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Effects of seedling age on blister rust resistance assessments in eastern white pine and its hybrid backcrosses

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Abstract: Seedling age at the time of artificial white pine blister rust (*Cronartium ribicola* J.C. Fisch.) inoculation can affect the duration and accuracy of resistance assessments for eastern white pine (*Pinus strobus* L.) and its hybrid backcrosses and thereby affect advances in breeding programs intended to enhance genetic resistance to the pathogen. Based on postinoculation seedling mortality rates, up to 5 years were required to rank resistance of eastern white pine genotypes when seedlings were inoculated with *C. ribicola* at 2 years of age compared with less than 2 years when they were inoculated after the first growing season. In this study, we evaluated and compared consistency of genotype rankings in seedling mortality rates between the two inoculation approaches. Assessment results from inoculating seedlings after the first growing season proved as reliable as those achieved by inoculating them after the second growing season. Inoculating seedlings at a younger age not only substantially reduced experimental time and costs but also allowed a larger number of seedlings to be screened for resistance, leading to higher experimental precision.

Résumé : L'âge des semis au moment de l'inoculation artificielle avec la rouille vésiculeuse du pin blanc (*Cronartium ribicola* J.C. Fisch.) peut influencer la durée et la justesse des évaluations de la résistance du pin blanc (*Pinus strobus* L.) et de ses hybrides issus de rétrocroisements et, par conséquent, avoir un impact sur les progrès réalisés dans les programmes d'amélioration visant à augmenter la résistance génétique au pathogène. Sur la base du taux de mortalité des semis à la suite de l'inoculation, il était nécessaire d'attendre jusqu'à 5 ans pour classer les génotypes de pin blanc en fonction de leur résistance lorsque les semis étaient inoculés avec *C. ribicola* à l'âge de 2 ans, comparativement à moins de 2 ans lorsqu'ils étaient inoculés après la première saison de croissance. Dans cette étude, nous avons évalué et comparé la cohérence des classements des génotypes basés sur le taux de mortalité des semis selon deux approches d'inoculation. Les résultats de l'inoculation des semis après la première saison de croissance se sont avérés aussi fiables que les résultats obtenus en les inoculant après la deuxième saison de croissance. Le fait d'inoculer des semis plus jeunes n'a pas seulement réduit de façon substantielle les coûts et la durée de l'expérimentation mais a également permis de tester la résistance d'un plus grand nombre de semis et d'obtenir ainsi une plus grande précision expérimentale.

[Traduit par la Rédaction]

Introduction

White pine blister rust, caused by *Cronartium ribicola* J.C. Fisch., has contributed to the dramatic decline of native five-needle pine species in North America (Samman et al. 2003). Although natural resistance to *C. ribicola* may be weak in native eastern white pine (*Pinus strobus* L.) populations, research has shown that breeding to enhance genetic resistance can be effective and may provide a promising option to restore eastern white pine on the landscape (Heimburger 1972; Kriebel 1983; Jurgens et al. 2003; Smith et al. 2006*a*, 2006*b*; Sniezko 2006; Lu and Derbowka 2009).

Genetic resistance to *C. ribicola* in five-needle pine species has been assessed in many artificial inoculation experiments (Hoff and McDonald 1980; Kinloch and Comstock 1980; Hunt 2002, 2004; Jurgens et al. 2003; Lu et al. 2005; Sniezko et al. 2008). In an artificial pathogen inoculation, white pine seedlings are exposed to *C. ribicola* basidiospores in a moisture- and temperature-controlled inoculation tent or chamber with conditions optimized for infection (Jurgens et al. 2003; Hunt 2004). Compared with long-term field studies of white pine naturally infected by blister rust, artificial inoculation can reduce experimental timeframes and increase experimental precision by allowing more uniform distribution of pathogen inoculum at higher inoculum density (Lu and Derbowka 2009).

Various approaches are used to assess resistance of inoculated white pine seedlings. Many articles have been published over the past several decades to describe white pine resistance reactions to blister rust infection, including needle morphological barriers to pathogen invasion (Woo et al. 2001; Smith et al. 2006*a*), patterns of needle reaction to infection and stem canker development (McDonald and Hoff 1970, 1971; Hoff and McDonald 1971, 1980; Kinloch and Byler 1981; Hunt 1997, 2002, 2004), histopathology of pathogen

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