Rooted Cuttings for Southern Pines

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INTRODUCTION

Producing planting stock for reforestation using rooted stem cuttings is becoming an increasingly widespread practice around the world (Ritchie 1994, Zobel 1992). Vegetative propagation can deliver planting stock of higher genetic quality compared to the system of bare-root seedlings derived from wind-pollinated seed that is currently being used in the southeastern United States.

Producing rooted-cutting planting stock for forestry presents some unique challenges as compared with vegetative propagation for horticultural applications. The foremost difference is acceptable cost. Reforestation stock is a high-volume, low-cost product. Over 1.2 billion seedlings of loblolly pine (*Pinus taeda* L.) and slash pine (*P. elliottii* Engelm.) are produced in the U.S. each year at a cost of only a few cents per seedling. Most horticultural crops are worth much more per plant and fewer plants are needed to meet market demand.

Another difference is the genetic make-up of the plants to be propagated. Most vegetatively propagated horticultural crops are produced as cultivars. A superior genotype is identified and then multiplied. This is a more difficult process for forest trees. One reason is that fairly extensive field-testing is required to identify the best clones. Another is that for most coniferous species, including the southern pines, donor plant maturation begins early and reduces propagation (rooting) efficiency of the identified clones.

This "Catch-22" has led to two scenarios for pine rooted-cutting propagation and deployment. In both scenarios, donor plants arise from controlled-pollinated crosses between genetically proven superior parents (a full-sib family). The first scenario involves mass propagation of the entire family. This has the advantage of eliminating the field-testing requirement, because the genetic values of the parents are already known from previous tests. It also minimizes the donor plant maturation problem, because donor plants can be used for a short time and then new seeds can be germinated to replace them. This full-sib multiplication scenario, however, has the disadvantage that the genetic quality of the reforestation stock is only moderately improved relative to open-pollinated seedlings and falls far short of the quality that can be obtained with the second scenario, clonal forestry.

Clonal forestry is analogous to the cultivar system with clones in horticulture. The donor plant maturation problem can be approached in several ways. First, seedlings are rigorously pruned to produce "hedges" or "stool plants" that produce large numbers of cuttings and remain juvenile, at least for a few years. Hedging alone, however, may not be sufficient to retain juvenility for an adequate period of time. Two techniques are currently being evaluated that, hopefully, will maintain the juvenile, easy-to-root, phase of the hedge plants: (1) continuous hedging and serial rooting where the most vigorous rooted cuttings in a clonal line replace the older donor hedges and (2) serial micropropagation accompanied by cold storage of tissue cultures (Aitken-Christie and Singh, 1987).

DONOR PLANT DEVELOPMENT

The development of clonal lines can begin with the identification of a small number of unrelated families that have a proven genetic superiority for particular traits (e.g., fast growth rate, pest resistance, wood quality) and the establishment of 100 to 200 seedlings from each family. Initially, the seedlings are hedged to provide the cutting material for an initial screening trial. Early field data can be used to select the top lines in each elite family. These top lines can then be re-evaluated in a series of advanced clonal trials that are replicated in several locations. This second round of tests can be used to select the top few lines in each family for operational deployment. This strategy has the potential to produce genetically superior individuals that will be 30% to 50% better than the improved material that is currently being produced in wind-pollinated seed orchards.

PRODUCTION SYSTEMS

A typical cutting is 8 to 10 cm (3 to 4 inches) long (from the terminal bud to base) and has a basal diameter of 3 mm. It may be from a dormant or actively growing shoot. In the latter case, collection of the cutting may be delayed to allow some lignification of the shoot that makes the cuttings more able to withstand rooting environments that are less then fully protected. Once the cutting is set, callus formation is evident in 2 to 3 weeks and the emergence of adventitious roots from the basal region of the stem occurs within 5 to 6 weeks.

Pine cuttings can be rooted in a field nursery, shadehouse, or greenhouse. Rooting directly in a field nursery bed has the advantages of reducing propagation costs (less labor-intensive handling of the rooted cuttings) and requiring no specialized structures for rooting. However, extreme variation in outdoor environmental conditions can result in a variable end-product and, in some cases, even loss of an entire crop. While a shadehouse does provide a more consistent rooting environment, in many climates, one is prevented from utilizing the dormant winter cuttings, because of low ambient temperatures. The rooting environment inside a greenhouse is the most controlled and has the additional advantage that two or three crops could be produced each year. But, the cost of the more specialized structure does increase production costs. In addition, containers and rooting substrate must be purchased for both the shadehouse and greenhouse rooting systems and the added cost of handling containerized planting stock during tree planting needs to be considered.

