Resistance of Canada Yew (*Taxus canadensis*) Branch Wood to Two Wood Decay Fungi

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Richter, Dana L., Amy M. Berns, and Clare F. Frederick. 2012. Resistance of Canada Yew (*Taxus canadensis*) branch wood to two wood decay fungi. Canadian Field-Naturalist 126(2): 160–163.

Wood of the larger yews (*Taxus* spp.) is reported to be decay-resistant, but little is known about the decay resistance of Canada Yew (*Taxus canadensis* Marsh.) wood. Branch wood from Canada Yew was compared to branch wood from Northern Red Oak (*Quercus rubra* L.) and Eastern White Cedar (*Thuja occidentalis* L.) in a standard laboratory decay test to evaluate its resistance to decay by two decay fungi. Canada Yew was shown to be significantly more resistant to decay by *Gloeophyllum trabeum* (Pers.) Murr. (a brown rot fungus) and *Trametes versicolor* (L.: Fr.) Quél. (a white rot fungus) than Northern Red Oak ($P \leq 0.05$). Canada Yew was shown to be equal to Eastern White Cedar in resistance to decay by *G. trabeum* and more than twice as resistant to decay by *Trametes versicolor* ($P \leq 0.05$). These results may have relevance for survival of Canada Yew, which is under pressure from browsing by White-tailed Deer (*Odocoileus virginianus*).

Key Words: Canada Yew, *Taxus canadensis*, *Gloeophyllum trabeum,* brown rot fungi, *Trametes versicolor,* white rot fungi, White-tailed Deer, *Odocoileus virginianus,* decay resistance, decay fungi, browse.

Canada Yew (*Taxus canadensis* Marsh.) is an evergreen woody shrub native to northeastern North America. It has gained attention in recent years, partly because of the presence of the anti-cancer chemical paclitaxel (Cameron and Smith 2002) and partly because of the apparent decline of the shrub due to over-browsing by White-tailed Deer (*Odocoileus virginianus*) (Holmes et al. 2009; Windels and Flaspohler 2011.

The genus *Taxus* contains seven species of trees and shrubs, principally of temperate regions (Harlow and Harrar 1969). Although wood of the larger yews is reported to be decay-resistant, little is known about the decay resistance of Canada Yew wood because of its small size. The related species, English Yew (*Taxus baccata*) and Pacific Yew (*T. brevifolia*), attain the size of small trees and their wood is of modest commercial importance (Harlow and Harrar 1969; Thomas and Polwart 2003). The wood of both of these species is considered strongly decay-resistant (U.S. Forest Products Laboratory 1974; Rayner and Boddy 1988), although this is based on field observations, and actual laboratory decay tests of the woods of these species are not known (see Thomas and Polwart (2003) for *T. baccata* and U.S. Forest Products Laboratory (1967) for *T. brevifolia*).

Decay fungi associated with *Taxus baccata* and *T. brevifolia* include many common and non-specific brown rot and white rot species found on conifer species worldwide. de Vries and Kuyper (1990, *cited in* Thomas and Polwart 2003) list 73 Basidiomycotina decay fungi associated with *T. baccata*. Farr et al. (1989) cite references that include 12 species of Basidiomycotina decay fungi associated with *T. brevifolia*. Although nothing is cited with respect to the decay organisms of Canada Yew (Farr et al. 1989), it is likely that a similar range of fungi are responsible for the decay of its wood, since the fungi associated with the larger yews are found on many woody species (Rayner and Boddy 1988; Schmidt 2006).

Wood decay takes place principally by the action of brown rot and white rot fungi (Rayner and Boddy 1988; Schmidt 2006). The fungi responsible for wood decay are commonly Basidiomycotina, although a few Ascomycotina white rot fungi are important decay organisms in forest ecosystems (Rayner and Boddy 1988; Schmidt 2006). Brown rot fungi act on the cellulose component of wood, leaving a brown residue consisting mostly of lignin (Rayner and Boddy 1988; Schmidt 2006). White rot fungi act on both the lignin and the cellulose components of wood (sometimes called simultaneous rot), leaving a white residue (Rayner and Boddy 1988; Schmidt 2006). There are far more white rot fungi than brown rot fungi (Schmidt 2006); however, both decay types are commonly used in wood decay resistance tests (ASTM 2005).

Canada Yew remains a shrub throughout its life, and its wood is rarely if ever used for structural or other purposes (Harlow and Harrar 1969). General botanical characteristics of Canada Yew are given in a U.S. Department of Agriculture technical report on the species (Martell 1974). However, apparently because it is not used as a woody species, there is no mention of its decay properties. Likewise, in the extensive list of fungi of plants of the United States, Farr. et al. (1989) cite no wood decay fungi associated with Canada Yew.

