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Effects of soil frost on the growth and longevity of fine roots in Norway spruce

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Introduction

The occurrence of soil frost, common in the northern hemisphere, depends on the quality of the snow cover, which is predicted to change in the future. We studied how soil freezing and its prolonged thawing affect the biomass, growth, and longevity of fine roots in 50-year-old Norway spruce (*Picea abies* L. Karst).

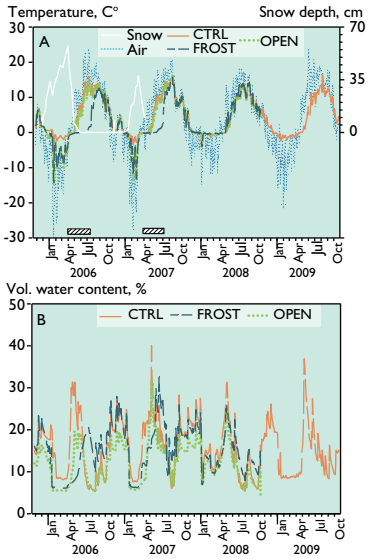

Fig. 1. Air and soil temperature (A) and soil volumetric moisture content (B) (at the depth of 5 cm). In A, the snow cover in 2005/06 and 2006/07 is given for CTRL only, for the snow was removed in OPEN and FROST. The insulation periods in FROST are indicated with vertical bars in A.

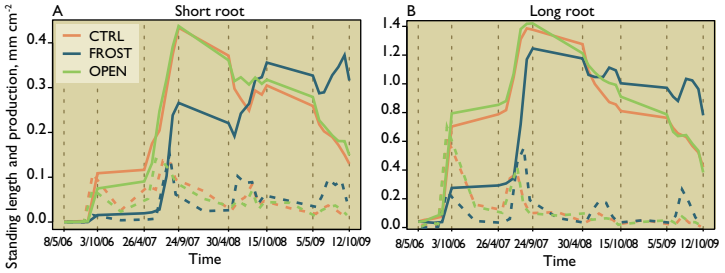

Fig. 2. The standing length (**continuous line**) and production volume (**dashed**) of live roots by treatment as a function of time for short (A) and long (B) roots.

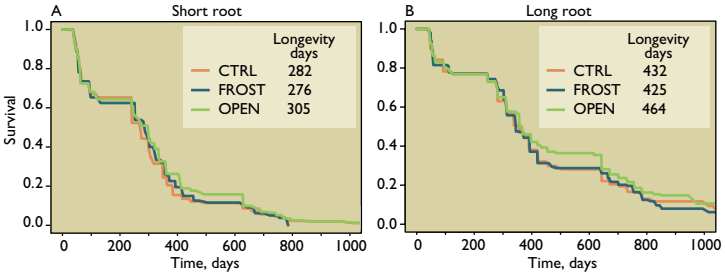

Fig. 3. Survival function and mean root longevity for short (A) and long (B) roots by treatment.

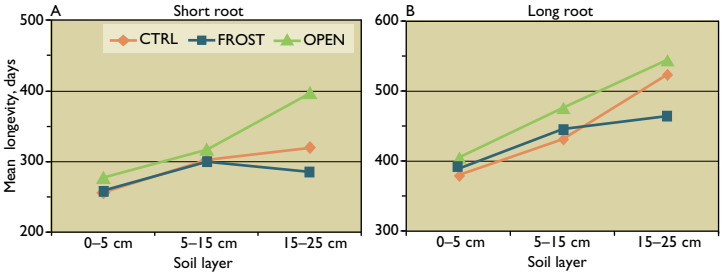

Fig. 4. Mean longevity of short (A) and long (B) roots by treatment as a function of soil depth.

Material and methods

- The stand was in the boreal coniferous zone inEastern Finland (62°36'N, 29°43'E, 84 m a.s.l.).
- The treatments with three replicate plots in two winters 2005/06 and 2006/07:
  - Natural snow cover (CTRL)
  - Snow removal during winter (OPEN)
  - As in OPEN, but the soil surface was insulated in late winter (FROST).
- The air and soil temperature and the soil moisture were monitored (Fig. 1).
- In autumn 2005, 27 minirhizotron tubes (3 tubes/plot) were installed at an angle of ca. 30°.
- Imaging (Bartz BTC-100X) and image analysis by RootView at one-month intervals in the four growing seasons between 2006 and 2009.
- The standing length and production volume of short and long roots (divided by the total imaging area) and their mean longevity were calculated.
- On interval-censored data, the survival function was estimated by means of nonparametric maximum likelihood estimation (NPMLE).

Results

- In 2007 the standing length of short and long roots was less in FROST than in CTRL and OPEN, but in 2008 and 2009 it was more (Fig. 2).
- In 2007 the production of short and long roots (judged by elongation) was delayed, and in 2008 and 2009 it was higher in FROST than in CTRL and OPEN (Fig. 2).
- The survival function of roots in OPEN differed from that in CTRL and FROST (Fig. 3).
- The lifetime of the roots was longer for the long ones than the short ones and longer in OPEN than in CTRL and FROST (Fig. 3 and Fig. 4).
- Root longevity increased with soil depth (Fig. 4).

Conclusions

- The standing length and production volume of roots were negatively affected by delayed soil thawing, but the roots were able to recover from these negative effects.
- Deep soil frost with a thin snow cover increased root longevity.
- Single winters with a thin snow cover may not be harmful for Norway spruce.

Acknowledgements

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