Effects of boron fertilization in the nursery or after planting on the performance of Norway spruce seedlings on boron-poor sites

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Boron deficiencies are wide-spread globally

Many forest soils in Finland are poor in boron (B), especially fertile (nitrogen-rich) soils and peatlands

Macronutrient fertilisation of boreal podzol sites and drained peatlands have triggered B deficiencies

Physiological roles of boron

- A fundamental role in the formation of the pectic structure in primary cell walls in plants
  - Impaired development of the primary cell wall in B-deficient trees → disorders in the structural development of organs and whole plants
- There are indications that B has other roles:
  - Membrane related functions
  - Expression levels of a number of genes

Symptoms of B deficiency

Boron deficiency causes loss of apical dominance in trees

Failure of budburst in the apical bud (white circle)

→ stunted, bushy appearance of trees
→ recovery in response to B fertilization

Restricted root growth

Lehto et al. 2010:
Boron in forest trees and forest ecosystems
Forest Ecology and Management 260: 2053–2069

Repeated top dieback in severely B-deficient *P. abies*
(Finland, photo Tenho Hynönen)

Recovery after B fertilization in *P. abies*
(Finland, photo Tenho Hynönen)

Lehto et al. 2010: Boron in forest trees and forest ecosystems
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Experiments

We studied the effects of extra B fertilization on growth and morphology in one- and two-year-old Norway spruce seedlings.

The experiments were carried out in Central Finland, Suonenjoki

Boron was applied in a nursery and/or after planting in a nursery-field and in a reforestation site, both known to be low in B.

B fertilization treatments at the nursery:

	Extra B, mg m^{-2}	Total B, mg kg^{-1} needles
1.*	0	19
2.	13	19
3.	29	24
4.*	55	28
5.	109	41
6.*	218	82
7.	218	119
8.	1744	419

* B treatments that were given for the seedlings that were used in the field experiments

Previous studies:	Foliar B concentration
Deficiency	4 mg kg^{-1}
Optimum	20-30 mg kg^{-1}
Toxicity	53-400 mg kg^{-1}

Nursery-field experiment

- One-year-old seedlings were planted in 2007
- Fine sandy soil with a layer of silt-clay-peat mixture
- Extremely low in B (0.12 mg kg^{-1} in the top-soil)
- Severe B deficiency symptoms in Norway spruce seedlings

- 3 nursery B fertilization treatments
- Four blocks (10 9 m)

  → two plots: B fertilization after planting (400 mg B m^{-2})
  no B fertilization

- Nutrient concentrations were followed for 4 years
- Growth and number of leaders were measured for 5 years

Reforestation experiment

- Clear-cut stand of medium fertility, podzol soil
- Spot-mounded
- Relatively low in B (1.6 mg kg^{-1} in the top-soil)

- 3 nursery B fertilization treatments
- Four blocks (26 × 42 m)

  → two plots: B fertilization after planting (200 mg B m^{-2})
  no B fertilization

- Nutrient concentrations were followed for 5 years
- Growth and the number of leaders were measured for 4 years

Nursery experiment

- The extra B applied in the nursery increased the B concentration in the needles in a direct relation to the amount of B fertilizer

- No effect on the N concentration of the needles nor growth and morphology

- Even the highest foliar B concentration (c. 400 mg kg^{-1}) did not have harmful effects on the seedlings

