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ORIGINAL ARTICLE

Frost tolerance of two-year-old *Picea glauca* seedlings grown under different irrigation regimes in a forest nursery

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Abstract

This study examined the impact of increased irrigation efficiency on the hardening and frost tolerance of 2-year-old containerized white spruce seedlings in the context of groundwater protection, irrigation management and the maintenance of seedling quality in northern climates. The seedlings were grown under three different irrigation regimes (IR = 30%, 40% and 55% v/v; cm^3 H_2O/cm^3 substrate) and were hardened under conditions of natural photoperiod and temperature. After being subjected to artificial frost tests on four sampling dates during autumn, the seedlings were compared for bud development and frost tolerance. IR had no influence on frost tolerance as determined by measurements of physiological (electrolyte leakage, root water loss) and morphological (shoot damage, root initiation) variables. At the end of the second growing season, there was no significant difference between IRs in seedling height, root collar diameter, shoot dry mass and root dry mass. The results indicate that the amount of water applied to large-dimension 2-year-old white spruce seedlings during the growing season can be significantly decreased without prematurely impeding their growth or hindering their acquisition of frost tolerance.

Keywords: *Cultural practices, freezing damage, hardening, irrigation.*

Introduction

Frost damage is one of the principal reasons that millions of seedlings are rejected each year in northern forest nurseries (Colombo, 1997). In the province of Québec in eastern Canada, seedlings are kept outside during winter and annual rejection rates due to freezing damage can reach 5–30% (Lamhamedi et al., 2005). Seedlings are sorted and classified in the nursery, but some damage to roots from freezing cannot be readily detected without destructive sampling (Bigras & Dumais, 2005). This is why plants whose roots have been damaged by frost are sometimes still delivered to reforestation sites (Bigras, 1995). Severe root damage has negative effects on growth and physiology of seedlings after outplanting (Coursolle et al., 2002; Dumais et al., 2002).

The acquisition of seedling frost tolerance begins with the cessation of height growth and the initiation of bud formation (Sakai & Larcher, 1987). Manipulation of the irrigation regimes (IRs) and the use of water stress in containerized tree seedling nurseries have been found to be one of the most effective cultural practices to initiate the hardening of seedlings (Landis et al., 1989). Towards the end of the growing season in the autumn (fall), seedling producers decrease fertilization and irrigation in temperate and boreal regions of North America. This practice induces bud formation and supports hardening (Landis et al., 1989; Silim & Lavender, 1994). However, it is still not clear to what extent the

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