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Morphological and Physiological traits related to $PM_{2.5}$ reduction capacities in 13 landscaping tree species

Kunhyo Kim[1,P], Jihyeon Jeon[1], Hee Jin Jung[1], Taekyung Kim[1], Jeonghyun Hong[1], Gi-Seong Jeon[2], Hyun Seok Kim[1,3,4,5,C]

[1][Department of Forest Science, Seoul National University, Seoul 08826, Republic of Korea]
[2][Korea Expressway Corporation Research Institute, Gyeonggi-do, 18489, Republic of Korea]
[3][Interdisciplinary Program in Agricultural and Forest Meteorology, Seoul National University]
[4][National Center for Agro Meteorology, Seoul 08826, Republic of Korea]
[5][Research Institute of Agriculture and Life Sciences, Seoul National University]

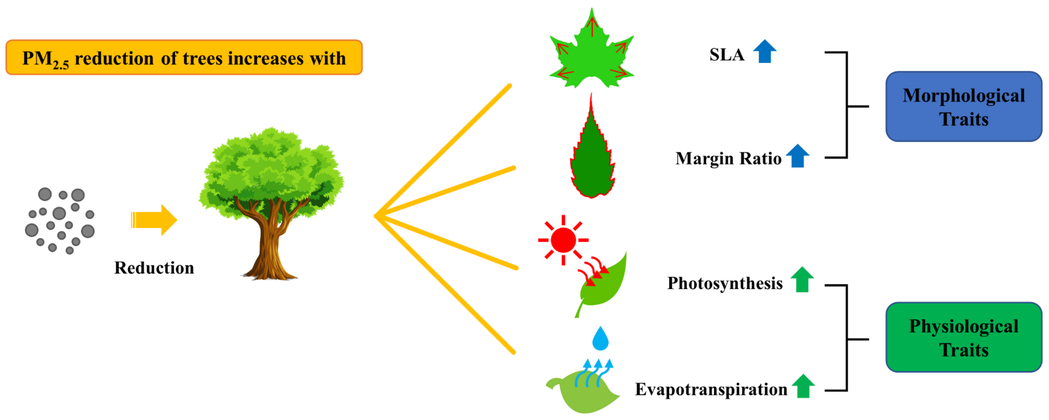
Abstract

> Background

- Increasing use of fossil fuels cause environmental problem with $PM_{2.5}$.
- Landscaping trees is important with their ability to reduce $PM_{2.5}$.
- Canopy density and leaf area index are directly related to $PM_{2.5}$ reduction.
- The concentration of $PM_{2.5}$ inside urban forests is lower than outside because of the effect of trees.

> Results

- Amount of $PM_{2.5}$ reduction differs among species.
- $PM_{2.5}$ reduction were described by morphological traits, specific leaf area(SLA) and length of margin per leaf area(ML_{leaf}).
- As well as, physiological traits, photosynthesis, evapotranspiration and photosynthetic pigments.



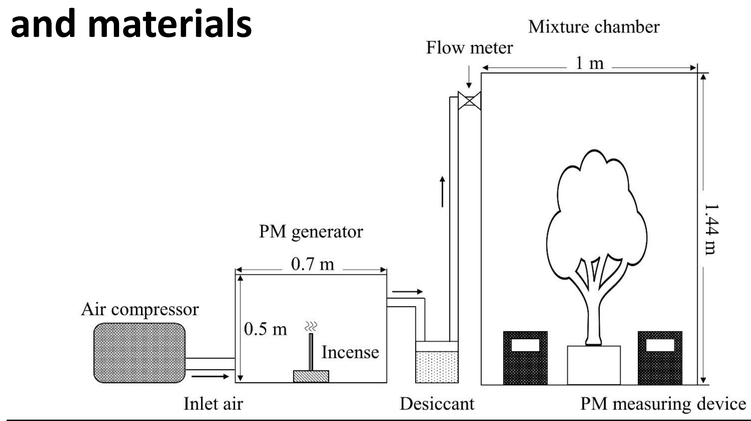
Research objects

- Comparison of reductions between living and dead trees / conditions of with and without light and water.
- Quantifying the capacity to reduce $PM_{2.5}$ of landscaping tree species.
- Determine morphological and physiological traits explaining the ability to reduce $PM_{2.5}$.

