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Effects of artificial shade on early performance of white spruce seedlings planted on clearcuts

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Abstract Chlorophyll fluorescence, chlorophyll content, growth, and mortality of white spruce (*Picea glauca* [Moench] Voss) seedlings were monitored for 2 years after planting under three scenarios of artificial shade: no-shade (control), shade in summer only, and shade all year. The shade frames allowed 50–60% light transmission, with limited effects on air temperature, relative humidity, soil temperature, and soil moisture around seedlings. Based on fluorescence yield and chlorophyll content measurements, summer-only shade reduced photoinhibition and photooxidation, especially in summer and fall; extending to all year shading did not further reduce either photoinhibition or photooxidation. Shade tended to reduce seedling diameter and mortality, but after 2 years the cumulative effect on mortality was not statistically significant. Study results support the establishment of white spruce seedlings under partial forest canopy, especially on sites with harsh environmental conditions.

Keywords Photoinhibition · Fluorescence · Chlorophyll content · Mortality

Introduction

White spruce (*Picea glauca* [Moench] Voss) is sensitive to planting stress and during the first few years after planting growth is often restricted and needles can become chlorotic (Vyse 1981; Burdett et al. 1984; Nienstaedt and Zasada 1990). Planting stress can lead to seedling mortality (Mullin 1963; Vyse 1981; Burdett et al. 1984), which according to a

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