→ We were not able to determine the toxicity threshold

Nursery-field experiment

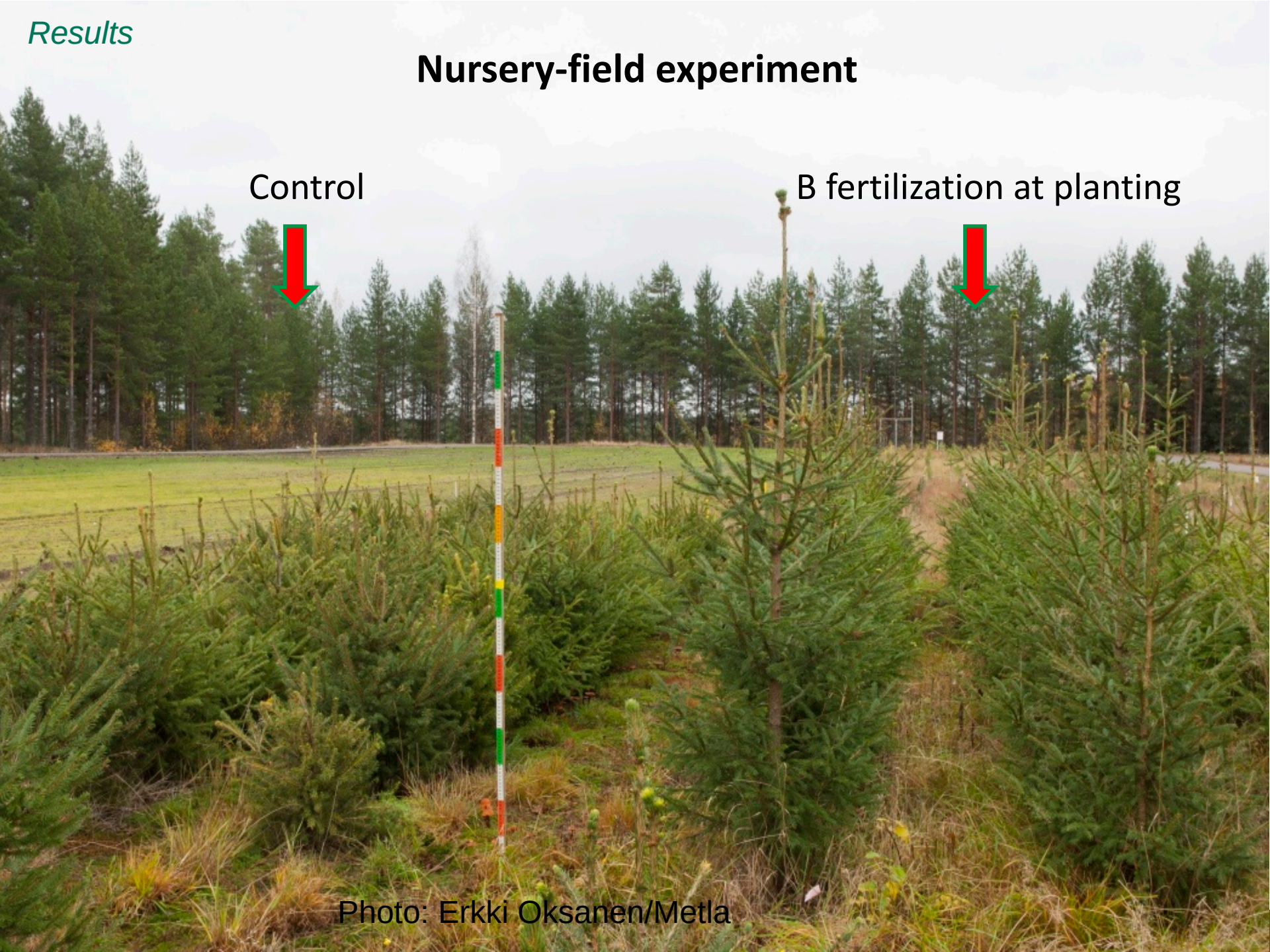
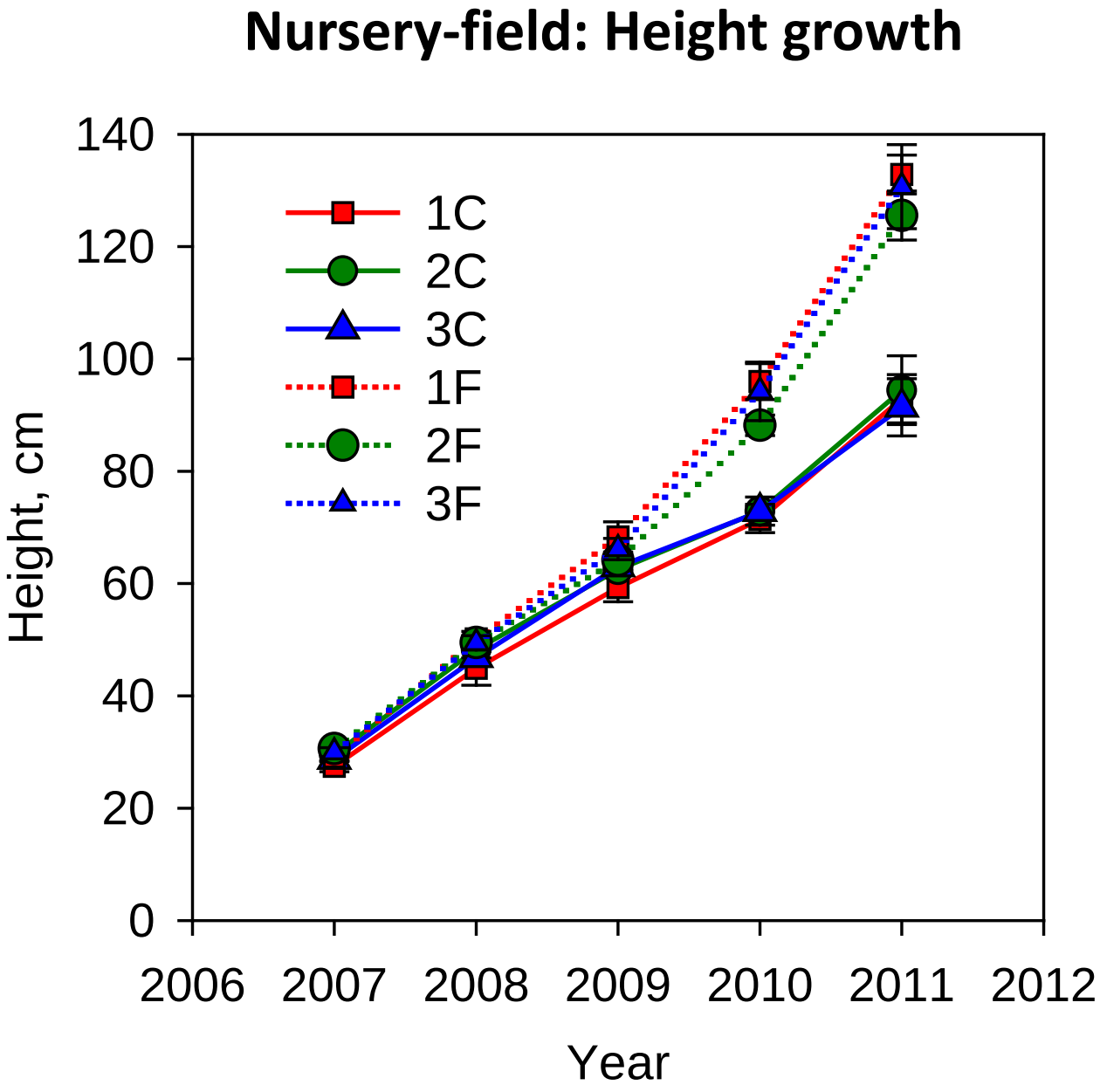


