Clonal Propagation of Biofuel Trees with Emphasis on Silver Maple

John E. Preece and Carl A. Huetteman
Department of Plant and Soil Science, Southern Illinois University, Carbondale, Illinois 62901

W.C. Ashby
Department of Plant Biology, Southern Illinois University, Carbondale, Illinois 62901

P.L. Roth
Department of Forestry, Southern Illinois University, Carbondale, Illinois 62901

There is a potentially great market for propagules to be used to establish woody biofuel plantations. Propagators and the nursery industry should be poised to profit from this market.

IMPORTANCE OF BIOFUEL CROPS

In the next 20 years there may be a new and expanding market for the nursery industry—the area of biofuels. Biofuels are trees and grasses that are grown for use as fuels or energy feedstocks (Wright et al., 1989). The primary grass being researched for biofuel production is switchgrass (*Panicum virgatum*). It is being grown as an agronomic crop and probably will not have much direct impact on the nursery industry. Among the woody species being studied for use as biofuels are: hybrid and pure species cottonwoods and poplars (*Populus* spp.), black locust (*Robinia pseudoacacia*), eucalyptus (*Eucalyptus* spp.), sweet gum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*), and silver maple (*Acer saccharinum*). These woody biofuels are being grown and studied under short rotation conditions. This means that the closely spaced crops generally will be harvested within 10 years of planting. Most woody species have been selected because of their rapid juvenile growth rates and their ability to sprout from stumps (coppice), thus growers will not have to replant after each harvest, but can allow the coppice growth to be the subsequent crop. Yields are expected to exceed 11.2 metric bone dry tons per hectare per year (5 bone dry tons per acre per year). The United States Department of Energy, through the Biofuels Feedstock Development Program administered by Martin Marietta Energy Systems, Inc. has sponsored most of this research in the U.S. Sale of propagules of these woody species may prove profitable to the nursery industry as biofuel plantations increase in number and area planted.

The potential for biofuels is tremendous. Energy usage on a nationwide or worldwide basis is often measured in quadrillion BTU (Quads, 1 quad = 10^{15} = 1,000,000,000,000,000 BTU, 1 BTU = the amount of heat required to raise the temperature of 1 pound of water 1°F). It is estimated that by 1995 the United States will use 87.9 quads of energy, 6.2 of these Quads will be from renewable resources (biofuels, including ethanol from corn, and hydroelectric power, etc.) (U.S.D.O.E., 1988). Biofuels may be burned directly, or used as feedstocks for the production of alcohol or gaseous fuels. Liquid and gaseous fuels (such as methane or natural gas) are easier to use than wood itself in industries such as transportation.

When fuels are burned they produce greenhouse gasses, especially CO_2. Unlike fossil fuels, the burning of biofuels is considered to be, at worst, CO_2 neutral, because the carbon dioxide that is being returned to the atmosphere was removed only recently when the plants were growing. At least over the short run, because trees store carbon in their roots and portions not harvested, they actually remove more CO_2 than they return to the atmosphere when burned. Another reason that there is increased interest in biofuel production is that it could reduce the dependence of many countries on imported fuel.

Woody biofuels are produced through "short rotation forestry," a technique more closely related to horticultural nursery production than to traditional forestry. Therefore the expertise of trained and experienced nursery personnel may prove invaluable as this technology advances.

As of December 1992, there were more than 22,455 hectares (55,500 acres) of hardwoods planted in commercial plantations under short rotation conditions in the United States. This area is much larger on a worldwide scale. Some people have estimated that production of biofuel crops could increase to as many as 20.2 million hectares (50 million acres) in the U.S. by the year 2010. There will be a large number of jobs created by this industry, involving both growers and users of biofuel crops. Members of the International Plant Propagators' Society should be aware of this market and industry members may apply their skills to facilitating the propagation and growing of these crops.

