

PROGRESS TOWARD OPERATIONAL DEPLOYMENT OF LOBLOLLY AND SLASH PINE ROOTED CUTTINGS

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The use of rooted stem cuttings of loblolly and slash pines offers an opportunity to capture additional genetic gain in plantations. Using rooted cuttings with high genetic performance values as planting stock is becoming increasingly common with many species around the world. Rooted cuttings are being utilized to capture genetic gain at two levels. The first multiplies seed from previously tested, outstanding crosses. This approach delivers genetic gain equivalent to mass controlled pollination and could be important when seed is in short supply, such as when superior crosses are first identified, but before they can be established in seed orchards and grown to sufficient size to meet reforestation objectives. The ultimate utility of both full-sib deployment methods will depend on the cost effectiveness and amount of genetic gain delivered in a given period of time. The second level of genetic gain to be exploited is that which comes from propagation of individual clones. This will deliver the most genetic gain, provided an efficient system can be developed for within-family selection and propagation.

Successful operational deployment of rooted cuttings will depend on efficient production procedures and acceptable field performance of rooted cuttings. One critical element of efficient production is the reliable rooting of many genotypes at high percentages. Significant improvements in rooting percentages have been achieved by implementing recent research results. In one study testing the effects of rooting powder treatments on cuttings from 4-year-old stock plants (hedges) of four full-sib loblolly pine families, the rooting percentage of all four families was 86% across all treatments (excluding controls). In another study screening cuttings from 2-year-old hedges from 25 open-pollinated loblolly pine families, the overall rooting percentage was 74% and 72% of the families rooted at 70% or higher.

One of the most important factors in achieving good rooting success is the production of large numbers of uniform cuttings with juvenile morphology and growth habit through rigorous hedge management. Research on hedge fertilization has revealed a beneficial effect of maintaining nitrogen tissue concentrations well above those normally found in bare-root seedling crops. Another experiment indicates that deficiencies of the micronutrient boron can effect rooting success. Cuttings from four full-sib loblolly pine families rooted at 67% when the concentration of boron in the tissue was less than 10 ppm, but rooted at 81 to 87% when the tissue boron concentration ranged from 11 to 35 ppm.

The rooting environment is being improved using mist application systems that have a high degree of uniformity and by research on the physiological processes in cuttings and hedges. Recent results have identified critical levels of water stress beyond which rooting performance declines and handling and storage practices that maintain the water status of cuttings above these

critical levels. Experiments are also underway to test the effects of light, temperature and CO₂ concentration on rooting.

Additional increases in rooting percentages can be achieved by culling poor-rooting families or individuals. Culling poor rooting families should not impact genetic gain for growth rate or rust resistance, as rooting ability is independent of these traits in open-pollinated slash pine families. Tests of correlations between rooting and growth are also currently underway for loblolly pine families and early results suggest independence.

Improvements in the morphology of cutting root systems, but not necessarily rooting percentage, have been achieved through the use of specific hormone treatments. Application of the synthetic auxin, NAA (1-naphthaleneacetic acid), increases the number of roots per cutting and the percent of cuttings with symmetrical root systems in dormant (winter) loblolly pine cuttings. NAA effects are less pronounced in succulent (spring and summer) loblolly pine and in slash pine cuttings. Results from a field test examining the effects of root morphology on growth of loblolly pine rooted cuttings reveal no significant effects of root number or root system symmetry on growth at the end of the first field growing season. However, growth, wind firmness and drought resistance will be monitored over the longer term.

Rooted cuttings must grow as rapidly as seedlings of equivalent genotype for this method of producing planting stock to successfully capture genetic gains. In addition, it is important to ascertain if family performance for rooted cuttings can be predicted based on seedling performance data. Six-year field results from loblolly pine seedling/cutting tests established in two locations indicate no overall differences between rooted cuttings and seedlings of the same full-sib families in height, diameter or volume. Rooted cuttings were consistently, though not significantly, less susceptible to fusiform rust infection. In addition, family mean correlations between seedlings and cuttings for the 9 full-sib crosses (3 x 3 factorial) were $r = 0.97$ for height growth and $r = 0.84$ for rust infection on the more uniform test site. Performance of the rooted cutting families was also highly correlated with independent progeny test data, indicating that full-sib families of rooted cuttings can be deployed without additional testing.

In order to implement true clonal forestry, maturation must be addressed. Juvenility must be maintained long enough to test and multiply individual clones before rooting percentages or the growth rate of rooted cuttings from hedges of these clones decline. A study to test the effect of hedging and serial propagation on the maintenance of juvenility in loblolly pine is underway. While definitive results from this study are not yet available, the maintenance of hedges with no apparent decline in rooting ability through four years (described above) is encouraging. A field test to determine growth rates and characteristics of the rooted cuttings from different aged hedges will be established this winter.

Results presented here indicate that full-sib multiplication of loblolly and slash pine is a viable biological procedure. Operational use will depend on the cost of producing planting stock relative to the additional genetic gain delivered. Clonal forestry with these species will depend on the success of procedures to maintain juvenility and, though not yet definitive, the combination of hedging and serial propagation appears to hold promise.