Photo: Erkki Oksanen/Metla


Nursery-field: Height growth
Height, cm
Year
0
20
40
60
80
100
120
140
2006
2007
2008
2009
2010
2011
2012
1C
2C
3C
1F
2F
3F

Nursery-field: Boron concentration in the needles

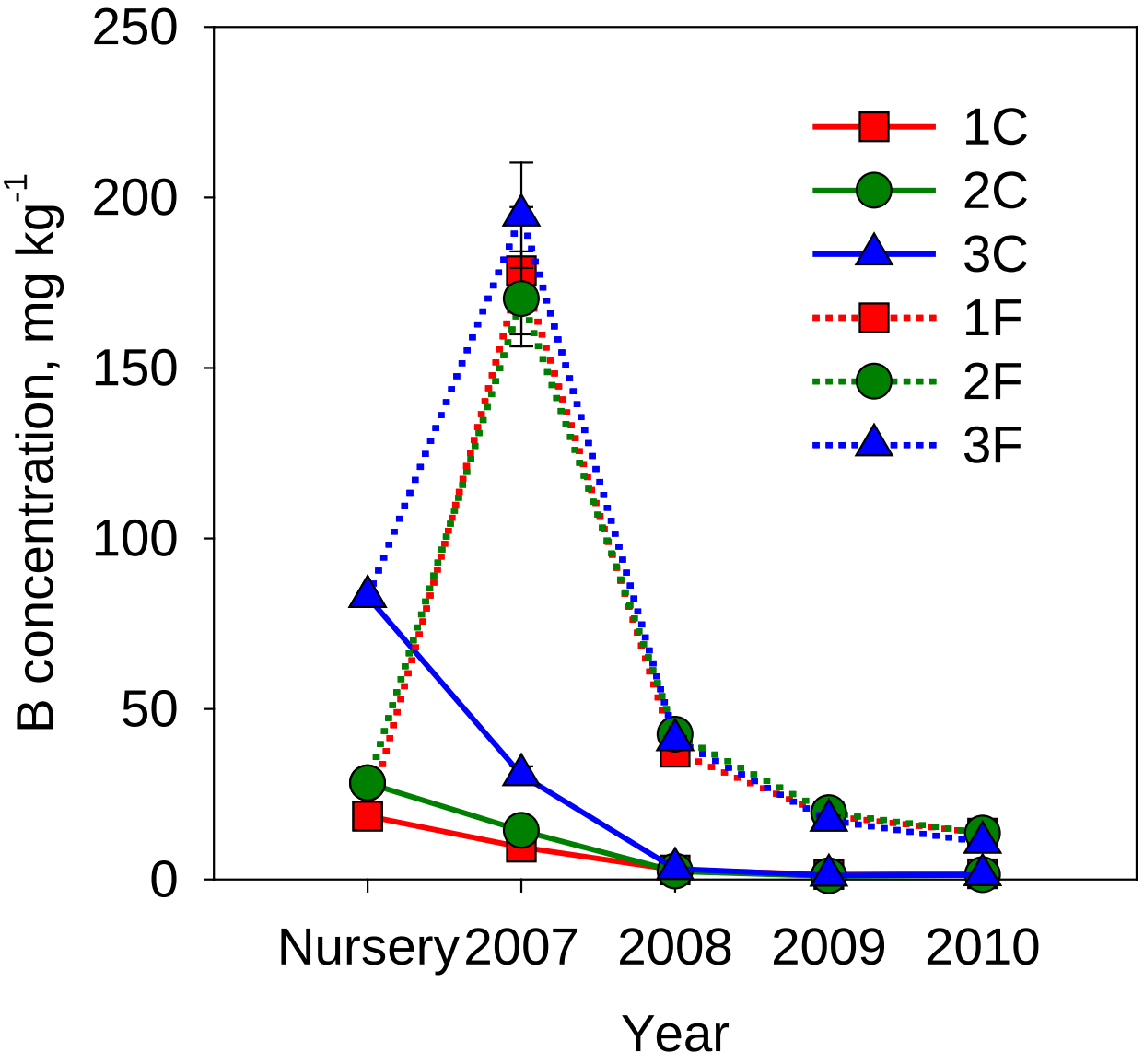
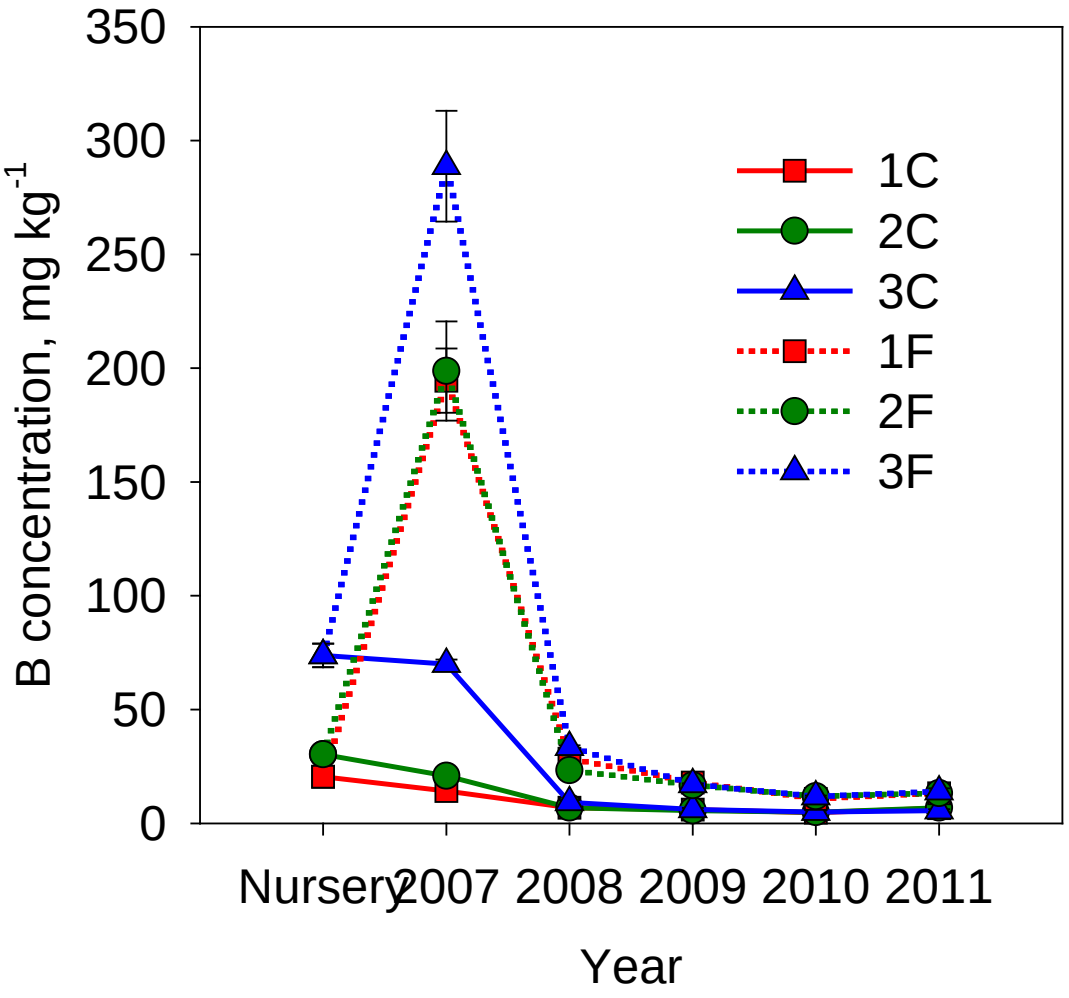



Photo: Risto Rikala

Reforestation experiment:

Boron concentration of the needles



Reforestation experiment

- No growth disorders at this site

← foliar B > 4 mg kg^{-1} even in unfertilized seedlings

- B fertilization did not affect the height growth
- Lower foliar N concentration in the B fertilized seedlings
- Other nutrients not affected

Conclusions

- The extra B fertilization at the nursery is likely to keep the B level sufficient for normal growth for 1-2 growing seasons in B-poor sites

- The B fertilization applied after planting can maintain a foliar B concentration that is above the deficiency threshold for at least five growing seasons

- However, very high foliar B conc. may have adverse effects in unfavourable growth conditions


Thank you!
Photo: Pekka Voipio