To provide information about the decay resistance of Canada Yew, we exposed mature branch wood to a brown rot fungus and a white rot fungus in a standard laboratory decay test. The decay of Canada Yew was compared with the decay of branch wood of Northern Red Oak (*Quercus rubra* L.), a species susceptible to decay, and branch wood of Eastern White Cedar (*Thuja* *occidentalis* L.), a decay-resistant species (Rayner and Boddy 1988).

Methods

All plant material was collected in Houghton County, Michigan (47.10248°N, 88.51702°W), from live, healthy plants growing in the wild, free from decay or other defects. Branches of Canada Yew were collected from a putative clone approximately 10 m in diameter and 1 m in height. Lateral lower branches of Eastern White Cedar and Northern Red Oak were collected from four small trees of each species less than 5 m in height. Two to three branches 30 to 60 cm long and 1.0 to 1.5 cm in diameter were cut from each tree species.

Pieces 2.5 cm long with the bark left intact were cut from the branches for the decay test. Pieces were combined within species, and 20 pieces from each species were selected for uniformity (roundness, free from knots, etc.) for the decay test (10 for each of the two fungi tested). Branch pieces were labeled and dried to a constant weight at 40°C for 24 h, and individual weights were recorded. Pieces were sterilized in an autoclave for 15 min prior to being inserted in jars and inoculated with decay fungi, as described below.

Branch pieces were exposed individually to pure cultures of fungi following a standard decay testing protocol (ASTM 2005). The brown rot fungus *Gloeophyllum trabeum* (Pers.) Murr. (Gloeophyllaceae), American Type Culture Collection isolate no. 11539, and the white rot fungus *Trametes versicolor* (L.) Lloyd (Polyporaceae), American Type Culture Collection isolate no. 12679, were used. Fungi were grown on 2% malt agar (Difco) in 100 mm Petri plates for approximately one week at 22°C–24°C prior to use. A square jar (5 × 5 × 13.5 cm) containing 100 g (range 99–101) of dried (50°C) forest topsoil was wetted with 30 mL (range 29–31) of distilled water to obtain a soil moisture holding capacity of 90%–100%. The pH of the soil was 5.8–6.0 (1:1 soil to water). A plastic lid with a hole 5 mm in diameter covered by a strip of adhesive cloth tape was placed tightly on the jar to allow respiration, and jars were autoclaved for 30 min. After the jars had cooled, a piece of agar inoculum approximately 1 × 2 × 0.5 cm colonized by the fungus from the actively growing culture was placed on the soil surface in the jar, and a branch piece was pressed firmly into the inoculum. Jars were incubated at 27°C (range 26–28) and a relative humidity of 80% (range 80–84). Ten replicate branch pieces were used for each woody species/fungus test.

After 16 weeks, the branch pieces were removed from the jars, were re-dried to a constant weight at 40°C for 24 h, and were weighed to determine weight loss due to decay. Mean percentage weight loss of replicate sets by woody species/fungus exposure within decay type were compared by one-way ANOVA, followed by Tukey's test to identify significant differences between means ($P \leq 0.05$) (Sigma Plot 12, 2010*).

Results

At the end of the incubation period, branch pieces were examined for colonization by fungi to note amount and type of coverage by mycelium. All branch pieces were colonized, and no contamination by mold fungi was present. Canada Yew branch pieces had light colonization overall by both *Gloeophyllum trabeum* and *Trametes versicolor*, Eastern White Cedar was colonized least by *G. trabeum*, and Eastern White Cedar and Northern Red Oak were moderately to heavily colonized by *Trametes versicolor*.

For both *G. trabeum* (brown rot) and *Trametes versicolor* (white rot), mean percentage weight loss due to decay was least for Canada Yew. The woody species most susceptible to decay by *G. trabeum* was Northern Red Oak (mean percentage weight loss of 12.8%), which differed significantly from Canada Yew, (mean percentage weight loss of 6.2%), and from Eastern White Cedar, (mean percentage weight loss of 7.7%) (Figure 1). The woody species most susceptible to decay by *Trametes versicolor* was Northern Red Oak (mean percentage weight loss of 62.2%), which differed significantly from Eastern White Cedar, (mean percentage weight loss of 37.4%), and from Canada Yew (mean percentage weight loss of 16.5%) (Figure 2). These data confirm that Northern Red Oak is susceptible to decay and that Eastern White Cedar is decay-resistant. Canada Yew is also shown to be a decay-resistant species.

Discussion

Although other species of fungi are likely to attack Canada Yew branches in the wild, *Gloeophyllum trabeum* and *Trametes versicolor* are considered "typical" decay fungi commonly used to represent a range of brown rot and white rot fungi in standard decay testing (ASTM 2005). Both fungi occur within the geographical ranges of the woody species tested (Gilbertson and Ryvarden 1986). The results indicate that Canada Yew branches are more resistant to decay than Northern Red Oak when exposed to *G. trabeum* (brown rot) and *Trametes versicolor* (white rot). Compared to Eastern White Cedar, Canada Yew branches are equal in resistance to decay by *G. trabeum* and more than twice as resistant to decay by *T. versicolor*.

