Elastic Modulus Determination of Transgenic Aspen Using a Dynamic Mechanical Analyzer in Static Bending Mode

Balazs Horvath Ilona Peszlen Perry Peralta Laszlo Horvath
Bohumil Kasal Laigeng Li

Abstract

The applicability of a dynamic mechanical analyzer (DMA) in determining the modulus of elasticity (MOE) of 2.5-year-old transgenic aspen (*Populus tremuloides* Michx.) was investigated. Fifty sample trees with diameters ranging from 8 to 14 mm were harvested from the greenhouse. The trees were from one wild-type group and three transgenic groups. DMA was used in static bending mode to determine the MOE of samples soaked in two different plasticizers: water and ethylene glycol. In addition, dynamic MOE by a nondestructive method and static MOE by a micromechanical test were determined. Results showed that DMA measurements were accurate in showing significant differences between the genetic groups. Although notably higher MOE values were obtained for dynamic MOE and static MOE compared with the DMA measurements, the trend of elastic moduli change across the genetic groups was the same for all three methods.

Advances in genetic engineering have enabled scientists to change the content and structure of lignin in aspen trees. By manipulating the lignin biosynthetic pathway with sense and antisense genes, lignin content of quaking aspen can be reduced (Hu et al. 1999) or the syringyl/guaiacyl lignin ratio (S/G ratio) can be increased significantly (Li et al. 2001). In addition, simultaneous transfer and expression of specific genes results in both decreased lignin content and increased S/G ratio. These genetic modifications have the potential to reduce chemical consumption, energy use, and environmental impact, thus providing advantages in pulp and paper manufacture and bioethanol production (Baucher et al. 2003). However, it is not clear how these modifications will influence mechanical properties, which are crucial for solid wood and engineered wood applications. Therefore, testing the mechanical properties of young trees (1 to 3 y old) with small diameters (8 to 14 mm) is essential in answering fundamental questions of how lignin genetic engineering changes the mechanical characteristics of transgenic wood (Kasal et al. 2007) and in providing timely feedback to geneticists during field trials (Chiang 2006).

Longitudinal modulus of elasticity (MOE), one of the basic properties of wood, is usually obtained through a standard three-point bending test, and calculated from the deformation of wood under low stress in the elastic region (US Department of Agriculture Forest Service, Forest Products Laboratory 1999). Bending is an easy way to measure MOE because sample preparation does not require tedious work and it simulates the important stresses that occur in most product applications and in living trees subjected to wind load. Standard procedures for bending by ASTM D143-09 (ASTM International 2010a) require relatively large sample dimensions, which are not suitable for cylindrical materials with small diameters. To overcome this problem, micromechanical testing was developed for small-diameter trees by modifying the ASTM D143-94 standard (Kasal et al. 2007). Mechanical testing of these nonstandard specimens is usually shape dependent and requires an expensive testing machine.

Elastic modulus can also be determined by a dynamic mechanical analyzer (DMA) in static mode using submersion clamps. DMA already has enabled scientists to

The authors are, respectively, Former PhD Student, Associate Professor, Associate Professor, and Former PhD Student, Dept. of Forest Biomaterials, North Carolina State Univ., Raleigh (balihorvath@gmail.com, ilona_peszlen@ncsu.edu, perry_peralta@ncsu.edu, laszlohorvathremeczki@gmail.com); Professor, Dept. of Civil and Environmental Engineering, Pennsylvania State Univ., University Park (kasalb@engr.psu.edu); and Professor, Inst. of Plant Physiology and Ecology, Chinese Academy of Sci., Shanghai (lgli@sippe.ac.cn). This paper was received for publication in June 2009. Article no. 10641.

Forest Prod. J. 60(3):296–300.