Propagating fast-growing for energy crops

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High rooting success has been achieved from seedling cuttings

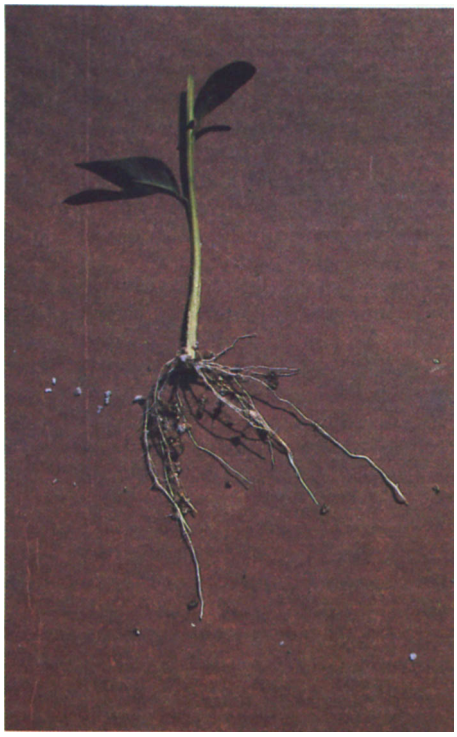
The wide adaptability and verified high yields of many eucalypts in California's varied climatic zones is a prime reason for their choice as a fast-growing source of renewable fuel. To fill the demand for plant material for the many small plantations being established throughout the state, nurseries and some entrepreneurs specializing in eucalypts are supplying seedlings in great quantity.

Although this response filled the early need, the inherent genetic diversity in these seedlings is greater than is desirable. Trees derived from seedlings selected for uniform initial high growth rates may differ by two- to three-fold in growth rates after transplanting to the field (table 1).

This difference in growth rate may be compounded during the resprouting period after a harvest; the stronger trees get stronger and the weaker trees weaker. With the eventual loss of the weaker trees, gaps begin to form in the plantation, which may reduce the yield potential with a short-rotation harvest schedule.

Clonal material has been suggested to replace seedlings and reduce genetic variability. Clones can be developed through use of one or more methods of asexual propagation, but rooting of stem cuttings is still considered the most economical. Although adult eucalyptus trees have the reputation of being difficult to root, success has been achieved in rooting cuttings taken from seedlings of many eucalypt species. Franclet of AFOCEL, a French forest-industrial firm, was able to root cuttings taken from seedlings of 58 species, but many became extremely difficult to root shortly after the seedling stage of development. Of more practical value, young leafy shoots (epicormic shoots) developing from cut stumps or below stem girdles of adult trees have been successfully rooted. Hartney lists 78 eucalyptus species, including many candidate species for biomass plantations, that have been rooted from seedlings, epicormic shoots, or both (V.J. Hartney, in *Australian Forestry Research* 10:191-211, 1980)

Cuttings are rooted in plastic planting tubes under intermittent misting.



Rooted C-1 eucalyptus stem cutting. Optimum rooting required about four weeks.

Source plants

An advantage of the genetic diversity in present plantings is the variety of trees to choose from for use in cloning. Our present studies have concentrated on red gum (*Eucalyptus camaldulensis*), an easy-to-root, fast-growing species reported to tolerate temperatures down to 20°F (−6°C). These red gums can adapt to a fairly wide range of environmental conditions making them suitable to a large part of California.

A planting of various species at Lodi

eucalypts

Trees from eucalyptus seedlings originally selected for uniformity may differ by two- or three-fold after transplanting because of genetic diversity.

by Dale Chapman, of Chapman Forestry Foundation, and Gary Hickman, Farm Advisor, San Joaquin County, has provided a good mix of trees for observation. Two of these trees were selected as source plants for cutting propagation research. The first tree (C-1) was selected because of its apparently high productivity in the first 18 months after planting. The other selection is from a red gum tree (C-2) that has proved to be a fast grower with few side branches and a straight bole. This tree resulted from seed from tree improvement programs in Spain and Florida. Other trees from the same seed source have performed well on several sites, some of them relatively alkaline or dry or with shallow soils.

Another source of material comes from two fast-growing, 18-month-old trees of a hybrid, *E. camaldulensis* × *rudis* (CR-1 and CR-2) on the Davis campus. Most seedlings from this source have proved successful in periodic flooding conditions; clones from this hybrid may be particularly useful for municipal wastewater disposal sites. The work discussed here was performed with C-1, but observations for C-2, CR-1, and CR-2 indicate that similar procedures will apply to them.

Propagation

In all cases we used subapical cuttings reduced to two to four nodes with leaves remaining on the upper one or three nodes. We discarded the terminal cutting, because rooting with this was usually very low; the same was true of the more basal cuttings without leaves. Leaf surface area was reduced by one-half so that cuttings could be packed more closely in flats or planting tubes.

Leaves are required for rooting of *E. camaldulensis* cuttings; any foliar disease or loss of leaves due to desiccation will be reflected in very low rooting percentages.

Cuttings were quick-dipped in a 4,000 ppm solution of indolebutyric acid (in 50 percent ethanol). Cuttings were then stuck in flats filled with perlite:vermiculite (50:50, v:v) or stuck directly into plastic planting tubes filled with a U.C.-type potting mix supplemented with dolomitic limestone. Planted flats or racks of tubes were placed in intermittent mist (5 seconds per 2.5 minutes) on beds with 80°F (26°C) bottom heat for 4 weeks.

