selection and clonal propagation of Eucalyptus

A. Sivarajan1, M. Anbazhagan2* and K. Arumugam3

1. Research and Development Center, Bharathiar University, Coimbatore-641046.
2. Department of Botany, Annamalai University, Annamalainagar-608002, Tamil Nadu, India.

* Corresponding author E-mail: anbungm@yahoo.co.in

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INTRODUCTION

We selected seedlings mainly from short-rotation intensively cultured plantations. We also planted seedlings in beds at 2- by 2-foot spacing and, after 4 to 6 months, selected the most vigorous for further study. For salinity and cold hardiness screening, subjected them to salt or cold stress, and then evaluated vigor and form of the surviving individuals. In other cases, screening for stress tolerances began after selection for form and vigor. A balanced root system consisting of more radically distributed roots is necessary to avoid wind-throw. Entire blocks of the G3clone suffered wind-throw because of a poor root system developed during the propagation period. In conventional forestry, selection of seedlings is normally done 20 or more years after planting, and trees are harvested 40 to 80 years after planting. During this period, some trees may initially grow rapidly and then slowdown to be overtaken by other trees. Although the stayers may be better adapted to non-irrigated, non-fertilized conditions, the sprinters have value.

The correlation between biomass and diameter at breast height is approximately the same as, and in most cases better than, that between biomass and height. DBH, which is more easily and accurately determined than tree height, was therefore used to estimate relative vigor of seedlings. We found that E. grandis seedlings that were among the top eight most vigorous in the first 12 months from out planting retained that ranking through harvest at 3 years. Upright growth habit, minimum lateral branch development, and a straight trunk are important selection criteria. Many E. camaldulensis seedlings have good form for a year, but develop crooked, heavily branched trunks in later years. The best E. camaldulensisclone examined, C-2, has ratio of trunk:branch biomass of 4:1 to 5:1 at 3 years from planting; 75% to 80% of the biomass harvested is thus recoverable for processing after delimbing. Tolerance of freezing temperatures likely to be encountered in northern Californias important. Several clones were exposed to low temperature of 18°F and suffered no apparent damage. However, a 2 hrs frost with a minimum temperature of 26°F caused terminal bud damage on several E. grandis and E. camaldulensisclones. This frost occurred after mild fall temperatures prevented hardening of the trees before exposure to subfreezing temperatures. Accurate measurements of cold tolerance require evaluation in a freeze chamber with control of both the hardening and thawing cycles.

Species used for cloning

Ease of rooting varies greatly among eucalyptus species and even within members of a species. Since mature growth of fall species, generally beyond a year from out planting, is very difficult to root, juvenile material is used almost exclusively. Ifa mature tree is selected for cloning, the first step is to cut the tree to its base and wait for the stump to sprout. Once a mother plant is thus produced for cloning, the sprouts are continually cut back to prevent growth of mature shoots. Eucalyptus camaldulensis now probably is the most widely planted species of eucalyptus. Because its natural distribution in Australia is very wide, across many climatic regions, there is great...
variability in growth rate and formin seedling plantations. It is also one of the most easily rooted species with rooting percentages often exceeding 60%. In a small plantation at Dixon with 2,719 trees per acre, estimates of average biomass accumulation range up to 27 tons per acre per year with more than 80% of biomass as wood in the bowl. Since these forks are easily broken in strong winds, with a consequent loss of harvestable biomass, it would be advantageous to select clones without this characteristic.

Twelve vigorous seedlings of *E. grandis* were selected from clonal propagation and evaluation. *Eucalyptus grandis* clones have a dominant central leader with trunks generally straighter than the best *E. camaldulensis* selections and little or no forking. Lateral branches of *E. grandis* grow rapidly with many more leaves per branch and a denser leaf canopy than those of *E. camaldulensis*.

**Production of clonal materials**

**Procedures:**

To develop clones, we use three to four node cuttings, approximately 1/16 to 1/8 inch (3mm) diameter. Thinner and thicker cuttings will root, but the number of roots initiated per cutting or the percentage of rooted cuttings is too low for large-scale production. Cutting sare dipped for 5 to 10 seconds in a 4000 to 8000mg/L aqueous solution of the potassium salt of indole butyric acid (IBA) and stuck in a vermiculite-perlite rooting medium. The rooting response for C-2 is optimal at about 3000 to 5000ppm IBA (table 2).

Flats of cuttings, approximately 100 per flat with 2 square inches per cutting, are placed on a mist bench with a 2.5-second mist every 2.5 minutes from early morning to early evening with 75°F bottom heat (provided by heating cables buried in a 3-inch sand base). Cuttings root after 2 to 3 weeks, depending on the clone and time of year, and are then transplanted to 4-inch peat pots filled with a well-drained peat/sand potting mix. Cuttings are hardened for a week in a mist bench (half the misting frequency of the rooting bench) and then transferred to a shaded greenhouse bench (50% shade).

