

## Original article

## Oak tree improvement in Indiana

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**Summary** — Oak tree improvement in the state of Indiana is currently in progress for 4 species: *Quercus rubra* L., *Q. alba*, *Q. falcata* var *pagodifolia* Ell., and *Q. robur* L. These applied programs were initiated in response to the increased demand for high quality reforestation stock within the state. The *Q. rubra* breeding program employs sublining and progeny testing by means of softwood cuttings derived from open-pollinated seeds. Limited range, provenance/progeny tests have been established for *Q. alba* at 4 locations in the state, of which 2 plantings are designated to serve as seedling seed orchards in the future. The feasibility of using exotic sources of *Q. falcata* var *pagodifolia* and *Q. robur* is currently under investigation.

**vegetative propagation / flowering / provenance testing**

**Résumé** — Programmes d'amélioration des chênes dans l'État d'Indiana. Des programmes d'amélioration génétique sont actuellement menés pour 4 espèces de chêne dans l'État de l'Indiana : *Quercus rubra*, *Q. alba*, *Q. falcata* var *pagodifolia* et *Q. robur*. Ces programmes ont été mis en route suite à la demande importante de plantations d'espèces produisant du bois de qualité. Le programme relatif à *Q. rubra* est basé sur plusieurs lignées (sublining) et des tests de descendance mis en place sous forme de boutures et issus de croisements libres. Des plantations de provenances et descendance de *Q. alba* ont été mises en place dans 4 stations; les provenances ne sont issues que d'une partie de l'aire de distribution. Deux plantations ont été conçues de manière à être transformées en vergers à graines de semis. L'utilisation effective des espèces exotiques (*Q. falcata* var *pagodifolia* et *Q. robur*) dépend pour l'instant des résultats des plantations.

**multiplication végétative / floraison / tests de provenance**

## INTRODUCTION

The *Quercus* genus is of critical importance to the wood-using industries in Indiana and comprises 18 commercial species. As an example, the oaks represented 46% (1.4 million m<sup>3</sup>) of the sawtimber harvested in the state in 1985. The *Quercus-Carya* forest type is predominant in Indiana and accounts for 33% of the state's 581 000 ha of total timberland (Smith and Goltz, 1988).

In response to the importance of *Quercus* to the state's wood-using industry and forests, the Indiana Department of Natural Resources, Division of Forestry nursery program has been active in producing high quality planting stock of several species for many years. Production of oaks by the state nurseries averages 1.5 million seedlings of approximately 11 species/year.

The intent of this paper is to present an overview of the oak tree improvement programs that are in progress in the state and to provide a brief discussion of the results obtained to date.

## MATERIALS AND METHODS

### *Quercus rubra* (northern red oak)

A clonal seed orchard approach that utilizes a sublining breeding strategy was initiated in 1984. Progeny testing will be conducted through the use of stem cuttings derived from subline origin seeds. Details of this program are given by Coggeshall and Beineke (1986) and Coggeshall (1987). A total of 180 phenotypes have been selected to date and successfully established in 6 sublines at the southern Indiana nursery at Vallonia. Grafted ramets have also been established in a clone bank at the northern nursery and in a hedge for use in further propagation studies. In addition, a series of provenance/progeny tests have been established at 2 sites in southern Indiana and at 1 site in southern Illinois by the US Forest Service that represent

from 57 to 86 common families of 12 sources. These test plantations will serve as replicates of the 1988 provenance collections established by European cooperators.

Several concurrent investigations are in progress: a study of cutting propagation techniques of both clonal and seedling material through the use of hedges, documentation of the flowering phenology and fecundity of all clones in the breeding population, and investigations of rootstock effects on delayed graft incompatibility.

### *Quercus alba* (white oak)

Provenance/progeny test plantations were established in 1984 at 4 locations containing from 50 to 70 common families of 17 sources. Fifteen of the 17 sources are of Indiana origin, with 1 additional source each from Illinois and Missouri. Two of these 4 plantings are located at the state nurseries and will be converted into seedling seed orchards in the future.

