Dynamics of Oak Production from Seed©

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INTRODUCTION

Most oak (*Quercus*) production in the United States is from seed using production techniques that have evolved over the past 50 years. The steps of production have become more specialized with various combinations of seed collectors, seed brokers, liner producers, and tree farms involved in the production chain. Distribution has changed from localized production to regional distribution over large areas with diverse climates. Production decisions usually center on whether to grow or buy bare root or containerized seedlings of the different oak species needed to meet production goals. Quality control consists of inspecting planting stock to assure the leaves are the right shape, growing straight scar-free trunks of appropriate caliper with proper crowns and keeping cull trees to a minimum. In all this activity little consideration is given to the genetic background of the oaks being produced. The innate genetic potential of acorn sources used to produce oaks can impact both production and the long-term landscape performance of trees.

Horticulturists generally place primary emphasis on selection of the proper species. However, great variation exists within different oak provenances of various species for growth rate, trunk straightness, and range of climatic adaptations (Schoenike et al., 1982; Adams et al., 1988; Stringer et al., 1995; Steiner, 1998). Identification of superior genotypes and establishment of seed orchards can be an expensive process when considering time and maintenance costs but projected paybacks, more efficient production and superior landscape performance, justify the expense. Struve and McKeand (1994) observed when superior seed sources are identified; it costs no more to produce seedlings from genetically superior seed sources than from inferior sources. Due to other research priorities little progress has been made in establishment of elite oak seed orchards, therefore, other alternatives need to be explored to help the nursery industry improve the genetic quality of oak production.

Provenance refers to the area where seed was collected. If seed is collected from native stands a number of assumptions can be made that have long-term implications. Southern pine species have been extensively studied to determine the effects of the geographic origin of seed on growth and survival of trees. Seed sources from warmer areas of the native range tend to grow faster than local sources due in part to the warmer-climate seed sources growing longer in the fall (Jayawickrama et al., 1998). Seedlings produced from seed collected from colder areas of the native range grow slower than local seed (Schmidtling, 1994). Pine germplasm from west of the Mississippi River generally grows slower due to adaptations for growth under dryer conditions (Schmidtling, 2001). The most important factor influencing growth and survival of southern pines is the average minimum temperature at the seed source (Schmidtling, 1997). Seedlings do best that originate from an area where winter temperatures are within 3 ºC (5 ºF) of the planting site's minimum. Movement of material should be limited to a 5.5 ºC (10 ºF) differential because as the temperature disparity increases there is a an increased risk of winter damage if stock is moved to colder areas and growth loss and heat stress if planted in warmer regions (Schmidtling, 2001). This conforms to movement of planting stock one cold hardiness zone south or north of the zone where native seed originated (U.S. Department of Agriculture, 1990). Observations made for other tree genera generally conform to the pine studies and are used when selecting seed sources for reforestation (Schmidtling, 2001).

PROVENANCE SELECTION

Collection of oak seed for nursery production is often based on seed crop availability as affected by frost and drought, ease of collection, price per pound, and/or germination percentage rather than development of a set of standards designed to obtain seed with superior genetic potential and climatic adaptation. Isolated open-growth oaks often produce abundant easily collected seed crops but should be avoided because of potential self-pollination that can produce weak seedlings with increased culls. Selection of segregated stands of the desired species from other oak species known to easily hybridize reduces the potential for unmarketable off-type hybrids. Superior general health and vigor of selected stands on average sites is the first indication of populations with superior innate genetic potential. Seed should be collected from sites that are available for collection over a number of years to avoid yearly surprises in seed performance. Several widely separated stands should be selected to reduce the potential for total loss of a seed crop due to frost, poor rainfall, or other calamity.

If we assume the same selection pressures that have affected the adaptation of southern pine species have impacted eastern oak species in a similar manner (Schmidtling, 2001), an assumption supported by several eastern oak species provenance studies (Schoenike et al., 1982; Adams et al., 1988; Stringer et al., 1995; Steiner, 1998), the best place to look for widely adapted oak provenances is no more than one cold hardiness zone south or north of where trees will be ultimately planted. Due to the marketing and distribution system used by the shade tree industry, the nurseries have a primary marketing area, but the ultimate planting site is generally unknown.