❖ Selection of species with a high ability to reduce $PM_{2.5}$ as landscaping trees or urban forests.

❖ Propose of management plan for landscaping trees.

Methods and materials

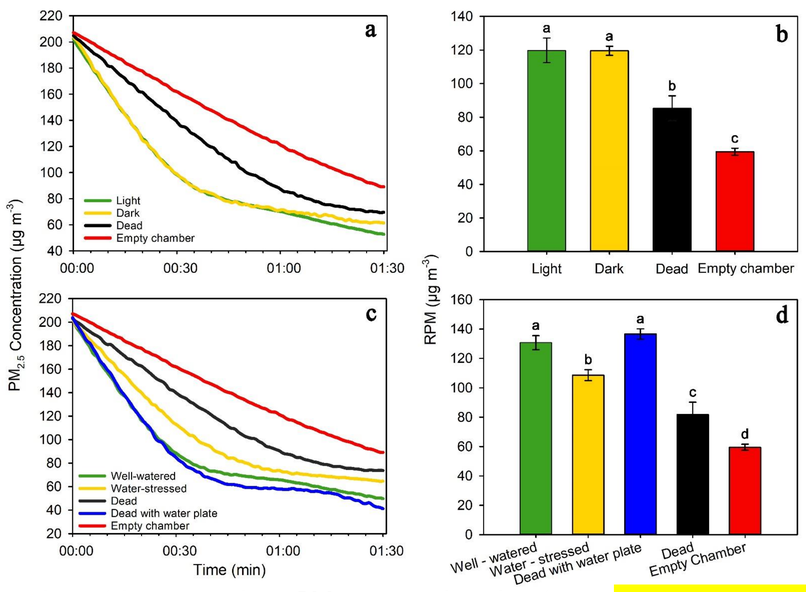


$$\mathrm{RPM}_{leaf}\ (\mu g\ cm^{-2}) = \frac{(\mathrm{CONC}_i - \mathrm{CONC}_{40} - \mathrm{RCONC}_g)\, V_{ch}}{\mathrm{TLA}}$$

- ✓ V_{ch} : volume of the chamber
- ✓ TLA : total leaf area
- ✓ $CONC_i$: initial concentration
- ✓ $CONC_{40}$: concentration at 40 minutes
- ✓ $RCONC_g$: concentration reduced naturally by gravity
- ✓ RPM_{leaf} : Reduction amount of $PM_{2.5}$ per leaf area

