Appendix II-B

Genetics and the Forest Products Industry Case Study

The Weyerhaeuser Co.

The Weyerhaeuser co., which has its main headquarters in Centralia, Wash., is the largest forest products company in the United States. In 1970, Weyerhaeuser initiated a program to research the mass propagation of Douglas fir trees by tissue culture. Douglas firs are the main species in many of the Nation's forests, over $3.1 billion (or about 8.5 billion board feet) worth were harvested in 1979. While they are normally propagated by seed in the field, the classical development of improved seed does not adequately satisfy the criteria of the rapid availability of trees of superior quality.

Specially selected clones have the potential to double the productivity of forestlands; each year that unimproved trees are planted is another year of "suboptimum" harvests 40 years from now. With the steadily increasing demand for forest products, planting substantially improved trees as soon as possible is of great economic importance.

Weyerhaeuser's tissue culture research began in 1974 with a project at the Institute of Paper Chemistry to produce Douglas firs. The project was expanded with a contract for additional research at the Oregon Graduate Center. Although the intention was to propagate select strains of mature trees, the main focus of the program, in 1974 to 1978, was to develop a basic, consistent system for propagation. From 1978 to the present, Weyerhaeuser has been conducting most of its applied research into Douglas firs at its own research facilities in Centralia, Wash. Basic research is still being funded at the Institute of Paper Chemistry, which services the entire forest industry. While specific figures for the tissue culture systems research have not been made available, the annual research and development budget at Weyerhaeuser specifically for biological work with forest species is on the order of $7 million to $8 million. '

The project in mass propagation of Douglas fir by tissue culture was initiated to establish a reliable, economic means for mass production of superior trees. The cloning of these trees could bring higher yields and shorter harvest cycles, as well as rapid production of tree stands for seed production.

The immediate results of 10 years of research are not overly impressive at first glance. To date, 3,000 tissue-cultured Douglas firs have been planted for comparison analysis and research of handling techniques, transfer procedures, etc.

The cost effectiveness of a tissue culture program is determined by several factors, of which labor intensity varies the most. The more streamlined the system can be made, the fewer labor-requiring steps that are needed—the less direct costs will be incurred. Ideally, cells would be cultured in sterile conditions and then planted for the direct embryogenesis of plantlets that are ready for the field. Steps that involve cutting shoots and rooting them on another media or repeated subculturing procedures are costly and cumbersome. The major problem affecting cost so far is the difficulty of achieving high volume plant regeneration from the tissue cultures. Efficient systems with more successful regeneration will reduce the labor and materials involved in culturing and result ultimately in a lower cost per plant.

In addition to problems of cost, Weyerhaeuser has run into the classic difficulty with woody species—the inability to obtain required results from plants more than 1 year old. In addition, the risk of induced genetic variability increases with every subculture of the tissues. The triggering techniques for effective manipulation of mature versus embryonic and immature tree tissues are not well understood, and unlocking the Douglas fir system may well provide insight into some basic physiological questions.

Some commercial companies do not want to get deeply involved in basic research because it is extremely expensive and time-consuming. However, it has been up to the major forestry companies, such as Weyerhaeuser, to independently fund essentially basic research into the biological triggers for organogenesis and embryogenesis of Douglas fir.

By comparison, no other plant has been as intensely researched for mass propagation purposes and proved so unyielding. Among other things, this indicates that questions of basic plant cell physiology will have to be addressed before major breakthroughs can be expected. The goals of the Weyerhaeuser program are exacting and demand the refinement of present techniques into a precise in-

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dustrial science. While it may seem that the investment has been disproportional to the returns at this point, it must be remembered that they are the forerunners of a new technology, both in terms of working with mature tree tissues of an especially intricate species and in terms of imposing stringent industrial standards on a mass biological production system.

Simpson Timber Co.

The Simpson Timber Co., whose central headquarters are in Seattle, Wash., is a large producer of redwood and other forest products, and has been involved over the past 5 years in a program to develop a mass production system for the coast redwoods through tissue culture. Approximately $250,000 has been invested in research performed at the University of" California, Irvine, by Dr. Ernest Ball, a recognized authority in the field of tissue-cultured redwoods.[2]

Coastal redwoods are normally a field-seeded crop and have a production cycle of around 50 years. The major reason for consideration of tissue culture over seed is the greater speed with which superior trees might be developed through tissue culture as compared to using seed stock. Simpson Timber Co., which has been involved in a controlled breeding program along conventional lines as well, and is approaching the creation of homozygous strains. Since a sequoia seedling does not reach sexual maturity before it is 15 to 20 years old, and since about 10 generations are normally required to produce a true homozygous strain,[3] the classical process is time-consuming and contains no guarantees that the end products will be better than the clones selected through tissue culture.

Elite trees are selected from wild stands for straightness of trunks, height, specific gravity of wood, and proper branch drop (branches that drop without tearing the stem). There are no major pests in redwoods, so pest and disease resistance have not been a concern. Two methods of selection are used. Clones of special trees are produced by rooting the uppermost branches of the tree, a process that takes up to 1 year. Although the rooting percentage may be as low as 10 percent, this method has the advantage of producing mature cloned plants that can continue to produce flowers and seed. Simpson is using roughly 200 elite trees for these clones.

Mite trees can also provide clones through tissue cultures of their needles, a process that is less time-consuming but which produces seed very slowly because of the time involved in maturation. Simpson Timber Co. has planted out 2,500 tissue cultured redwoods for field comparisons with seedling material. The results so far have been encouraging, but it may take another 10 to 15 years before definite conclusions can be drawn. The major factors being analyzed are field growth rates and outplanting survival percentages. Clones of elite varieties will also have to be compared to the parent trees for the traits originally selected for, such as wood quality. Since the operation] cost of tissue-cultured plantlets is about twice that of seedlings, the quality of tissue cultured plants must be markedly superior if the program is to be cost effective,

Dr. Ball is confident that the tissue culture system which has been developed for the rapid multiplication of elite redwood trees is ready for implementation at a commercial production facility.[4] Simpson Timber (:0. is planning the construction of a tissue culture lab at their California headquarters within the next 2 years, The pilot plant is expected to cost $250,000 and produce upwards of 200,000 plantlets in its first year of production. As mass production techniques are perfected, the company plans to expand the facility to a production capacity of over 1 million plantlets per years

[2]Ernest Ball, University of California, Irvine, personal communication [illegible] the Plant Resources Institute in the working report, Commercial [illegible] of Plant Tissue Culture and Potential Impact of Genetic Engineering on Forestry, prepared under contract [illegible]

[3]Klaus Rdelius, Simpson [illegible] personal communication [illegible] Plant Resources Institute in the working report, Commercial [illegible] of Plant Tissue Culture and Potential Impact of Genetic Engineering on Forestry, prepared under contract [illegible]

[4]Ball, op. cit.

[5]Redelius, op. cit.