Obtaining seed from the proper cold hardiness zone for a particular sales area is an important consideration in improving oak landscape performance. Growers should consult a range map for the species of interest to determine where native populations are located. Range maps for most North American tree species are available on the Internet at: <http://climchange.cr.usgs.gov/data/atlas/little/>. The native range of the species should then be compared with the U.S.D.A. Cold Hardiness Zone Map (http://www.usna.usda.gov/Hardzone/ushzmap.html) and projected sales area to select a seed collection area with properly adapted germplasm. The process is illustrated in Fig. 1 for a hypothetical middle Tennessee nursery producing willow oak. The nursery's northern sales area includes Indianapolis, Indiana, and Columbus, Ohio and the southern marketing area includes Birmingham, Alabama and Atlanta, Georgia. The sales area ranges from USDA cold hardiness Zones 5 to 7. Following the rule to collect seed one cold hardiness zone south or north of

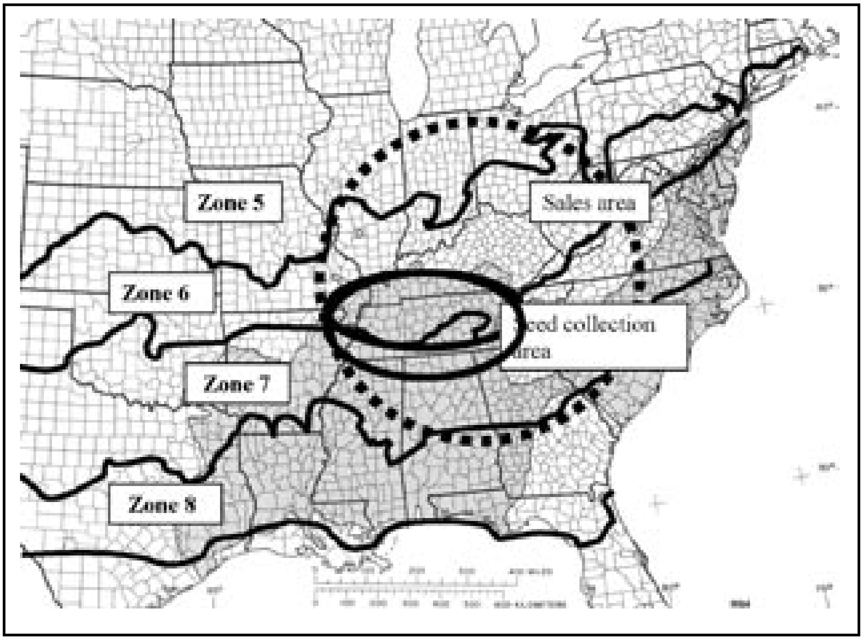

Figure 1. Range map of native *Quercus phellos* L. (willow oak) with an overlay of U.S.D.A. cold hardiness Zones (5-8). Sales area of a hypothetical central Tennessee nursery is outlined in coarse dashes and the solid circle defines proper seed collection area.

the ultimate planting site indicates Tennessee would be an ideal collection area to service the projected sales area. However, if the nursery decides to purchase liners grown from seed collected in south Louisiana (Zone 8), customers in Birmingham and Atlanta may have satisfactory results, but the customers in Indianapolis and Columbus may decide Tennessee-grown willow oaks have too much winter injury in their area and change to another oak species or supplier.

Once the proper cold hardiness zone where seed should be collected is chosen, sites available for annual seed collection that meet the general collection guidelines can be screened by doing production trials to select sites giving superior performance. Most collectors and seed dealers keep minimum information on seed origin and blend seed from multiple locations. Keeping seed from different sites separated and observing growth can reveal provenances that grow slower, produce more culls, and have higher percentages of off-type seedlings. Compare information on plant size, grade, and culls from the provenances in production to determine if production can be improved by eliminating specific provenances from future production.

A study conducted in south Mississippi and central Tennessee compared height growth of six provenances (1=Arkansas, 2=Arkansas, 3=Louisiana, 4=Louisiana, 5=North Carolina, and 6=Tennessee) of willow oak obtained from commercial seed dealers in four different sets of environmental conditions (1=Miss-Miss, 2=Tenn-Tenn, 3=Tenn-Miss, and 4=Miss-Tenn, Year 1 to Year 2, respectively) showed that provenances varied both in growth and sensitivity to environmental changes (Figs.

