Responses of Scots pine to wintertime flooding

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Introduction

- Climate change may increase the risk of flooding in winter and early spring in boreal forests.
- Flooded soil is low in oxygen, which disturbs root and rhizosphere function. Also, metabolism and growth of plants can be severely affected.
- The aim of this study was to evaluate the effects of flooding and soil frost on Scots pine saplings during their winter dormancy.

Material and methods

- Four-year-old Scots pine saplings from a forest plantation site were replanted into root containers (Fig 2, Table 1).
- The FLOOD and FROST treatments took place during winter.
  - *FLOOD: the pots were filled with lake water.*
  - *NONFLOOD.*
  - *FROST: soil temperature -2 ºC.*
  - *NONFROST soil temperature +2 ºC.*
  - *FROST+FLOOD: soil was frozen after water addition.*
- Needles were sampled for dark-adapted chlorophyll fluorescence (Fv/Fm), water potential and starch analyses.
- Trunk sap flow was measured by a heat balance method by two trees per treatment.
- The biomass of the above-ground parts of the trees was measured.

Figure 2. The study was performed in a special type of growth chambers, dasotrons, where air and soil conditions can be controlled independently. Photo: Eija Koljonen.

Results

- Soil:
  - *Oxygen concentration was low in the flooded pots during the simulated winter (Fig 3).*
- Shoots:
  - *Chlorophyll fluorescence: recovery after low levels in the winter (Fig 4).*
  - *The lowest sap flow was recorded in FROST+FLOOD after the treatments (Fig 5).*
  - *FROST reduced foliar water potential in winter and in the beginning of the following growing season (Fig 6).*
  - *FROST increased starch concentration in the needles in the following growing season (Fig 7).*
  - *FROST tended to decrease shoot growth (Fig 8).*

Figure 1. Springtime flooding in the forest in Karsikko, Joensuu. Photo: Leena Karvinen.

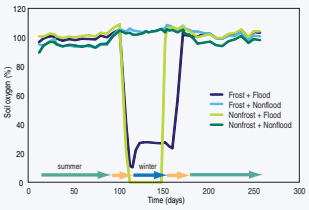

Figure 3. Six weeks flooding caused hypoxia in soil. Time refers to days from the beginning of the experiment.

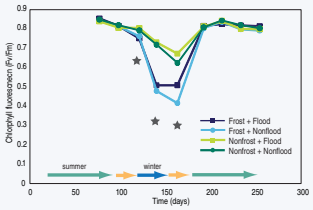

Figure 4. Chlorophyll fluorescence (Fv/Fm) in the needles. Stars indicate the difference between the frost treatments (P<0.05).

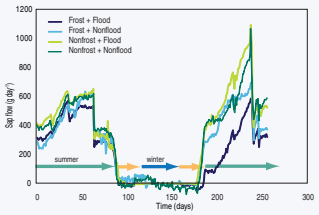

Figure 5. Trunk sap flow.

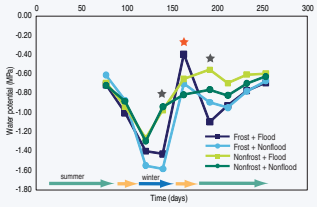

Figure 6. Water potential in the Scots pine needles. Stars indicate differences between the frost (★) and flood (★) treatments (P<0.05).

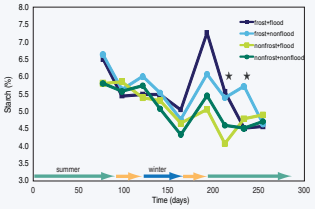

Figure 7. Starch concentration in the needles. Stars indicate the difference between the frost treatments (P<0.05).

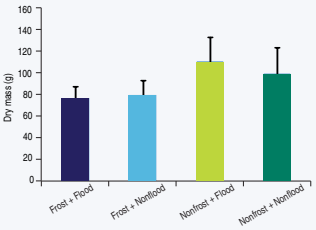

Figure 8. The biomass of current year needles in Scots pine saplings. Means + SD.

Table 1. Chamber conditions during the experiment. The season was changed gradually.

	Growth season I		Winter	Growth season II	
Duration (weeks)	9	3	6	9	3
Photon flux density (µmol m^{-2} s^{-1})	300	200	200	300	200
Photoperiod (day/night) h	18/6	6/18	6/18	18/6	6/18
Air temperature (day/night) °C	20/15	20/15	4/2	20/15	20/15
Soil temperature –FROST –NONFROST	15	15	- 2 +2	15	15

Conclusions

- In general, pines tolerated hypoxic root conditions during the dormancy period.
- Soil frost caused water stress, changes in carbohydrate metabolism and reduced shoot growth. Root growth analyses are in progress.

Acknowledgments

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