Vegetative Propagation of Cuttings of Douglas-Fir (*Pseudotsuga menziesii*)©

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INTRODUCTION

Douglas-fir (*Pseudostuga menziesii*) has been used in many parts of the world as a Christmas tree, forest tree, and landscape plant. Much of the need for Douglas-fir is for reforestation and as such seed propagation is common and relatively easy. The Christmas tree and landscape industries have been limited in the development of commercially available cultivars of Douglas-fir due to difficulties with vegetatively reproducing clones of desired unique plants. Mass production by vegetative propagation has been successful but limited to "bulking up" seed supplies of elite families of Douglas-fir for the forest industry (Richie, 1993). High percentage rooting has been limited to propagating from juvenile seedlings. Success is significantly reduced with rooting of cuttings when stock plants experience their first dormancy as a seedling. Mature cuttings not only are difficult to root but the resulting plants are often very plagiotropic (horizontal) in growth causing plants to have undesirable form.

Gary Richie a researcher with Weyerhaeuser conducted significant work with cuttings propagation of Douglas-fir and reported some of his work in the I.P.P.S. Combined Proceeding in 1993. (Ritchie, 1993) Weyerhaeuser production of Douglas-fir has achieved high rooting percentages with the result of production of over 3 million rooted cuttings per year. An excellent paper was written and published in 2000 by the Ministry of Forest Research Programs British Columbia on the Cultural Procedures of Rooted Cuttings of Sitka Spruce, Western Hemlock, and Douglas-fir in British Columbia by Wigmore and Woods (2000). This paper summarizes work by numerous researchers. Much of this I.P.P.S. presentation will be a summary of Mr. Richie's publications along with Weyerhaeuser and the Wigmore and Woods paper.

SUCCESSFUL ROOTING OF CUTTINGS FROM SEEDLINGS

Success with the rooting of cuttings has emerged from the use of cuttings from intensively grown seedlings. The juvenile condition of seedlings appears to be directly related to providing cuttings with high rooting potential. Juvenility can be successfully maintained or induced with many plants. Typical procedures include hedging, serial propagation, and grafting. None of these methods works to keep Douglas-fir juvenile.

Below is a summary of the steps that may be taken to grow seedlings that will produce high percentage rooted cuttings (Wigmore and Woods, 2000; Ritchie, 1993).

Seed. Cones are harvested in August and September then after-ripened for several weeks. Seed is extracted and requires stratification for 9 weeks. Sow seeds in January into plug trays.

Transplanting. Early May transplant seedlings to 1-gal pots. The medium should be a well drained mix which allows for wet dry cycles [i.e., peat, perlite, bark (3 : 1 : 1, by volume)]. A slow release 3–4 month fertilizer application is recommended (8–9 month is not advised).

Pruning. A light pinch of the terminal is desired at transplanting. A second pinch in late July is recommended for lateral branch tips.

Spacing. Pot-to-pot spacing encourages vertical growth and maximizes use of space.

Environment. After transplanting to gallon pots it is recommended to grow plants in greenhouse structures with sidewalls removed. To maintain juvenility photoperiod should be artificially extended until late September.

Irrigation. Plants are fertigated with150–200 ppm N, two to three times per week or as needed. Nitrogen application below 75 ppm results in chlorosis. Occasionally leaching of salts may be necessary. Use of drip irrigation is recommended to limit botrytis problems. It is important that seedlings are in maintained nondormant (free growth) from the time they emerged from the seed until cuttings are collected (Ritchie, 2007). Once dormancy sets in with a seedling the rooting percentages drop dramatically and plagiotropic growth becomes a problem.

Cuttings. The desired cutting is partially lignified with large buds and beginning to move into dormancy. The optimum cutting has a whitish stem; a green stem is too succulent and a brown stem is too lignified. In mid-September steps are taken to initiate dormancy. Supplemental photoperiod should be discontinued and fertilizer and heat reduced.

If plants are programmed into dormancy, cuttings with partial lignification of tissue will be available from December through February. If properly grown, seedlings will be 1 m tall with 50 branches. Each seedling will provide 30 to 50 cuttings. Cuttings should be collected and stuck within 24 h; although Weyerhaeuser routinely has good results with collecting cuttings and storing them at -1 °C for up to 4 months.

Only tip cuttings of 4–8 cm should be used. Terminal leader cuttings should be avoided as these produce plants with multiple leaders. Cuttings from the lower third of the seedling stock plants usually provide best rooting results.

The type of rooting medium recommended is a peat and perlite mix (3 : 2, v/v). The medium temperature should be 20 °C and fungicide should be applied if sanitation is an issue.

Liquid hormone seems to give best result. With IBA a 1- to 2-sec dip at 5000–10,000 ppm gives the best result. Cuttings should be treated with 5000 ppm for cuttings that are soft and 10,000 ppm for cuttings that are lignified.

