Is foliar water uptake fostered by aerosol deposition?

Irmgard Koch[1], Ansgar Kahmen[2], Jürgen Burkhardt[1]
[1] Institute of Crop Science and Resource Conservation, University of Bonn, Germany
[2] Botanical Institute, Basel, Switzerland
irmgard.koch@uni-bonn.de

Background

- Foliar water uptake has been found in more than 100 species and recently also in beech trees.
- Possible mechanisms for uptake: trichomes, cuticles or stomata.
- **Hypothesis**: Deposited, deliquescent aerosols penetrate the stomatal pores, creating a pathway for liquid water into and out of the plant.

Methods

Beech trees were grown in greenhouses with ambient air (AA) and with filtered, almost aerosol free air (FA).

Deposited aerosols on leaves

- Leaves were washed of in ultrasonic bath and ions were analysed with ion chromatography, atomic absorption spectrometry, flame photometry and continuous flow analysis.

Drying speed of leaves

- The weight of detached leaves was recorded during drying process.

Foliar water uptake

- Leaves were cut and left to dry (fig. 4; 5 steps between 0 to 60 min to achieve different water potentials) and sprayed with deuterated water (keeping them wet for 60 min). Leaf water was extracted (fig. 5). Extracted water was analysed with mass spectrometry. FWU_{HR} was calculated according to Schreel et al (2020).

Deposited aerosols on leaves

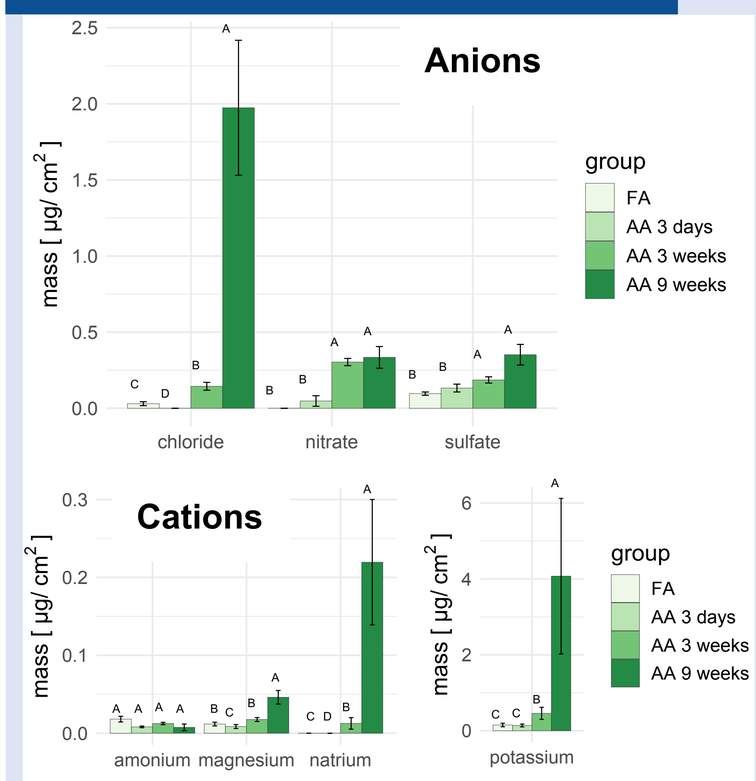

Figure 1: Aerosol mass per leave area of groups of plants grown in filtered air (FA) and for different time spans in ambient, unfiltered air (AA). Standard error and significant differences are shown (n=10).

- Leaf washing revealed larger amounts of surface aerosols with longer aerosol exposure time.

Figure 4: Drying process of leaves.

Conclusions

Deposited Aerosols:

- Increased the drying speed of detached leaves.
- Supported foliar water uptake.
- Highest FWU_{HR} was observed for short drying times. This suggests that for the uptake process, wider stomatal apertures were more relevant than lager water potential gradients.

→ **Aerosol deposition fosters foliar water uptake.**

Drying speed of leaves

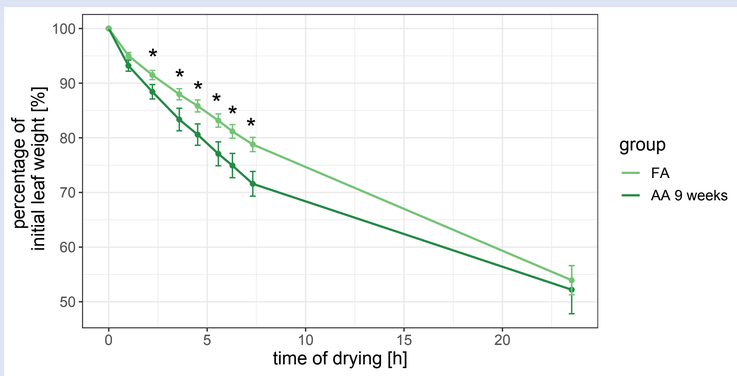

Figure 2: Reduction of leaf weight for samples grown in filtered almost aerosol free air (FA) and ambient, unfiltered air (AA). Standard error and significant differences (*) are shown (n=15). Temperature: 24,3 °C; Humidity: 38,2 %.