One possible solution is a transplant production system where the cuttings are rooted in small plugs inside a greenhouse and then transplanted to a conventional forest tree seedling nursery. The greenhouse provides optimal and uniform rooting conditions, and allows one to expand the time of year cuttings are set. Small plugs allow the grower to maximize expensive greenhouse space. Certain types of small plugs might be amenable to transplanting to a bare-root nursery to allow the rooted cutting to finish growing like a bare-root seedling. The rooted cutting can then be handled like its seedling counterpart and the costly logistics of handling millions of containerized plants in large-scale reforestation operations could be avoided.

Cost-efficient rooted cutting production systems will be critical to the success of clonal forestry, because if it does not make economic sense, clonal propagules will never be planted on a large scale. Current costs of producing rooted cutting planting stock at a research scale are very high relative to the current system of bare-root seedlings. Future improvements in efficiency and economies of scale will be needed to make this technology more price competitive.

One such improvement could come in the form of automating the more labor-intensive steps involved in producing rooted cuttings. Forest products companies cannot afford to pay for the high-cost of labor necessary to collect, set, or transplant cuttings, because of the relatively low-value of pine propagules compared to high-value, horticultural, container crops. Mechanization of any one of these labor-intensive propagation steps will help reduce unit costs. This will require forest tree propagation specialists to be creative in modifying existing equipment (e.g.,transplanters) and designing new equipment (e.g., cutting harvesters and stickers) to handle the special needs of pine cuttings.

Nevertheless, it is reasonable to expect that rooted cuttings will never be as inexpensive as bare-root seedlings. The higher cost of rooted cuttings can be counter balanced by deploying them on high quality lands where high-input silviculture can be practiced (e.g., site preparation, weed control, fertilization, and pest control) in competitive markets (Stelzer and Goldfarb, 1997). In these locations, the greater return on investment should make the increased initial cost economically feasible

ROOTED CUTTINGS AND FUTURE TECHNOLOGIES

There are several emerging technologies that could be easily coordinated with an operational rooted cutting program. Controlled mass pollination is a process whereby pollen collected en masse from one parent is used to pollinate isolated female flowers of another parent. This would provide seed that could be raised as seedlings in existing bare-root nurseries, would be the equivalent genetic value as the full-sib multiplication (but not clonal forestry) option with rooted cuttings, and, probably, will be less expensive than rooted cuttings. However, in some situations, the large number of seed necessary for meaningful levels of reforestation could be difficult to produce. In these cases, the resulting elite family could be vegetatively propagated using rooted cuttings (full-sib multiplication).

Somatic embryogenesis (SE) and the cryopreservation of SE germplasm could mitigate the problems of hedge maturation and rapid clonal scale-up in the clonal multiplication strategy. Somatic embryos could also serve as a suitable vehicle for inserting genetically engineered genes into elite pedigrees. While SE is a clonal multiplication system in its own right, rooted cuttings are currently cheaper, primarily due to the high costs involved in establishing and operating a tissue culture lab, and because of some current biological barriers in the SE process for loblolly and slash pines. An ideal system could entail: (1) initiation of clonal lines using SE, (2) cryopreservation of SE lines for juvenility maintenance, (3) establishment of clonal trials using a limited number of SE plants, (4) rapid multiplication of selected clonal lines using SE to produce sufficient plants for hedge populations, and (5) production of reforestation stock using rooted cuttings.

CONCLUSIONS

With 1.2 billion pine seedlings produced annually in the southern U.S., rooted cuttings will probably never completely replace open-pollinated bare-root seedlings. Rooted cuttings are, however, increasingly becoming a viable option for increasing the genetic quality of forest planting stock in high wood cost areas and on the most productive sites. Despite the progress made in rooting pine cuttings, more research is needed on efficient production systems, maintaining hedge juvenility, selecting the best clones, evaluating the growth and yield of those clones, and the ecological consequences of clonal forestry.

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