PROPAGATION OF WOODY BIOFUEL CROPS

To maximize crop uniformity, woody biofuels will likely be propagated vegetatively. Elite germplasm with rapid growth rates and resistance to pests and diseases will be most desirable to biofuel growers. This germplasm will likely be patented, and propagators will need to calculate the costs of royalties into their cost of production. Because of the high risk of planting large monocultures, biofuel growers should mix clones in their plantations or plant relatively small areas in a patchwork quilt design using several different clones. This quilt-like pattern facilitates harvesting, since clones will vary in growth rate. Propagators must therefore be willing to provide a variety of clones to biofuel growers.

Direct Field Rooting. Hybrid cottonwoods, poplars, sycamore, and willows are often planted directly in the plantation as nonrooted hardwood cuttings (Meridian Corporation, ca. 1986). This is attractive to biofuel growers because of the low expense compared to transplanting rooted cuttings. However, to be successful, cuttings must root in high percentages.

With easy-to-root species, propagators will only make a large profit if they produce and sell a sufficiently large number of cuttings. Future demand for woody biofuel species should be high if the propagator can provide excellent clonal material. The propagator will need to establish cutting blocks and produce sufficient numbers of high quality, disease-free cuttings. Using hybrid poplar (*Populus* × *canadensis*) clones, Tolsted and Hansen (1992) established cutting blocks of stock plants spaced 1 × 1 m in northern Wisconsin. They found that cutting production during the third year was enhanced by more than 200% if they did not harvest any cuttings during the year of establishment, but waited until the second year before harvesting cuttings.

It is desirable that cuttings be harvested during the dormant season and stored properly to maintain their viability. The optimum cutting length is 20 to 30 cm (8 to 12 in.) with a cutting diameter of 1 to 2 cm (1/4 to 3/4 in.) (Meridian Corporation, ca. 1986).

Producing Rooted Cuttings or Plantlets for Transplanting. Sweetgum, black locust, and silver maple can all be rooted using softwood cuttings under high humidity. Silver maple can also be rooted (up to 50%) by using dormant hardwood cuttings stuck directly in the field (Fig. 1 and Preece et al., unpublished). All woody biofuel species discussed in this paper can be clonally micropropagated. If biofuel trees are propagated by softwood cuttings or micropropagation they will be more expensive to the biofuel grower than if hardwood cuttings are stuck directly in the field. However, all propagation methods offer opportunities for the commercial propagator.

The majority of our experience has been with silver maple. We first investigated stem cuttings and micropropagation (Ashby et al., 1987; Preece et al., 1991a) and learned that single node softwood cuttings rooted easily when treated with 1000 ppm IBA in talc, and that micropropagation of this species was not difficult if the phenylurea cytokinin thidiazuron was incorporated into the culture medium.

