USES OF HARDWOOD CLONES IN FORESTRY RESEARCH

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Clones of forest trees can be of considerable value as research tools. Furthermore, for high valued species or specific products or for special use, planting vegetative propagules may be more desirable and perhaps more economical than planting seedlings. Horticulturists have for years used clones to increase production and to improve the quality of a variety of fruits and ornamental plants. The use of hardwood clones in forestry is not, of course, a new concept. Poplar has been managed and propagated for a long time in Europe (Schreiner 1959) and great strides have been made in the same direction throughout the southern central United States with cottonwood (Mohn, C. A., W. K. Randall, and J. S. McKnight 1970). However, the use of poplar or cottonwood clones has been rather restrictive in that they produce well on only exceptionally fertile land and thus growth rate is the single most important selection criterion (McKnight 1970). The primary reason perhaps for the use of so few hardwood species as clones in forestry in the past was that so few commercially important hardwoods could be vegetatively propagated. Recent advances in both the art and science of rooting cuttings from forest trees has made it feasible to put clonal lines into specialized uses.

As researchers, you can readily see the advantage of having clonal lines of selected trees growing on their own root systems and available for use in seed orchards, fertility studies and in studies pertaining to disease and drought resistance. However, more important than the specialized use of clones in specific physiological or genetic studies is their potential use to gain a better understanding of the biological mechanisms of species adaptability. At the Forestry Sciences Laboratory and at the School of Forest Resources in Athens, Ga., we have been working on a small scale in using vegetatively propagated materials of several species for about 10 years. The investigations were initiated when McAlpine (1964) successfully propagated yellow-poplar and then expanded his procedure to other species. Some of his original yellow-poplar clones have been propagated on a small scale continuously since 1962 and have provided numerous leads that indicate the potential of clones in forestry research.

SPECIES ADAPTABILITY

What, here, is meant by "species adaptability"? Species adaptability most surely would include those environmental adaptations mediated by the photo-periodic or temperature regimes by which races are recognized: these intra-specific adaptations are accepted and are well documented. However, species adaptability can be more specific than that recognized in races or

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even varieties, and is encountered in all phases of forestry. It is perhaps best exhibited in the ability of a species to adapt and compete successfully over a wide range of site conditions. Few hardwoods are so restrictive in their site requirements that they make suitable growth only in a narrow range of environmental conditions. Thus, while hardwoods grow best on certain sites such as well-drained bottomlands and coves, they also make suitable growth on other sites. A forester does not go into the woods many times before he encounters a given hardwood species growing "off-site" and making respectable growth: from an infinite number of such observations probably arose the concept of "soil-site studies." For years, with limited success, we have attempted to measure soil and other site variables and put limits on a species growth potential based upon measurable environmental factors. Variability in soil properties has been uniformly encountered in these studies and to this item has been attributed our ability to correlate only gross site characteristics to tree growth (Mader, 1963; Ike and Huppuch, 1968; Kormanik, 1966; and Trimble and Weitzman, 1956). It is easy to blame soil variability--which is so well documented--for our failure to obtain both practical and workable equations for predicting growth but it is short-sighted for it stresses soil variability and thus ignores the importance of species adaptability. Thus, while the limiting factor for assessing growth potential may not be soil variability but rather species adaptability, the latter has received little attention. Some earlier workers (BUsgen and MUnch, 1929) recognized such adaptation under the broad headings of "local physiological and soil races." It is possible that with species that adapt to a wide range of sites, we may be able to identify and propagate varieties for planting on specific sites.

PATHOLOGY

One of the potential uses of clonal lines is in the field of forest diseases. Vegetative propagules are ideally suited for studies to determine susceptibility to root pathogens and for development of control measures. In fact, among the five yellow-poplar clones propagated at Athens one was highly susceptible to attack by *Fusarium solani.* Progressive dying 'among large numbers of ramets of this clone enabled the disease to be observed in early and late stages of decay. Possible uses of this specific clone are in pretesting for the presence of F. *solani* in planting sites and in observing rate of spread of the pathogen from spot inoculations.

PHYSIOLOGY AND MORPHOLOGY

Another potential use of clones in forest research is in correlating morphological adaptations with physiological responses. Through investigations in this broad area, mechanisms responsible for species adaptatibility can be found. While randomly selected clones will yield information among species, careful selection of individuals from specific sites will be needed to establish intraspecific differences. We are making such selections now but most of our studies have included only clones propagated from random selections.

Elongating root tips probably have the highest respiration rate of any tree organ (Kramer and Kozlowski, 1960) and the ability of roots to carry on this process favorably under a range of soil conditions would be a potential asset. Root respiration rates seem to vary among species (Kramer and Kozlowski, 1960) and Steinbeck and McAlpine (1966) using root tips from four clonal lines of four species found significant respiration rates among all four species: significant inter-clonal rates were measured in only one species, black willow. Unpublished work from the Forestry Sciences Laboratory with randomly selected clones of sycamore and yellow-poplar has revealed no significant clonal differences and little relationship between root respiration and clonal growth rate.

As alternate uses for the fertile bottomlands take precedence over growing trees, production of hardwoods on upland sites becomes more and more a reality. This means that species best adapted to moist coves and bottomlands must grow on drier sites. Recently some of our original yellow-poplar clones were used in a study to determine the feasibility of using potted plants to determine adaptability to a range of moisture stress from very wet to very dry. In this case, all clonal lines rapidly succumbed to flooding within seven days. The same clones were kept under a minimum watering schedule and again all clones faired badly with the faster growing clones wilting back more rapidly than the slower growing ones. No significant intra-clonal differences were detected, but some differences in formation of the casparian strip in response to drought was apparent within 5 cm of the root tip.

