Direct impact of atmospheric aerosols on the ecophysiology of *Cinnamomum camphora*

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Background

Deposited aerosols on leaf surfaces have generally been imagined as inert and crystalline entities. However, most aerosols are hygroscopic. Close to transpiring stomata, these aerosols become mobile by deliquescence, forming highly concentrated solutions. They can enter into the stomata ('hydraulic activation of stomata' - HAS; Burkhardt, 2010) and may affect leaf water relations.

Here, we evaluated the hypothesis of a direct impact of ambient aerosols on physiological parameters of camphor trees (*Cinnamomum camphora*). The approach included two field sites in Taiwan with different aerosol concentrations, and a greenhouse study in Germany. The main research focused on comparing camphor leaves grown in the greenhouse with ambient air (AA) and the other one with filtered air (FA; less then 1% of AA aerosol concentration).

Methods

Distribution of deposited aerosols on leaf surface

- Scanning electron microscope (SEM)
- Determine aerosol loading of leaves by foliar rising and ion chromatography analysis

Effects of deposited foliar aerosols on plant physiology

- Leaf water potential at turgor loss (π_{tlp}) measured by an osmometer
- Determination of proline level
- Carbon dioxide discrimination ($\delta^{13}C$)
- Maximum photosynthetic capacity (A_{max}) measured by Li-6800 (a steady-state gas exchange system)

Scanning electron microscope images

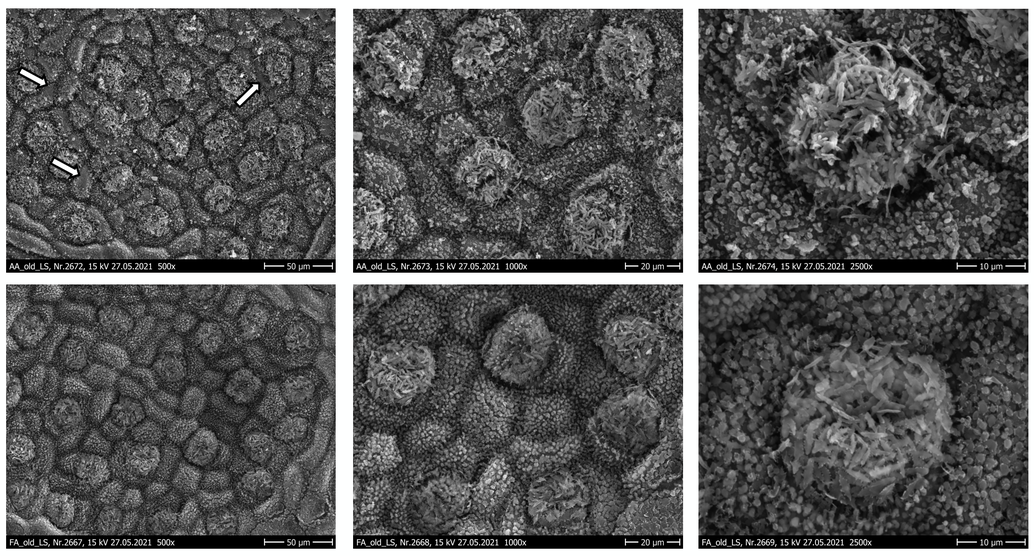

Figure 1. Images of lower leaf surface from AA leaves (upper row) and FA leaves (lower row)

There were clear differences in the microstructures of AA leaves (upper row) compared to FA leaves (lower row). Flat areas (arrows) may indicate salt crusts which result from deliquescent, hygroscopic aerosols, and cover the original wax crystals. The stomata on AA leaves appear less concrete than on FA leaves, and the structure of stomata is less visible.

Aerosol concentration on leaf surfaces

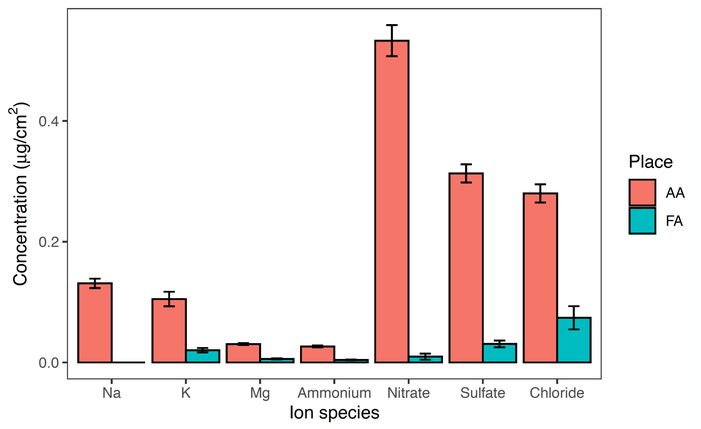

Figure 2. Aerosol concentration on leaf surfaces from AA and FA leaves

The total concentration of deposited aerosols on AA leaves (1.42µg/cm^2) is 10 times higher than on FA leaves (0.15µg/cm^2).

