 5. Cutting survival as of 9/22/05.

	Total survival	% survival
Peachleaf willow	92/120	77
Coyote willow	6/110	5
Black cottonwood	9/120	8

Conclusions

Because this trial was conducted under natural field conditions, we encountered several unexpected challenges which may have affected the results of the experiment. Fluctuating water levels, rocky soil conditions and competition from competitive grasses all played a roll in the survival of the cuttings. More reliable data may be obtained by conducting similar experiments under more controlled conditions (i.e. in irrigated pasture or farmland), but the information provided here shows the reality of field riparian plantings. Placement of the dormant cutting into the proper soil/water profile with good soil to stem contact is probably more critical and important than pre-soaking the cutting. Weed control can also play an important role in cutting survival. By late summer the perennial grasses had grown well over the tops of our cuttings providing competition for root space, nutrients, moisture and sunlight. It is likely that chemical weed treatments prior to planting would have provided much better control of weedy grasses and increased the chance of cutting survival.

Some pre-soaking treatments of dormant cuttings seem to provide increased survival rates during the initial establishment period. Our results show that each species tested here reacts differently to the various soaking treatments. Care should be taken to use the most beneficial soaking treatment for the species being planted. More testing is necessary to develop soaking protocols for the different riparian species being used in revegetation efforts throughout the Intermountain West. Our results indicate that cuttings with pre-formed roots survive better than cuttings without roots. Many roots are being broken and shorn off during transport and planting; however root tips that have not yet emerged from the nodules are near the surface of the cutting and quickly emerge and aid in moisture and nutrient uptake following planting.

Based on this work and other studies cited herein, it is our recommendation that dormant cuttings be pre-soaked in well oxygenated water for approximately 7 days, depending on species and temperature, prior to planting. When possible, cuttings should be soaked in warm water to allow for faster nodule formation and root initiation. Care should be taken not to completely submerge cuttings in order for roots and shoots to form. Cuttings should be planted when there are large numbers of root nodules but few emergent roots. Certain species will establish and survive more readily from dormant cuttings. Those which quickly produce root nodules followed by rapid formation and elongation of roots while soaking are more likely to survive the stressful conditions of planting. Always chose the species best suited to the local conditions (ie moisture availability, soil type and structure, elevation and climate).

References

Darris, D.C. and S.M. Lambert. 1993. Native willow varieties for the Pacific Northwest. USDA-NRCS Plant Materials Center. Corvalis, OR.

Edwards, W. and W. Kissock. 1975. Effect of soaking and deep planting on the vegetative propagation of *Populus* and *Salix*. In: FAO, International Poplar Commission 15 session. Rome, Italy. 13 p.

Hoag, J.C. 1993. Technical Note 23: How to plant willows and cottonwoods for riparian rehabilitation. USDA-NRCS, Boise, ID. ID-TN23, Sept. 1993. 15p.

Hoag, J.C., B. Simonson, B. Cornforth, and L. St. John. 2001. Technical Note 39: Water-jet Stinger - A tool to plant dormant unrooted cuttings of willows, cottonwoods, dogwoods, and other species. USDA-NRCS, Boise, ID. ID- TN39, Feb. 2001. 13p.

Martin, L.T., S.R. Pezeshki and F.D. Shields, Jr. 2004. High oxygen levels in a soaking treatment improves early root and shoot development of black willow cuttings. The Scientific World. Vol. 4: 899-907.

Schaff, S.D., S. R. Pezeshki and F. D. Shields, Jr. 2002. Effects of pre-planting soaking on growth and survival of black willow cuttings. Restoration Ecology Vol. 10 no. 2: 267-274.

Stannard, M. and H. Guenther. ??? . Rooting characteristics of black cottonwood and pacific willow. USDA-NRCS, Pullman, WA. WA-TN39.

Zar, J.H. 1999. Biostatistical Analysis. Fourth Ed. Delhi (India). Pearson Education, Inc. 663 p.