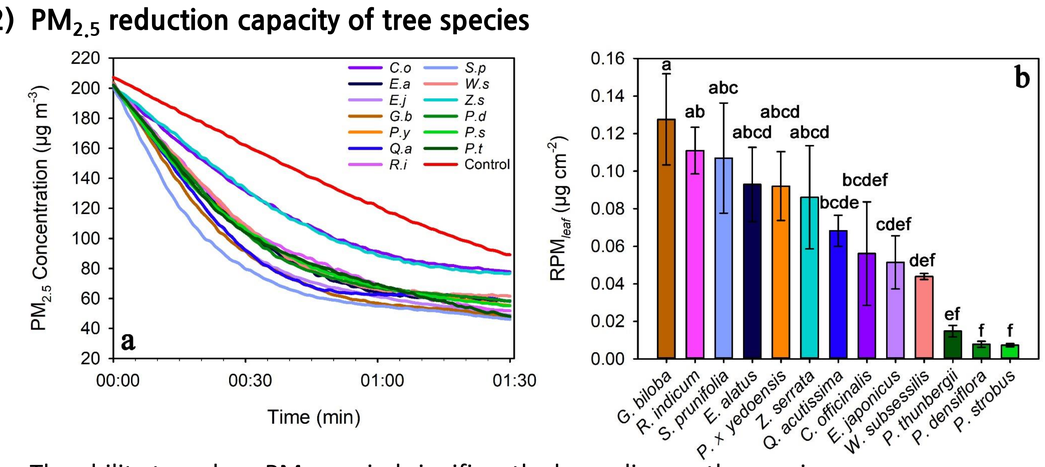
Results and Discussion

1) Quantification of physical and physiological ability of trees to reduce $PM_{2.5}$



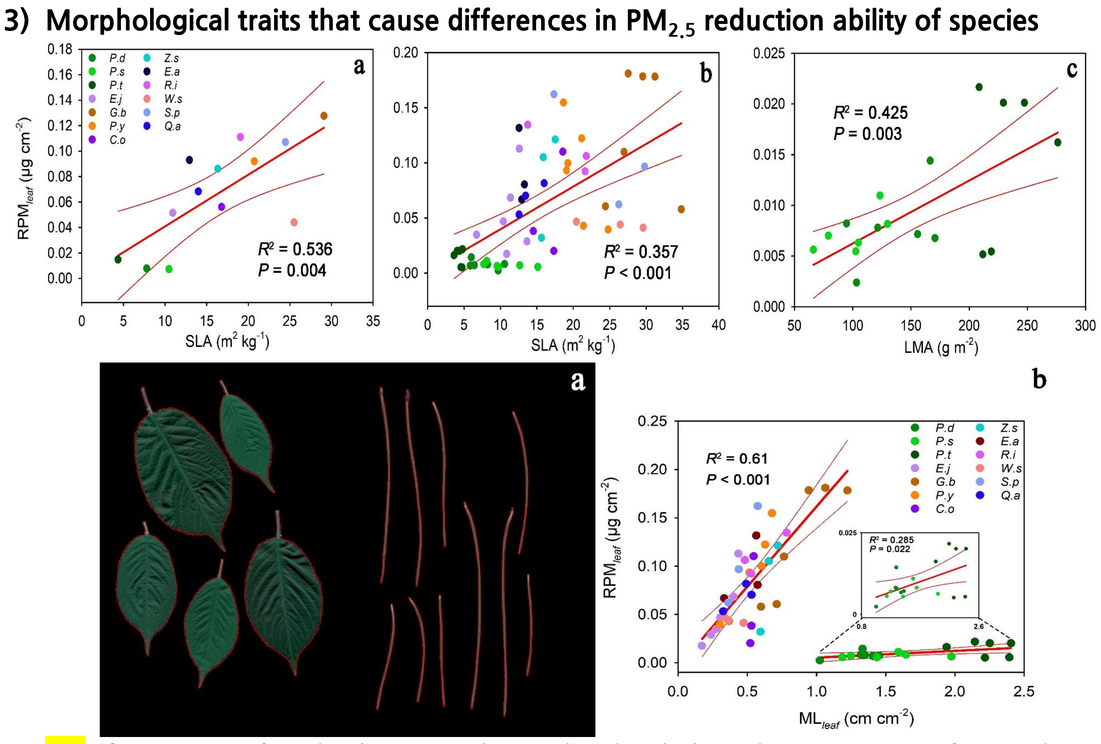
- Empty chamber without any plant, $PM_{2.5}$ was reduced owing to gravitational sedimentation.
- The reduction amount of PM of dead pine tree indicating an additional reduction owing to physical adsorption without physiological activity.
- Before tree death, under light condition with sufficient photosynthesis, the reduction amount of PM was significantly high. However, even under dark condition, the reduction was not different.
- Immediately after sufficient irrigation, the reduction amount of PM of pine tree was 130 μg m^{-3}.
- The reduction amount of PM of the same tree after 96 h without irrigation decreased significantly.
- To determine the effect of water vapor on $PM_{2.5}$ reduction, dead pine tree and plate containing water were placed together, the results indicated the reduction of 136 μg m^{-3}, which was not different from the reduction amount by trees in active transpiration after immediate irrigation.