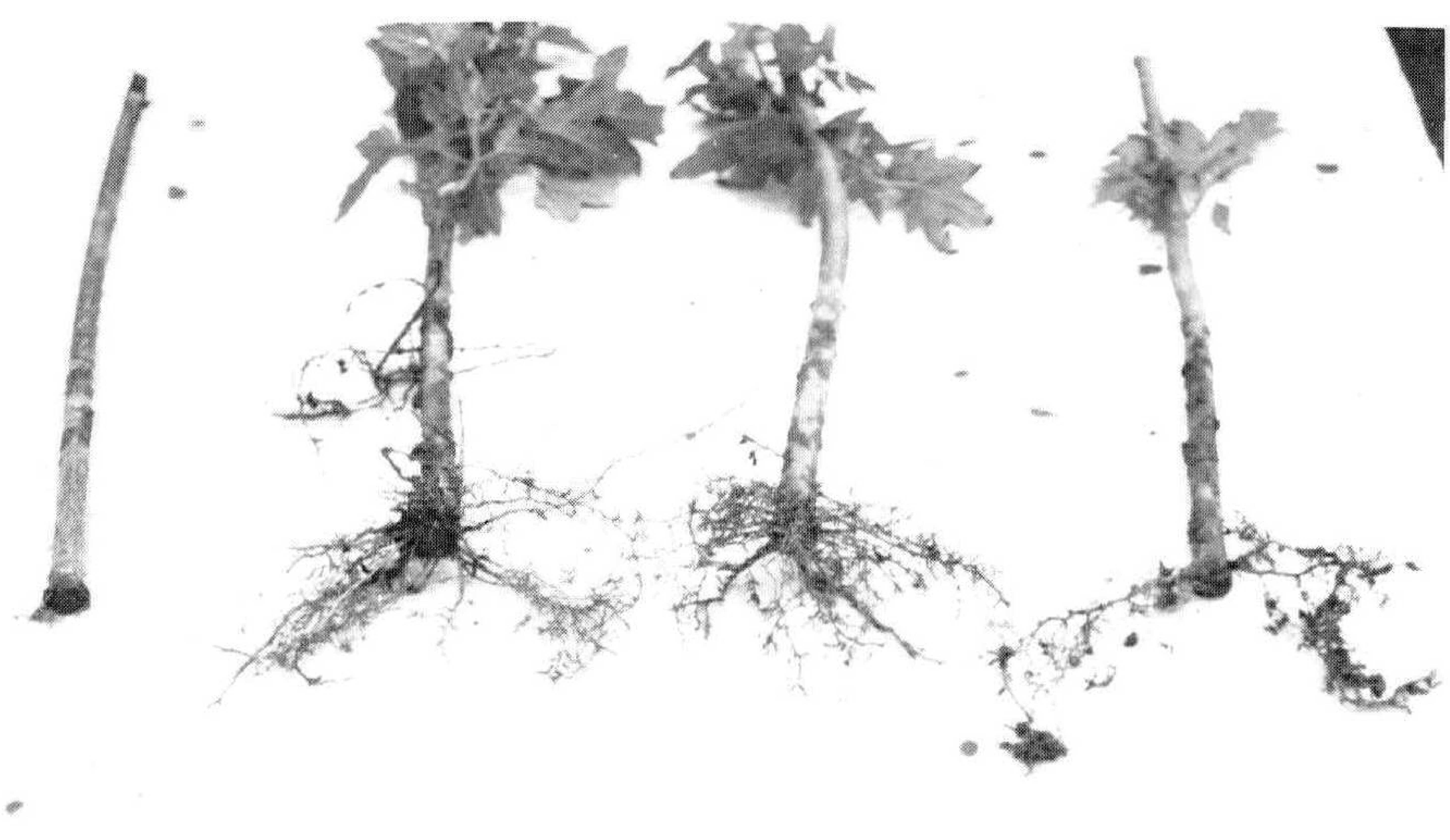

Figure 1. Root system development on silver maple cuttings stuck directly in the field as hardwood cuttings during the spring. Cuttings lifted and photographed during the early autumn of the same growing season.

Using this information, we selected 90 juvenile clones of silver maple trees that represented the native range of the species. After a single growing season in Carbondale, Illinois, the selected clones were cut into single-node cuttings and placed under intermittent mist, or nodal and shoot tip explants were surface disinfested and placed in vitro for micropropagation (Preece et al., 1991b). There was a significant effect of clone within provenance, both for rooting of cuttings and establishment of the explants in vitro. Cuttings rooted from 26% to 100%, with most clones rooting > 90%.

We tested commercially available auxin rooting formulations on rooting of 2-node, 15-cm-long softwood cuttings of four silver maple clones that were among the most difficult to micropropagate (Table 1). The most consistent high percent rooting and survival of plants after transplanting was when they were treated with a 1:20 dilution of Wood's Rooting Compound. The most difficult to root clone (number 045) rooted more poorly with Hormex, Hormodin, and Rootone than with Wood's; however, the easiest to root clone (number 043) rooted better with the other auxin formulations than with Wood's.