Leaf water potential at turgor loss

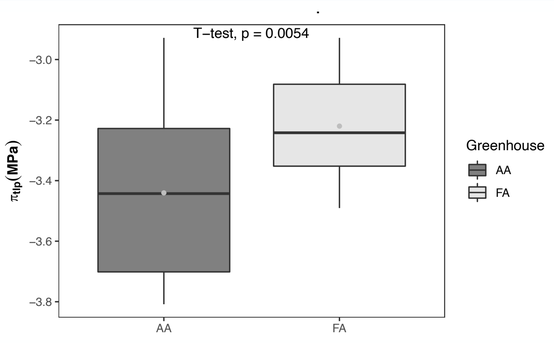

Figure 3. π_{tlp} of AA leaves and FA leaves

The leaf water potential at turgor loss (π_{tlp}) of AA leaves is lower than π_{tlp} of FA leaves, indicating the plants in AA experienced more water stress due to aerosols.

Foliar proline concentration

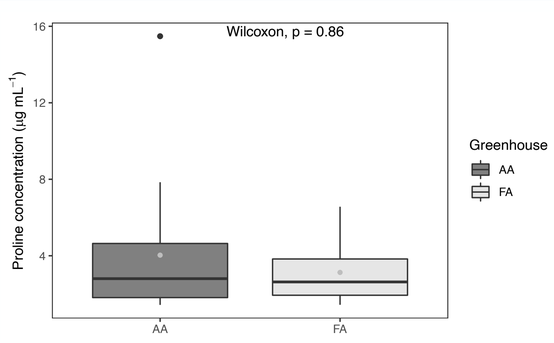

Figure 4. Proline concentration in AA leaves and FA leaves

The result of proline concentration here shows no significant difference between AA leaves and FA leaves.

Carbon dioxide discrimination

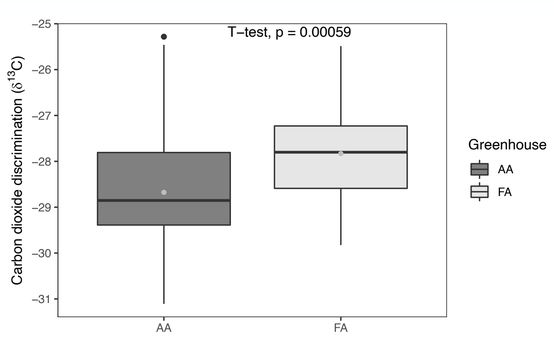

Figure 5. Values of $\delta^{13}C$ in AA leaves and FA leaves

The $\delta^{13}C$ value in AA leaves is lower than in FA leaves, indicating the stomata are more widely open and the plants have lower water use efficiency.

Maximum photosynthetic capacity

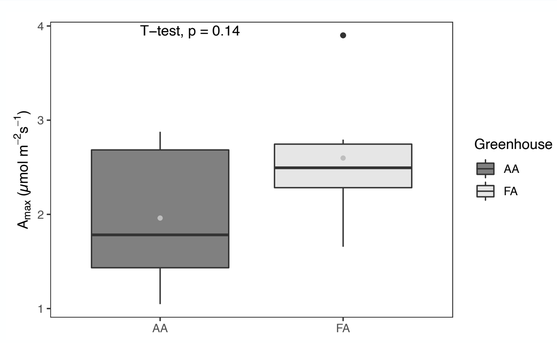

Figure 6. A_{max} of AA leaves and FA leaves

There was no difference between maximum photosynthetic capacity (A_{max}) of AA and FA leaves. A possible tendency of lower AA values was masked by considerably scattered data.

Field research

Based on the aerosol tracking data from 2007-2016 (Taiwan Air Quality Monitoring Network, Environmental Protection Administration, Taiwan) and the MOST-DAAD PPP Project, two cities in Taiwan were chosen; Hualien city is located in east Taiwan and the vegetation was planted in 2002, Pingtung city is located in south Taiwan and the vegetation was planted in 2006.

The two sites were expected to represent different aerosol environments. However, from the ion chromatography results of the leaves rinsed with deionized water, it shows that the aerosol concentration on leaf surfaces in Hualien leaves (1.26µg/cm^2) are not remarkably different from the Pingtung leaves (1.54µg/cm^2).

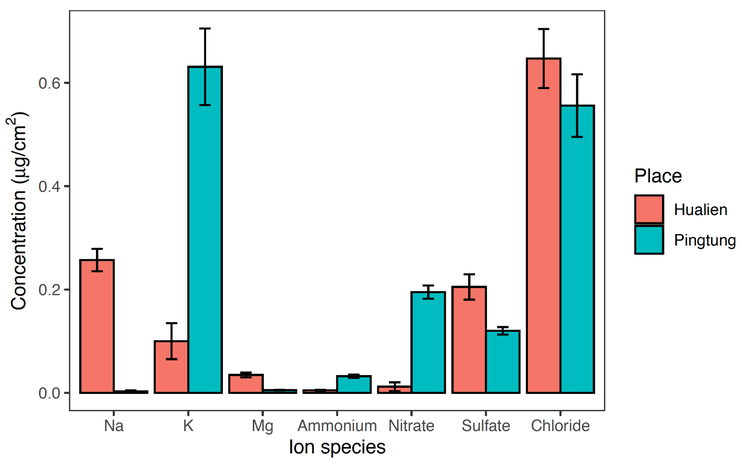

Figure 7. Aerosol concentration on leaf surfaces from the fields in Taiwan

Conclusions

- According to the leaf water potential at turgor loss (π_{tlp}), aerosols cause water stress to the camphor leaves.
- Aerosols could cause lower photosynthetic efficiency of the plants.
- Isotopic results indicated lower water use efficiency and more widely open stomata under aerosol exposure.
- The connection between field research and greenhouse study needs to be clarified.
- The level of HAS effect on *Cinnamomum camphora* is still elusive.

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References

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