Canada Yew is a native shrub species that is considered to be in decline across its natural range due to several factors (Holmes et al. 2009; Windels and Flaspohler 2011). One factor proposed for the decline of Canada Yew is over-browsing by White-tailed Deer. For example, in their comprehensive review of the ecology of Canada Yew, Windels and Flaspohler (2011) state that larger patches (>1 ha) are browsed mainly on the outer portions of the clone, and they suggested this pattern was due to the fact that White-tailed Deer have difficulty penetrating the inner portions due to the stiffness and density of its branches. Results of our study of the decay resistance of Canada Yew support the obser-

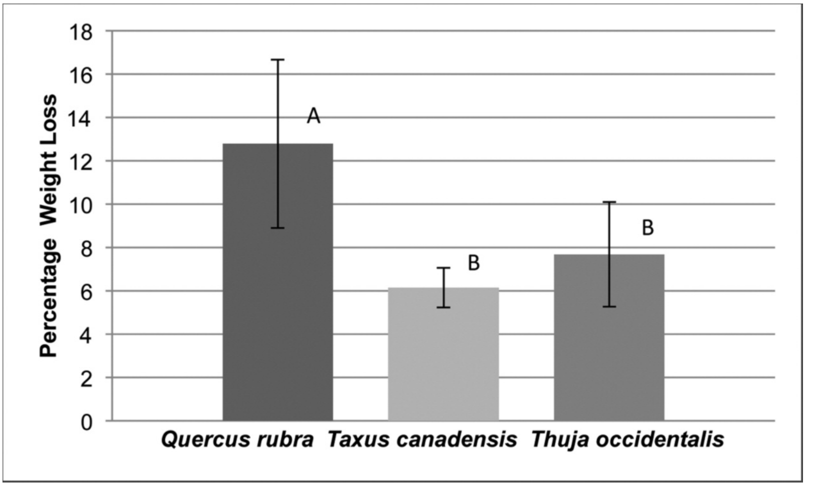

FIGURE 1. Mean percentage weight loss of branch pieces of the woody species Canada Yew (*Taxus canadensis*), Northern Red Oak (*Quercus rubra*), and Eastern White Cedar (*Thuja occidentalis*) by the brown rot fungus, *Gloeophyllum trabeum* ATCC 11539 (n = 10 for each woody species). Bars with different capital letters are significantly different (ANOVA $P \leq 0.05$); lines within bars represent the standard deviation.

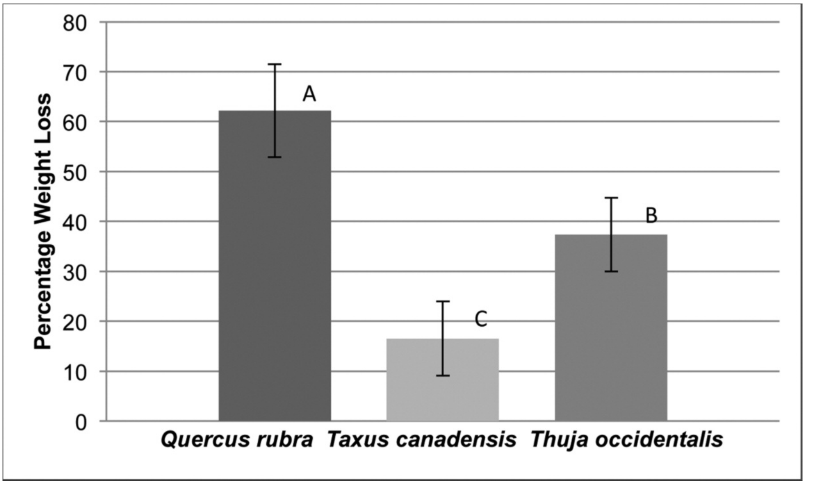

FIGURE 2. Mean percentage weight loss of branch pieces of the woody species Canada Yew (*Taxus canadensis*), Northern Red Oak (*Quercus rubra*), and Eastern White Cedar (*Thuja occidentalis*) by the white rot fungus, *Trametes versicolor* ATCC 12679 (n = 10 for each woody species). Bars with different capital letters are significantly different (ANOVA $P \leq 0.05$); lines within bars represent standard deviation.

vation that dead branches remain stiff and intact for long periods in nature (i.e., they are resistant to decay), thus deterring White-tailed Deer from browsing the interior portions of a clone or patch and providing “refugia” (Windels and Flaspohler 2011) for sexually reproducing branches on the interior of the clone or patch.

Acknowledgements

The authors acknowledge financial support from GMO LLC, Boston, Massachusetts, and Dr. Andrew J. Storer, School of Forest Resources and Environmental Sciences, Michigan Technological University, Houghton, Michigan; additional appreciation is extended to Dr. Storer for reviewing the manuscript and to two anonymous reviewers.

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Received 22 June 2012
Accepted 8 August 2012