Shoot Winter Injury and Nut Cold Tolerance: Possible Limitations for American Chestnut Restoration in Cold Environments?

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Abstract

Approximately 100 years ago, American chestnut (*Castanea dentata* (Marsh.) Borkh.) was rapidly removed as an overstory tree by the fungal pathogen *Cryphonectria parasitica* (the causal agent of chestnut blight). Currently, the most effective method of restoration involves the hybridization of American chestnut with the highly blight-resistant Chinese chestnut (*Castanea mollissima* Blume), with subsequent backcrossing of resistant stock to American chestnut sources. However, preliminary evidence suggests that backcross material may not have the cold hardiness needed for restoration in the north. Two factors that can significantly influence cold tolerance are plant genetics and environmental parameters (e.g., cold exposure of plant tissues). Also, the cold tolerance of nuts is of concern because reproductive tissues are particularly sensitive to freezing damage. To contribute to the successful restoration of American chestnut in the north, the focus of this research was to analyze the cold tolerance of American chestnut through 1) an assessment of first-year growth and shoot winter injury of a range of American and Chinese chestnut and red oak (*Quercus rubra* L., a native competitor) seedlings under three silvicultural treatments (open, partial, and closed canopies) in the Green Mountain National Forest, Vermont, and 2) the comprehensive evaluation of nut cold tolerance for a range of American and Chinese chestnut nuts and red oak acorns. We examined American chestnut sources by temperature zones (warm, moderate, or cold) that differentiated sources based on winter low temperatures in the areas where they originated.

Seedlings grown under open canopies exhibited greater growth than seedlings grown under partial and closed canopies, but also experienced increased shoot winter injury. Chinese chestnut seedlings had significantly greater growth, but also experienced greater winter injury than American chestnut and red oak seedlings. Among American chestnut sources, seedlings from sources from warmer, low-elevation southern and central locations grew more, but experienced greater winter injury than seedlings from sources from the colder north. Additionally, nuts of Chinese chestnut were significantly less cold-tolerant than either American chestnut nuts or red oak acorns. Among American chestnut sources, nuts from warm and moderate temperature zones exhibited similar levels of cold tolerance, but were significantly less cold tolerant than nuts from the cold temperature zone. There were significant differences among sources within the warm and moderate temperature zones, but not among sources within the cold temperature zone. We believe that the temperature zone index may provide a reliable guide for targeting sources with lower winter shoot injury and greater nut cold tolerance. Our results suggest that both silvicultural treatment and genetic selection can influence growth and winter injury of American chestnut at the northern limit of its range. There was also a strong correlation between nut cold tolerance and winter shoot injury, suggesting that nut cold tolerance measurements (that can be obtained in weeks rather than years) may be a reasonable screening tool for identifying sources with greater shoot hardiness.

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