Table 1. Effect of commercially available auxin formulations and clone on rooting and survival of 15-cm-long softwood 2-node stem cuttings of silver maple under intermittent mist.

Auxin (ppm)		Formulation		Trade		Clone	Rooted	Survival
IBA	NAA	Talc	Liquid	name	Provenance	number	(%)	(%)
515	255		×	Wood's	So. IL	043	77.8	77.8
				(1 : 20)	So. IL	045	77.8	77.8
				dilution	E. Cen.MN	192	88.9	88.9
					Cen. KS	202	88.9	88.9
130	2400		×	Hormex	So. IL	043	100.0	77.8
					So. IL	045	11.1	0.0
					E. Cen. MN	192	100.0	100.0
					Cen. KS	202	55.6	55.6
1000	2000	×		Rootone	So. IL	043	100.0	100.0
					So. IL	045	55.6	44.4
					E. Cen. MN	192	77.8	77.8
					Cen. KS	202	77.8	66.7
3000	0	×		Hormodin	So. IL	043	100.0	100.0
				No. 2	So. IL	045	22.2	22.2
					E. Cen. MN	192	100.0	88.9
					Cen. KS	202	88.9	88.9
Significance							*	*

*Significant auxin × clone interaction at the 5% level according to F-test.

Silver maple micropropagation was from single node shoot segments excised from clonal stock plants from the greenhouse. A mean of 65 axillary shoots grew from each explant after 4 months in vitro. The microshoots were rooted and plantlets were transplanted into test plantations for evaluation.

To facilitate scaling up to a micropropagation production level of producing thousands of plantlets for field establishment, clones that did not propagate well were eliminated. Ease of vegetative propagation has also been used to select or eliminate clones of most tree biofuel crops. Therefore, elite clones ultimately used to establish plantations should propagate easily.

CONCLUSIONS

As plantings of woody biofuel crops increase, so will the demand for high quality propagules. The commercial nursery industry should be positioning themselves to supply this potentially lucrative market. Currently the factor most limiting to production is the low number of facilities to use and/or process the biofuels. As fossil fuels become less available and political pressures rise, biofuels will become an increasing important method of harnessing the sun's energy.

LITERATURE CITED

Ashby, W.C., J.E. Preece, C.A. Huetteman, D.F. Bresnan, and **P.L. Roth**. 1987. Silver maple tree improvement for biomass production. In: Proceedings of the Fifth North Central Tree Improvement Conference. Sponsored by: North Central Tree Improvement Association. pp. 6-23.

U.S.D.O.E. 1988. Five year research plan 1988-1992. Biofuels: Renewable fuels for the future. Biofuels and Municipal Waste Technology division, Office of Renewable Energy Technologies, U.S.D.O.E. DOE/Ch10093-25. 37 pp.

Meridian Corporation. (circa 1986). Short-rotation intensive culture of woody crops for energy, principles and practices for the Great Lakes Region. Falls Church, VA. 85 p. plus appendices.

Preece, J.E., C.A. Huetteman, W.C. Ashby, and **P.L. Roth.** 1991a. Micro- and cutting propagation of silver maple. I. Results with adult and juvenile propagules. J. Amer. Soc. Hort. Sci. 116: 142-148.

Preece, J.E., C.A. Huetteman, W.C. Ashby, and **P.L. Roth.** 1991b. Micro- and cutting propagation of silver maple. II. Genotype and provenance affect performance. J. Amer. Soc. Hort. Sci. 116: 149-155.

Tolsted, D. and **E. Hansen**. 1992. Age of hybrid poplar stools at first cut influences third-year cutting production. USDA, Forest Service, NCFES. Research Note NC-357. 3 pp.

Wright, L.L., J.H. Cushman, and **P.A. Layton**. 1989. Dedicated energy crops. Expanding the market by improving the resource. Biologue 6(3):12-19.

THURSDAY MORNING 3 DECEMBER 1992

The morning session was convened at 8:00 a.m. with Charles Tubesing serving as Moderator.