First roots should emerge in 7–8 weeks. Plants may be weaned to growing-on in 12 to 15 weeks. If cuttings are stuck in December they will; be rooted and ready for transplant in spring.

Rooting percentages with this method will vary from 39%–95%. High percentage rooting can be expected if environmental conditions are optimized throughout this process.

If these rooted cuttings are planted to containers they are often very plagiotropic. Conversely, if bed planted using bare-root transplants, the plants will be plagiotropic the first year and will develop orthotropic growth after that.

Plagiotropism. Plagiotropism of Douglas-fir rooted cuttings and grafts has been studied by numerous researchers. With mature Douglas-fir tissue comes plagiotropic growth. This condition results in undesirable growth characteristics and poor quality plant growth. As stated previously; hedging, grafting, or serial propagation may assist with rooting and reducing plagiotropic growth of other plants, but has limited affect with Douglas-fir.

The above method of rooting cuttings is a very effective. The difficulty with this system is that stock plants are seedlings and will only perform well as stock plants for one season. The resulting cloned plants from cuttings are of mature physiology and thus cannot be used for serial propagation of more clones. This seedling to rooted cutting process works well for forest tree "bulking" of sibling plants but does not provide for mass cloning of individual plants.

Efforts to reproduce clonal material of older Douglas-fir plants are frustrating. In 2003, George Hudler, a pathologist at Cornell University, and I began a collaboration on a project to look for needlecast resistant Douglas-fir. It was observed that Christmas tree plantations of Douglas-fir are devastated with needlecast disease, but a few plants in a field are often clean. The assumption was that these plants had some degree of needlecast resistance. We decided to attempt to propagate from these clean plants to develop a stock of cloned plants for further testing. This seemed like a reasonable approach until Douglas-fir did not cooperate.

Previous research work by Copes and Mandel of the U.S. Forest Service focused on use of mist and fog and various concentrations of IBA and NAA. The results showed no difference between use of fog or mist and fairly low rooting percentages were common. Rooting percentages for controls were in the range of 15%–50% while treatments with IBA showed results of 38%–76% and 39%–57% rooting with NAA. The summary of this work indicated that IBA and NAA were beneficial to rooting but did not provide high percentages of rooting. Most combinations of IBA and NAA showed no benefit. In other work, Copes found that cuttings from plants hedged to .5 meters rooted better than those hedged to 1 and 2 meters (Copes, 1992). Top cuttings rooted less than side cuttings, while side cuttings were more plagiotropic.

At S.U.N.Y. – Cobleskill and Cornell University we investigated the rooting of cuttings and grafting of Douglas-fir. The issues we attempted to address were low rooting percentages and plagiotropism. At S.U.N.Y. – Cobleskill our work was survey work and simply looked at various rooting environments, types of cuttings (softwood and hardwood), terminal versus lateral cuttings and various hormone treatments. Hardwood cuttings were collected in January from field-grown Christmas trees. The environments used for trials were: sand beds with bottom heat, shade and plastic for maintaining humidity and adjusting light. Mist was also trialed versus a plastic cover of the crop. Various stages of softwood cuttings from very new shoots to 2 week old shoots were trialed under mist. Each trial produced results of low rooting percentages to total failure. Grafting is possible with Douglas-fir. Grafts were taken with some success but all grafts exhibited plagiotropic growth. Low

percentages and plagiotropism were not overcome. Etiolation was suggested and attempted at Cornell but results are inconclusive as of this date.

In addition to the above trials, we attempted foliar applications of nutrients and hormones with no improvement. We utilized IBA soaks over 24-h periods. These also gave no improvement of rooting. With most treatments cuttings would commonly develop callus but not produce roots. We did not attempt cutting in the period of fall through December. Less dormant wood may have some possibility of success. Juvenility seems to be the only key right now.

One last point that is off the topic of cuttings but related to Douglas-fir production is the following. One literature source from New Zealand (Swale, 2006) made reference to the affect of mycorrhizae on growth and health of Douglas-fir transplants. This paper suggests that many nursery grown plants have developed with existing nursery mycorrhizae associations. When these plants are planted out in native soils the populations of mycorrhizae may be completely different and the mycorrhizae associated with the roots will be replaced with the exiting soils mycorrhizae. This process apparently delays rooting in of transplants and may set back plants. The message seemed to be to try to establish plants in the nursery with mycorrhizae that are native to the planting location. A connection of mycorrhizae to rooting was not investigated.

CONCLUSION

Significant research and development has gone into the rooting of vegetative propagules of Douglas-fir. Success has been achieved with cuttings from seedling of first year growth. With tissue maturation rooting is significantly lowered and plants will exhibit horizontal plagiotropic growth. Efforts to root older stock plants have resulted in lower rooting percentages and plants which exhibit plagiotropic growth. Much work has been attempted with this plant. Clonal propagation of mass numbers of plants as of this date is limited and restricted to high-value plants.

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