ONEforest

The effect of increasing precipitation on hemiboreal tree species: the FAHM experiment

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Introduction

According to the climate change projections, in Northern Europe, including the Baltic region, the global warming will lead to an increase in the average temperature and a lengthening of the growing season of plants, as well as an increase in the amount and frequency of precipitation. This in its turn means that periods with high air and soil humidity will be longer and more frequent in future. According to different climate scenarios, the precipitation in Estonia will increase by 5-30% by the year 2100.

In order to study the effects of the increase in precipitation, in 2006-2007, a world-unique free air humidity manipulation experiment (FAHM) of the forest ecosystem was established in Rõka village, south-eastern Estonia to elucidate the effects of elevated air humidity and soil moisture on growth and functioning of different tree species and forest ecosystems.

As part of ONEforest project (Task 1.5: Evaluation of changing climatic conditions on Boreal forest stands) tree growth monitoring was carried out during three seasons (2021-2023) in FAHM and the collected data was analysed together with the previous long-term datasets from the experiment.

Methodology

FAHM includes 9 experimental circle plots, i.e. small „experimental forests“:
- Humidification plots (*n* = 3), relative air humidity is elevated by 5-7% over ambient level
- Soil irrigation (*n* = 3), 15% is added to normal precipitation via irrigation
- Control plots (*n* = 3) with ambient air humidity and soil moisture

Fig. 1. Outlines of the Free Air Humidity Manipulation (FAHM) experiment.

FAHM experimental site lies in Rõka village, Järvselja Experimental Forest District (58°14'N, 27°18'E) in South-Eastern Estonia (https://sisu.ut.ee/fahm1/main?lang=en). FAHM covers 2.7 ha, containing nine 14×14-m experimental plots surrounded by a buffer plantation of hybrid aspen (Fig. 1).

Out of the nine plots, three are control plots (C) with ambient conditions, three plots are elevated air relative humidity (H) plots and three are elevated soil moisture (I) plots (Fig. 1).

During the first two manipulation periods (FAHM1: 2008-2012 and FAHM2: 2012-2019), silver birches (*Betula pendula* Roth) and hybrid aspens (*Populus tremula* L. × *P. tremuloides* Michx.) were grown in FAHM experimental plots as test species. During the third study period (FAHM3: since 2020) the experiment involves *B. pendula* and Norway spruce (*Picea abies* [L.] Karst.) planted in monospecific and mixed (50:50) sub-plots.

Basic growth traits (height, stem diameter) of all trees growing in FAHM plots are measured at the end of each growing period.