In studies to determine adaptability within and among species, anatomical investigations of roots will be needed with special consideration given to the endodermis and its casparian strip. Studies involving three species--swamp tupelo, yellow-poplar and American sycamore--revealed some interesting differences in internal structure of the roots. Seedlings of swamp tupelo growing in a well drained medium readily developed a well-differentiated endodermis with distinct casparian strips in the 2 cm root tip segments examined, but in *a* flooded medium the endodermis was poorly organized and the casparian strips were not present (Hook et al., 1971). In a similar study with yellow-poplar clones, flooded roots decomposed so rapidly that histological examination of roots was not possible. However, roots of yellow-poplar ramets not flooded and others from which water was withheld had well differentiated endodermis with prominent casparian strips. Yellow-poplar does not normally survive in nature under flooded conditions.

In other exploratory work we found that sycamore, which is intermediate in flood tolerance between the very tolerant swamp tupelo and intolerant yellow-poplar, exhibited endodermal development different from either of the above: the cells of its endodermis were occluded with a substance that exhibited a bright yellow color when the root tips were stained with safranin and fast green. With sycamore, the casparian strips were not nearly as prominent as in yellow-poplar although the endodermis was more highly developed. Thus, superficial work among just three species, whose site requirements differ, revealed three distinctly different patterns of endodermis specialization. It seems likely that some degree of species adaptability may hinge on changes in properties of cells making up the endodermis.

Nutrient requirements and response to natural and artificial fertility regimes are other areas of study for which clones may be ideally suited. With this type of work the objectives of the study will to a great extent dictate the care which must go into ortet selection. Steinbeck 2/ in a greenhouse study was able to show some intra-clonal response of random yellow-poplar clones to different concentrations of a basic Hoagland nutrient solution. Unfortunately, there was complete uniformity in the clones' susceptibility to a sudden white fly and aphid infestation and the study came to a premature end. Recently, however, Steinbeck (1971) used the same approach with randomly selected clonal lines of sycamore with good results. He reported intra-clonal differences in branching characteristics as well as **in** dry matter production and height growth. He concluded that a search for nutritional varieties should be fruitful.

Planting ramets in pots for intensive testing may be the first step in ascertaining the desirability of specific lines, but it may also be quite feasible to select desirable clonal lines by simply comparing the propagules after they have over-wintered in the transplant beds. An example of this was reported by Steinbeck and Kormanik (1968) with two clones of yellow-poplar. In this case, the root system of one clone was consistently larger than cuttings of another rooted at the same time. After one year in a field planting, the clone with the larger root system outgrew the smaller one in every characteristic measured. Furthermore, four yes after planting, the faster growing clone still maintains this advantage.--

The afore mentioned examples are a few of the instances in which the availability of clones in research has proved helpful. Perhaps in the not too distant future continued work in vegetative propagation will make possible the clonal testing of our selections over a wide range of soil and site conditions years before the first progeny are available from seed orchards.

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20 Personal communication, Dr. Klaus Steinbeck, Assistant Professor, School of Forest Resources, University of Georgia, Athens.

30 Steinbeck, Klaus, George D. Kessler and Paul P. Kormanik. Root and shoot development of two clones of Liriodendron tulipifera L. four years after planting. In Process.

LITERATURE CITED

BUsgen, M., and Munch E. 1929. The structure and life of forest trees. John Wiley & Sons, Inc., New York. 436 p.

Hook, Donal D., Claud L. Brown and Paul P. Kormanik. 1971. Inductive flood tolerance in swamp tupelo (Nyssa sylvatica var. biflora (Walt.) Sarg.). J. Exper. Bot. 20(70): 78-89.

Ike, Albert F., Jr., and C. D. Huppuch. 1968. Predicting tree height growth from soil and topographic site factors in the Georgia Blue Ridge Mountains. Ga. Forest Res. Counc. Pap. 54, 11 p.

Kormanik, Paul P. 1966. Predicting site index for Virginia, loblolly and shortleaf pine in the Virginia piedmont. Southeast. Forest Exp. Sta., U. S. Forest Serv. Res. Pap. SE-20, 14 pp., illus.

Kramer, P. J., and Kozlowski, T. T. 1960. Physiology of trees. McGraw-Hill Book Coe, Inc., New York. 642 p.

Mader, D. L. 1963. Soil variability - a serious problem in soil-site studies in the Northeast. Soil Sci. Soc. Amer. Proc. 27: 707-709.

McAlpine, Robert G. 1964. A method for producing clones of yellow-poplar. J. Forest. 62(2): 115-116.

McKnight, J. S. 1970. Planting cottonwood cuttings for timber production in the South. South. Forest Exp. Sta., U. S. Forest Serve Res. Pap. SO-60.

Mohn, C. A., W. K. Randall and J. S. McKnight. 1970. Fourteen cottonwood clones selected for midSouth timber production. South. Forest Exp. Sta., U. S. Forest Serv. Res. Pap. S0-62.

Schreiner, Ernst J. 1959. Production of poplar timber in Europe and its significance and application in the United States. U. S. Department of Agric. Handbook 150. 124 pp.

Steinbeck, Klaus, and Robert G. McAlpine. 1966. Inter-and intra-specific differences in the root respiration rates of four hardwood species. Forest Sci. 12: 473-476.

Steinbeck, Klaus. 1971. Growth responses of clonal lines of American sycamore growth under different intensities of nutrition. Can. J. Bot. 49(3): 353-358.

Steinbeck, Klaus, and Paul P. Kormanik. 1968. First-year root system development of two clones of yellow-poplar. Ga. Forest Res. Counc. Pap. 55, 4 pp.

Trimble, G. R., Jr., and S. Weitzman. 1956. Site index studies of upland oaks in the northern Appalachians. Forest Sci. 2: 162-173.