### *Quercus falcata var pagodifolia* (cherrybark oak)

A single provenance/progeny test of 30 families from 8 southern US sources plus Indiana was established at Vallonia in 1983. The 9 seed sources ranged from 30°30' to 37°54' N latitude.

An opportunity to evaluate the winter hardiness of these sources presented itself in December 1989. A 10-day period of extreme cold (−23 to −31 °C) resulted in crown damage and mortality in most sources. All trees were evaluated using a subjective scoring system (1 = healthy, 7 = dead) in June 1990 in an attempt to quantify the effects of this cold injury. These data were then compared to source latitudes.

### *Quercus robur* (English oak)

Through the generous assistance of several European cooperators, 80 seedlots from 8 sources (10 seedlots per source) were provided to Indiana in 1982: 50 seedlots from Germany, 20 from France and 10 from Yugoslavia.

A single provenance/progeny test of 73 seedlots from these 8 sources, plus 1 commercial check and 6 seedlots from cooperators at Michigan State University was established at the southern nursery in 1985.

The severe winter temperatures of December 1989 that damaged the cherrybark oak planting also impacted the English oak test. The same scoring system (1 = healthy, 7 = dead) was also employed in June 1990 to evaluate the injury and relate it to seed source origin.

## RESULTS AND DISCUSSION

### *Quercus rubra*

Late winter bench-grafting in the greenhouse has been very successful, with an average of 90% success achieved with 180 clones over 6 years. Subsequent establishment in the field, however, has encountered moderate difficulties due to delayed graft incompatibility in some clones. Symptoms of incompatibility include overgrowth and vigorous suckering from the rootstock, and becomes apparent up to 4 years after grafting. A total of 103 clones expressed signs of incompatibility in at least 1 ramet by age 4 years, out of a total of 150 clones observed (69%). In addition, 102 incompatible ramets out of 206 observed produced pistillate and staminate flowers at age 5 (49.5%).

Widespread flowering in grafted red oak occurred at age 5 years. A total of 73 clones of 150 observed (48.7%) produced both staminate and pistillate flowers on at least some ramets. A total of 156 ramets flowered of 869 observed (18%). However, successful pollination and/or fertilization resulting in 1-year-old acorns was much less. Of the 156 ramets that flowered, only 55 produced seed (35%).

Acorns obtained from the sublimes will be used as a source of seedling rootstocks

for incompatibility studies and also hedges. The production of rooted cuttings derived from these hedges is planned for 1994. Progeny testing of all clones in the Indiana breeding population will employ the use of cutting-origin propagules.

### *Quercus alba*

Field survival and growth data at age 5 years was analyzed for the 2 southern Indiana provenance/progeny test plantations. Overall survival at the 2 locations was 83.1% and 84.4%, respectively. Mean total heights ranged from 2.11 m at site 1 to 0.97 m at site 2. This difference in growth can be directly attributed to weed competition effects. Analyses of variance at each site indicated significant family within-source variation for 5th year heights, while source variation was not significant at site 1. The local source performed above the plantation mean at both locations. It also appears from these early data that growth advantages can be gained by utilizing seed sources from up to 2° latitude north of the planting site.

### *Quercus falcata var pagodifolia*

Mean survival was 78.2% and mean total height was 4.33 m after 7 years in the field. Significant seed source and family within source variation was detected by analyses of variance. Results of the winter injury survey conducted during the 8th growing season revealed a highly significant correlation with seed source latitude (Spearman rank correlation coefficient  $r = 0.983$ ). Based upon this limited population, winter-hardy seed sources could be found up to 5° latitude south of the planting site. However, the "local" Indiana source was superior in growth, survival and hardiness.

**Quercus robur**

Mean survival was 88.4% and mean total height was 2.85 m after 5 years in the field. Highly significant seed source and family within-source variation was detected by analyses of variance. Results of the winter injury survey conducted during the 6th growing season indicated a non-significant correlation with seed source latitude ( $r = 0.333$ ), but a significant relationship of decreasing winter injury with increasing seed source longitude ( $r = 0.714$ ). The best European sources for winter hardiness, growth and survival were from Walkenreid and Peine in Germany.

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