Results

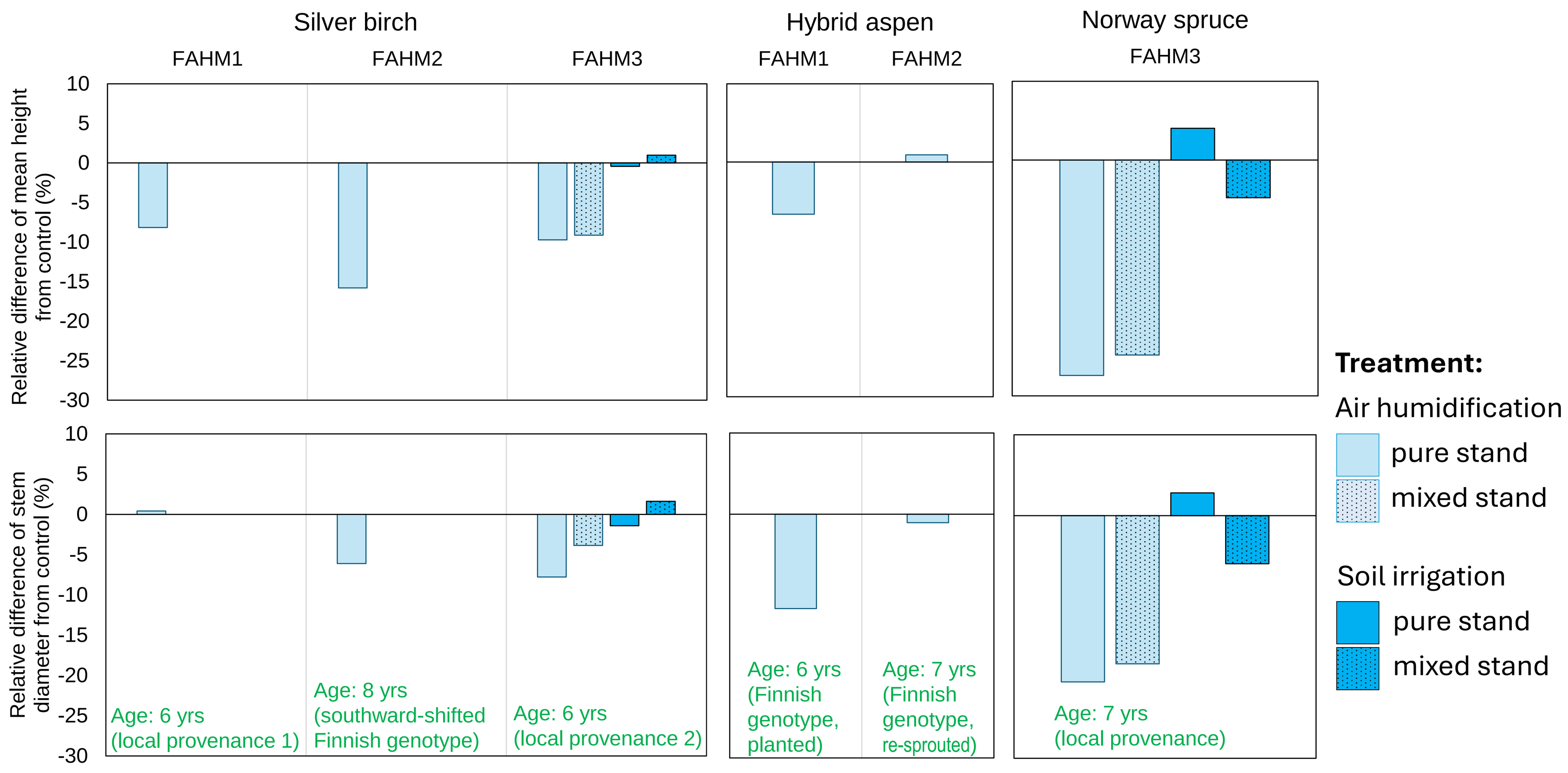

Fig. 2. The effect of FAHM treatments on tree growth in the final years of three study periods (FAHM1: 2012; FAHM2: 2019; FAHM3: 2023).

- Tree height growth was more strongly affected by elevated air humidity than stem diameter growth (Fig. 2), resulting in increase of sapwood to leaf area ratio.
- Negative effect of humidification on growth occurred in planted aspens but not in re-sprouted trees (Fig. 2).
- Negative effect of humidification was less pronounced or did not reveal in droughty growing seasons.
- Nutrient uptake was hindered under humidification in some years.
- Birch acclimation with elevated air humidity involved prolonged leaf retention and diameter growth and adjustments in fine root morphology.
- Treatment effect was less pronounced in late-flushing spruces and when growing in mixture with birch.

Conclusions

To summarize, FAHM research during 17 years has revealed that increasing air humidity (which will accompany climate change induced rise in precipitation in hemiboreal/boreal forest region) can cause slower growth of trees, whereas the magnitude of this effect is species-specific. Out of the three studied tree species, Norway spruce was most sensitive to elevated air humidity. On the other hand, spruce benefitted from elevated soil moisture, which may counterbalance the humidity effect. Growth of silver birch, especially the southward-shifted genotype, responded also negatively to high humidity. In hybrid aspen, negative effect on growth that was seen in the first planted generation, had levelled off in the second generation with re-sprouted trees.

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