2) $PM_{2.5}$ reduction capacity of tree species



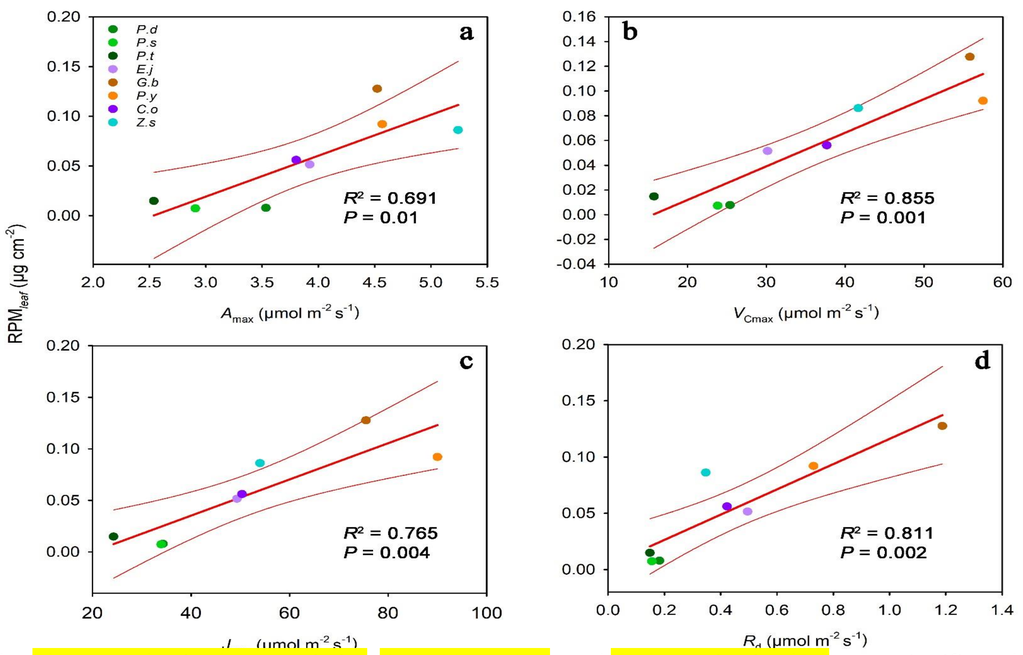
- The ability to reduce $PM_{2.5}$ varied significantly depending on the species.
- It was found that needleleaf species of *Pinus thunbergii*, *Pinus densiflora*, and *Pinus strobus* had lower mitigation capacity than broad-leaved species.

3) Morphological traits that cause differences in $PM_{2.5}$ reduction ability of species



- SLA of species was found to be positively correlated with the reduction amount of PM, indicating that species with thin leaves were more capable of reducing $PM_{2.5}$.
- ML_{leaf} also showed positive correlation with RPM_{leaf}, thus the larger the margin length, the greater the reduction in $PM_{2.5}$.

4) Physiological factors that result in differences in the $PM_{2.5}$ reduction ability of species



- The photosynthetic characteristics, A_{max}, V_{Cmax}, J_{max}, and dark respiration(R_d) were significantly and positively correlated with RPM_{leaf}.
- Stomatal conductance and transpiration showed a positive, but not significant correlation.

Conclusions

- The process of $PM_{2.5}$ reduction by trees was shown to involve not only structural adsorption and blocking according to the morphological properties, but also absorption and deposition effects from physiological activities.
- Morphological – Larger SLA and ML_{leaf}
- Physiological – High photosynthesis capacity
- High capacity – *G. biloba*, *R. indicum*, *S. prunifolia*, *E. alatus*, *P.* x *yedoensis*
- Low capacity – *P. thunbergii*, *P. densiflora*, *P. strobus*

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