During the 2- to 3-week rooting period, some shoot tips and immature leaves die, but new shoots begin to grow during the hardening period (usually one shoot per cutting is retained). In good cultural conditions, this shoot will grow 8 to 12 inches in six weeks and the cutting will be ready to plant. The same procedures have been adopted for all selected seedlings for all species, although we have found large differences among species and clones in ease of rooting. These differences are, in part, inherent. For example, G-14 did not root, whereas all others prouts from *E. grandis* seedlings rooted to some extent. Among the relatively easy-to-root clones of *E. grandis*, however, some of the variance is related to the care and culture of the mother locks. The best rooting was obtained with cuttings from recently rooted cuttings or from relatively young mother plants that were cut back frequently. Mother plants in containers in the can yard yielded few easy-to-root cuttings, regardless of species and seedling selection.

**Quality of root system**

Many trees in our first clonal plantation were blown over by strong winds during their first two years after planting. Wind-throw of trees in clonal (and seedling) plantations is related invariably to poor root system development during the propagation period. Damage at planting or cultural conditions during the first 12 months after planting may contribute to problems. However, the wind-throw of entire blocks of G-3, a relatively difficult-to-root clone of *E. grandis*, adjacent to blocks of G-1 and C-2 that did not blow over, suggests that the problem in this planting was primarily related to the quality of the root system. The most prevalent cause of instability in clonal
trees is unbalanced distribution of roots, a problem that can be avoided by better evaluation of rooted cuttings. Cuttings with only one or two major lateral roots or with roots distributed predominantly on one side will develop unstable tree root systems and should be culled. In addition, rooted cuttings must be handled and potted carefully to avoid damage. Roots should be pruned rather than coiled or bent during potting to fit the container. Three or more radially distributed rooted were formed on nearly 75% of three- to four-leaf cuttings of *E. camaldulensis* taken *Eucalyptus camaldulensis*, probably the most widely planted species is easily rooted. The C-2 clone of this species, shown where at 10 months, has superior vigor and form and may grow as tall as 50 feet in four years.

When rooting was attempted in the winter, however, range numbers of plants with one and two roots per cutting were produced. Cuttings of other more difficult- to-root species produced fewer roots per cutting, often with an asymmetrical distribution. In these cases, since large numbers of cuttings must be discarded, larger numbers of cuttings must be stuck initially. In many clones relatively few of the rooted cuttings had adequate root systems for plantation establishment.

**Timing of propagation**

We obtained high rooting percentages in the Davis
are primarily during April through October, when mother plants were growing rapidly. High rooting percentages and high quality root systems were occasionally obtained from cuttings of field-grown plants in December, but results depended on weather conditions during the late fall and early winter. Year-round production is possible when cuttings are from mother plants held in greenhouses, but even in this case, best cottage production occurs in the spring to fall, when growth rates are high. Light energy is the primary limiting factor in the winter. Since the optimum period for beginning plantations is in the early spring, cuttings are best made in October (fully 3 to 4 months ahead of planting).

**Size of mother blocks**

We estimate that a 2-year-old mother block of C-2, maintained 1.5 feet high by 1.5 feet wide, will produce 30 to 40 cuttings per linear foot per month during April to October. If a 50% rooting success were achieved, 600 to 800 linear feet of outdoor mother blockangel would have to be maintained for each clone to produce enough rooted cuttings to plant 10 acres of an SRIC plantation with 1,200 trees per acre. If the rooting percentage were 25%, twice the number of cuttings would have to be stuck and twice the size of mother block maintained.

**Future work**

**Storage of cuttings**

Rooted cuttings grow rapidly after potting and acclimation, making it difficult to hold them in a greenhouse or shade area before planting. We are testing methods to hold rooted cuttings of *E. camaldulensis* for 6 to 12 weeks. If successful, those will permit more efficient use of propagation facilities, greater annual production of cuttings, and smaller mother blocks.

**Cold tolerance**

Although *E. grandis* and *E. camaldulensis* can be rooted from cuttings, these species are not necessarily the best adapted for biomass production in the many cooler sites available in India. Tissue-culture procedures have been tested for propagation of cold-tolerant, difficult-to-root species, such as *E. viminalis*, *E. dalrympleana*, and *E. nitens*. Shoot proliferation and root initiation have been achieved in *E. viminalis*, but theroots for the most part are not connected to the proliferating shoots. Propagation from stump sprouts of superior 20-year-old trees. Tissues from these trees have been placed in sterile culture for further study.

Shoot tips from vigorous 2- to 3-year-old trees of *E. nitens*. Blocks of *E. globules* (blue gum, *E. camaldulensis*, *E. dalrympleana*, and *E. viminalis*) have been established. The *E. globules* blocks contain excellent candidates for biomass plantations, and an attempt to propagate many perennial crops, clonal propagation done by grafting of scion wood to seedling or clonal rootstocks. Although this technique has had limited success with eucalyptus, studies will begin with the more difficult-to-root species.

**Salt tolerance**

Selection of relatively vigorous seedlings of *E. camaldulensis* seedlings planted in large numbers on salinities has begun under sponsorship of the India. Vigorous seedlings that passed a 200 meq/L irrigation screen (irrigation with 50,100, and finally 200 meq/L saline solutions of mixed sodium, calcium, chloride and sulfate salts) have been propagated vegetatively and are now ready for field testing.

**Seed orchards**

A statewide effort to improve the *E. camaldulensis* seed available in India has begun with the establishment of seed orchards. From this project additional, probably better adapted clones can be selected.

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