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SHORT COMMUNICATION

^{15}N-uptake in *Abies lasiocarpa* and *Abies nordmanniana* at low root temperatures

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Abstract
Low soil temperatures limit nutrient uptake with negative consequences for growth and foliage quality. A better understanding of the temperature sensitivity of root N uptake is required to improve the best management practices for fertilization of conifers. Uptake of ^{15}N in saplings of *Abies lasiocarpa* (Hook) Nutt and *Abies nordmanniana* (Steven) Spach was studied at root temperatures of 3–15°C in hydroponics. ^{15}N accumulation in shoots increased with temperature, showing accelerated accumulation from 7°C upward. At 3°C, uptake rates were low for both species. Between 7 and 12°C, ^{15}N accumulation in shoots increased by a factor of 5 in *A. lasiocarpa* and by a factor of 3 in *A. nordmanniana*. The temperature response of N uptake was similar to root growth responses to temperature documented by previous studies. The results have implications for early season fertilization, where fertilization of both species should be withheld until soil temperatures reach 10–12°C.

Keywords: *Nitrogen, nordman fir, nutrient uptake, subalpine fir, soil temperature.*

Introduction

Low soil temperatures limit nutrient acquisition and growth of vegetation in cold climates through effects on physical and chemical properties of soil and soil water, soil microbiology, and plant root growth and physiology (Pregitzer & King, 2005). Different plant traits have contrasting responses to temperature (e.g. Cheng, 2009), but for root growth a soil temperature of 6°C seems to be a minimum temperature in many temperate and boreal trees (Alvarez-Uria & Körner, 2007). In terms of nutrient uptake there seem to be differences among species in their responses to soil temperature (Atkin & Cummins, 1994), and off-season nutrient uptake has been documented for several species (Amponsah et al., 2004; Andresen & Michelsen, 2005; Domisch et al., 2002). During snow-melt and early spring, N availability is elevated both in soils that have been frozen or remained unfrozen under snow (Brooks et al., 1998). This pulse is important for N dynamics of alpine vegetation although the ability to exploit N resources in spring differs between growth forms (Bilbrough et al., 2000). Further, spring fertilization with ammonium and nitrate is used in commercial silviculture, but to improve fertilization practices more knowledge is needed about the temperature responses of early-season nutrient uptake in conifers.

Both *Abies nordmanniana* (Steven) Spach from high-altitudes in the Rocky Mountains and *Abies lasiocarpa* (Hook) Nutt from the Caucasian Mountains south and east of the Black Sea (Liu, 1971) are cultivated for Christmas tree production under similar North-European conditions. Their different origin and contrasting growth responses to temperature and climate would imply that their ability to benefit from early-season fertilization may differ. In this study we quantify nitrogen uptake at low temperatures and test the hypotheses that: (1) *A. lasiocarpa* has a lower base temperature for uptake of N than *A. nordmanniana*; and (2) *A. lasiocarpa* has a higher N uptake at lower temperatures than *A. nordmanniana*.

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