Quality Assessment of Hardwood Seedlings

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Abstract
"Seedling quality" is an expression used to describe the extent to which a seedling may be expected to successfully survive and grow after outplanting (Duryea 1985; Mattsson 1997). For many decades, measurements of morphological and physiological characteristics have been used to predict field performance of seedlings and their ability to tolerate mechanical and environmental stresses. However, compared to conifers, literature is relatively deficient in hardwood seedling quality research. Research cooperatives such as the Purdue University/USDA-Forest Service Hardwood Tree Improvement and Regeneration Center are focusing on seedling quality, production, and regeneration problems specific to hardwood species.

Hardwood/Conifer Comparison
Foresters in both research and industry have been grading conifer seedlings for quality for many years (e.g., Curtis 1955). This is because conifers are produced in the greatest numbers worldwide. Quality assessment of hardwood seedlings has recently increased in importance as seedling demand has increased (Michler and Woeste 2002), particularly for restoration purposes (Lockhart et al. 2003). Physiological and morphological differences (e.g.,Tinus 1978; Smith et al. 1997) (Table 1) need to be accounted for when applying the concepts of conifer seedling quality assessment to hardwood species. One of the most critical differences is the lack of leaves for hardwoods during the dormant phase.

Table 1. Some key general differences between common temperate zone hardwoods and conifers that impact the way seedling quality is measured and how new quality assessment and improvement programs are implemented.

	Conifers	Hardwoods
Taxonomic family	Pinaceae; Cupressaceae; Taxodiaceae	Aceraceae; Betulaceae; Fagaceae; Hamamelidaceae; Juglandaceae; Magnoliaceae; Oleaceae; Platanaceae; Rosaceae
Growth and form	Straighter stems; central leaders; vigorous autumn root growth; evergreen needle or scale-like leaves; waxy buds strong apical dominance; slower growth	Spreading crown; deciduous; expansive root systems; numerous lateral buds; weak apical dominance; fast growth
Growth environments	Can occupy higher elevations and latitudes; better adapted to colder and drier conditions	More mesic environments and moderate temperatures; require higher fertility

Morphology
Morphological measurements of quality are commonly used with hardwood seedlings. Parameters such as height (Figure 1), root collar diameter, root volume (Figure 2), and number of first order lateral roots have been used with moderate success (Thompson and Schultz 1995; Ward et al. 2000; Jacobs and Seifert 2004), however their effectiveness depends on seedling physiology and site environmental conditions. Having a large size does not necessarily indicate viable stock at the planting site. To date, studies of different morphological tests have given inconsistent results which are likely due to different cultural practices, species, and environmental conditions.


Figure 1. Measuring height of black walnut.

Figure 2. Measuring root volume.

Physiology
Measurements of physiological activity within seedlings can give a more accurate assessment of cold hardiness, dormancy status, and overall stress resistance (Ritchie 1984). Physiological tests are practiced operationally in many locations and give reliable results. The use of improved seedling stock is one reason for the success with conifer seedlings. Other than tests of root growth potential, physiological methods have not been evaluated extensively with hardwoods. Tests of electrolyte leakage (EL) (Figures 3,4) and water potential are examples of methods that may prove useful in future hardwood research for evaluating seedling stress resistance (O'Reilly et al. 2002; Wilson and Jacobs 2004).


Figure 3. Quantifying EL from stem tissue with an electrical conductivity meter.

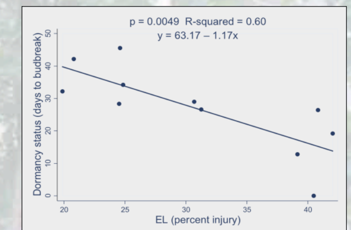

Figure 4. EL is an indicator of dormancy status in northern red oak.

Conclusions
It will be necessary to adjust timing and methodology of sampling procedures to account the deciduous nature of hardwoods. An integrated approach to quality assessment (Grossnickle et al. 1991) will likely be needed to account for the many cultural, environmental, and genetic traits responsible for variability in hardwood seedling morphology and physiology. Results from most quality tests in hardwoods thus far have given contrasting results, depending on the species, location, and researcher. Therefore, a solid consensus on methodology will be necessary. Additionally, the prevalence of improved seedling stock in conifer production has resulted in increased sensitivity and accuracy in quality testing, though hardwood seedling production has yet to reap these benefits. A greater understanding of hardwood seedling physiology, mineral nutrition, silvicultural practices, and genetic characteristics needs to be cultivated through systematic and innovative long-term studies.

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