- Leaves dried out quicker with deposited aerosols.

Foliar water uptake

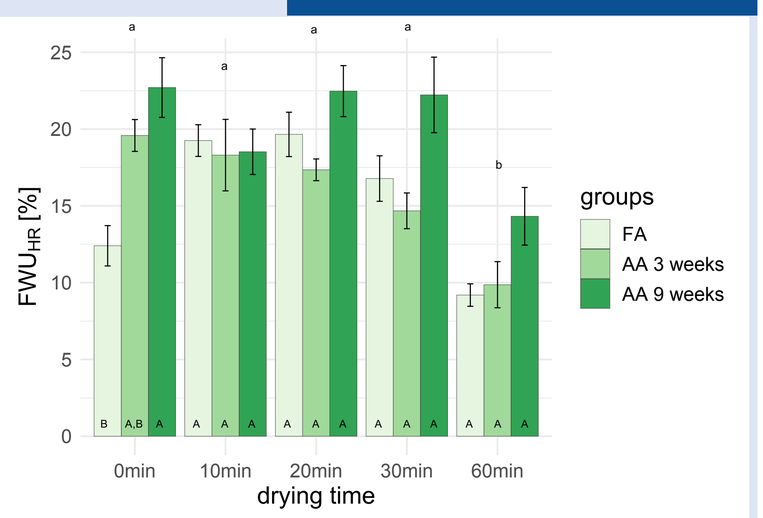

Figure 3: FWU_{HR} for leaves grown in filtered air (FA) and leaves that were grown different time spans in ambient, unfiltered air. Drying times varied from 0 to 60 minutes. Standard error and significant differences are marked (n=5).

- FWU_{HR} was detected.
- It was higher with more deposited aerosols supporting the hypothesis.
- The biggest difference was found at the start of the drying process indicating a higher uptake with open stomata.

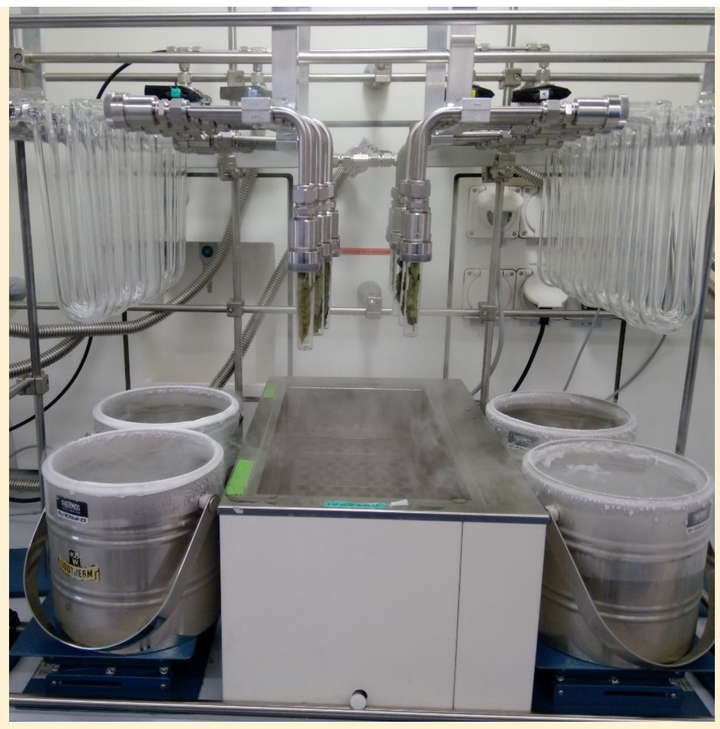

Figure 5: Leaf water extraction in a vacuum system; Water in leaf samples evaporates during cooking and gets caught in U-tubes sitting in liquid nitrogen.

References:
Schreel, J. D. M., & Steppe, K. (2020). Foliar Water Uptake in Trees: Negligible or Necessary? Supplemetal Information. Trends in Plant Science, 25(6), 1–14. https://doi.org/10.1016/j.tplants.2020.01.003.