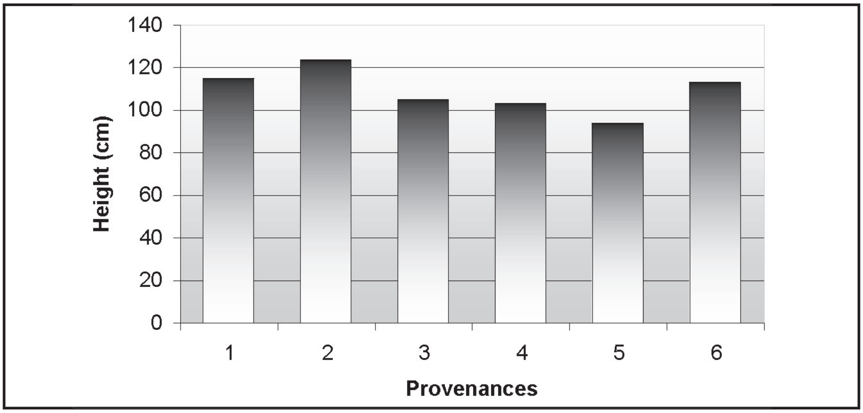

Figure 2. Average seedling height growth during the second growing season from four different sets of environmental conditions (Miss-Tenn, Tenn-Miss, Miss-Miss, and Tenn-Tenn, year1 to year 2, respectively) for six willow oak provenances obtained from commercial seed dealers (1=Arkansas, 2=Arkansas, 3=Louisiana, 4=Louisiana, 5=North Carolina, and 6=Tennessee).

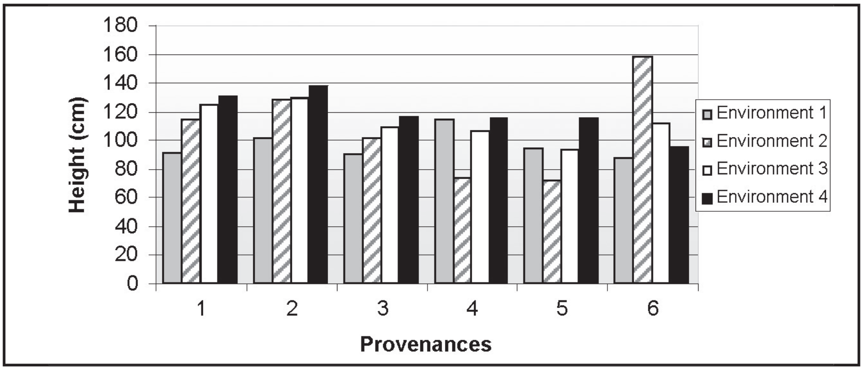

Figure 3. Mean height growth during the second growing season from four sets of environmental conditions (1=Miss-Miss, 2=Tenn-Tenn, 3=Tenn-Miss, and 4=Miss-Tenn, Year 1 to Year 2, respectively) for six provenances (1=Arkansas, 2=Arkansas, 3=Louisiana, 4=Louisiana, 5=North Carolina, and 6=Tennessee) of willow oak obtained from commercial seed dealers.

2 and 3). Average yearly height growth for willow oak seedlings varied from 94 cm (37 inches) for Provenance 5 to 124 cm (49 inches) for Provenance 2, a growth difference of 32%.

Testing provenances in multiple environments (years or locations) determines how sensitive provenances are to climatic variation. A seed source that produces superior uniform performance under a range of conditions is more valuable in both the production and landscape environment than one that requires very specific conditions for optimum growth. Average height growth recorded for willow oak provenance in the study indicated Provenances 2 (124 cm), 1 (115 cm), and 6 (113 cm) to be superior to Provenance 3 (105 cm), 4 (103 cm), and 5 (94 cm) (Fig. 2). It is evident from height growth that Provenance 2 (101, 128, 129, 138 cm) and 1 (91, 114, 124, 131 cm) produced more uniform growth in the four environments than Provenance 6 (87, 158, 110, 96 cm) (Fig. 3). Superior growth performance by Provenance 6 in one environment had a major impact on the overall mean which indicates a greater sensitivity to environmental variation and a less desirable candidate for general production than Provenances 1 and 2.

SUMMARY

Shade tree producers have an opportunity to improve the performance of oak species produced commercially from seed by being more diligent in selection of seed sources. Native populations have evolved adaptations to climatic variation, which should be considered in combination with climatic zones in the projected marketing area. Ultimate planting site should vary no more than one cold hardiness zone from the seed collection site to minimize long-term environmental tree stress.

Provenances within proper climatic zones for a particular marketing area also vary in growth and environmental sensitivity. Keeping seed from known provenances separated during annual collection and monitoring subsequent growth during the production cycle, will eliminate poor performing provenances which have a direct impact on production growth rate and uniformity and ultimately on performance in the landscape environment.

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