Root emergence occurred in seven days on some cuttings, but optimum rooting (and subsequent survival of cuttings) required about four weeks under mist. Root initiation exceeded 70 percent in all tests (table 2).

After the mist treatment, cuttings were moved to a less frequent mist regime (one week), then to cheesecloth-shaded benches where sunlight irradiance was reduced by 50 percent (two weeks), and then to greenhouse benches. Cuttings in flats were transplanted to

TABLE 1. Variation in tree growth of three seedling eucalyptus plantations; seedlings selected originally for uniform growth rate

Species	Trunk diameter (inches)		
	Range	Mean	Standard deviation
*Eucalyptus camaldulensis**			
Border	3.25-6.50	4.39	1.02
Interior	3.00-4.50	3.67	0.50
E. camaldulensis†			
Interior	1.51-4.93	2.93	1.06
E. camaldulensis × *rudis**			
Border	1.75-5.50	3.82	0.87
Interior	1.00-4.00	2.53	1.09
E. globulus 'Compacta'*			
Border	4.00-6.00	5.08	0.61
Interior	1.00-3.50	2.50	1.04

* Davis plantings. Tree measurements at 1-foot height. Trees approximately 3 years old at time of measurement; planted on 2.5 × 2.5-foot spacing.
† San Diego planting. Tree measurements at 4.5-foot height. Trees approximately 2.5 years old at time of measurement; planted on 5- × 5-foot spacing.

TABLE 2. Rooting of cuttings from stem of C-1 red gum *(Eucalyptus camaldulensis)*

Month*	Mean % rooting
March	79.0
April	77.3
July	82.2
August	83.3
September	87.6
October	84.0
November	83.5
December	71.6

* Month cuttings were taken from plants.

continued

Extruded soybeans for mid-lactation

The dairy cow, like other ruminants, has four compartments in its stomach. The first compartment, the rumen, partially degrades feedstuffs by anaerobic microbial fermentation processes. The fourth compartment, or abomasum, corresponds to the single stomach of nonruminants, where final degradation of ingested material takes place.

Depending on the degree of degradability, dietary protein can be partially or totally degraded into ammonia and used by ruminant microorganisms to synthesize microbial protein. The degree of protein degradability in the rumen depends on inherent feed characteristics, rate of intake and feed passage to the lower digestive tract, and limitations in rumen fermentation processes.

Much of the microbial protein and rumen undegradable feed protein is eventually digested in the lower digestive tract, and the resulting amino acids are used for body

Propagating eucalypts, continued

the desired lining-out containers, generally 1.5-inch-diameter by 8-inch-deep planting tubes. The size of the root system makes smaller tubes difficult to use. A well-drained potting mix (U.C. type) was used. Irrigation included a complete, half-strength fertilizer solution.

After another two weeks, the cuttings were moved outdoors, usually to a lathhouse or to an unshaded greenhouse bench, where they remained until planting out. Growth was rapid in the tubes; in the March-to-October interval in Davis, rooted cuttings were ready for planting out within three months after sticking.

High rooting percentages have been obtained on cuttings taken from plants during March to November. When eucalyptus plants are maintained in heated greenhouses during the winter, cuttings are available year-round. But insect and disease (mildews) problems have occurred on the mother plants, with lower rooting percentages on the cuttings taken from these plants. Research is continuing on year-round production and rooting of leafy softwood cuttings; for the present, however, cuttings are made from spring to fall.

For all selections tested, rooting percentages have been high with cuttings from hedged mother plants up to 18 months old, some with flowers and fruit. At least an eight-fold increase in plant number per growing shoot can be expected in the mother block during a six-month period of rapid growth.

Future research

The red gum clones developed are not necessarily the best trees for energy plantations. They are fast growing (seedling plantations yielded about 15 dry tons per acre in a 2-year cycle), but we do not know that they will produce the maximum biomass yields in high-density plantations with 3- to 5-year harvest cycles over a 25- to 50-year lifetime. Nevertheless, these clones will provide base yield data for comparison with seedling plantations and with other fast-growing clones selected in the future. Our current goals for intensively managed energy plantations are approximately 15 tons (7 to 8 cords) oven-dried matter per acre per year.

Clones of low-temperature-tolerant eucalyptus species and hybrids with high growth rates are being propagated by relatively expensive tissue-culture techniques in several laboratories. Recently, procedures for rooting stem cuttings have been developed for these clones, which should make them economically feasible for energy (timber, pulp, fuel wood) plantations in the low-temperature regions of California.

Direct sticking of stem pieces in the field is practiced with hardwood cuttings of poplar and willow species. If this can be done with indolebutyric-acid-treated leafy cuttings from some fast-rooting eucalyptus species at certain times of the year, propagation and planting costs can be significantly reduced. High initial investment cost is an important factor limiting development of fuel wood plantations.

Mist propagation with relatively large droplet size and residual water and leaf surfaces may not be the best method for rooting eucalyptus cuttings; disease and leaching problems are apparent in some species. Other authors report better success with high humidity chambers equipped with fogging-type nozzles. These will be tested at Davis.

Mother block maintenance and renewal to maximize annual cutting production for plants maintained outdoors is not sufficiently well known to make definitive recommendations. Hedgerows would appear to be satisfactory, but it is not known how long high rooting percentages can be maintained.

A list of commercial nurseries selling these plants under the trade names of C-1, C-2, CR-1, CR-2 is available through the Department of Environmental Horticulture, University of California, Davis, CA 95616.

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