Seasonal canopy uptake of dry deposited ^{15}N-NH_3 under different N concentrations and the interaction with leaf physical properties

Sandy ADRIAENSSENS[1], Jeroen STAELENS[1,2], Shari VAN WITTENBERGHE[3], Pascal BOECKX[2], Roeland SAMSON[3] and Kris VERHEYEN[1]

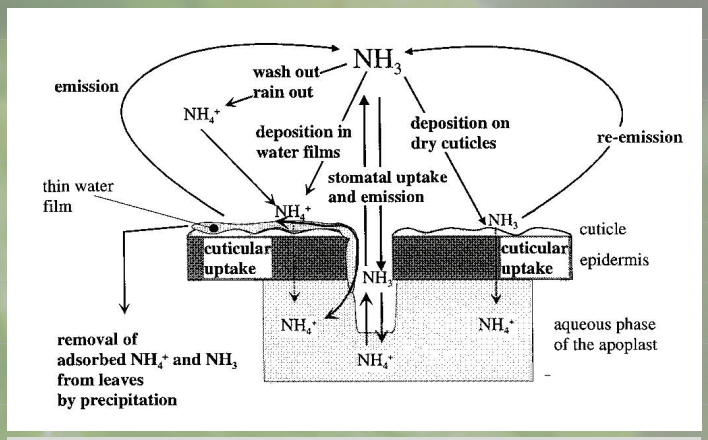
[1]Laboratory of Forestry, Ghent University; [2] Laboratory of Applied Physical Chemistry (ISOFYS), Ghent University; [3] Dep. Bioscience Engineering, University of Antwerp

contact: Sandy.Adriaenssens@UGent.be

INTRODUCTION

- Semi-natural ecosystems such as forests are exposed to high inputs of atmospheric ammonia gas (NH_3) and reactive nitrogen (N) oxides (NO_x) originating from anthropogenic sources.
- This increased input is manifested largely by the dry deposition of gaseous compounds, of which NH_3 is the most important.
- Aboveground N uptake can contribute significantly to the total N demand and could potentially drive additional C gain in historically N-limited forests.
- Stomatal conductance and cuticular adsorption play an important role determining the fluxes of NH_3 to the foliage.

How is NH_3 uptake by foliage affected by tree species, N concentration and time and how does this interact with leaf physical properties?

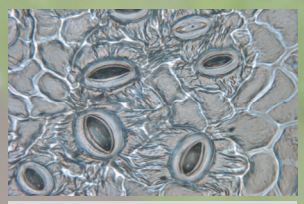


Mechanisms of NH_3 exchange between the atmosphere and foliage (Rennenberg and Gessler, 1999)

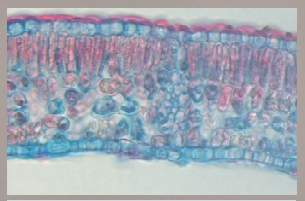
MATERIAL AND METHODS

- A ^{15}N-labelled source was applied to young trees of three deciduous species, i.e. European beech (*Fagus sylvatica* L.), pedunculate oak (*Quercus robur* L.) and common birch (*Betula pendula* L.), and one coniferous species, i.e. Scots pine (*Pinus sylvestris* L.). Living twigs in plastic bags were exposed to ^{15}N-NH_3 during 1 hour for examining gaseous N uptake, corrected for varying light conditions.
- Four different levels of N concentration were used, representing 1, 4, 10 and 20 times the average ambient NH_3 concentration in Flanders (Belgium).
- ^{13}C-CO_2 was added to account for photosynthetic activity during the experiment.
- The experiment was repeated three times during the growing season, namely in June, August and October 2008.

Injection of ^{15}N-NH_3 and ^{13}C-CO_2



Stomatal imprint of an oak leaf (400 x)



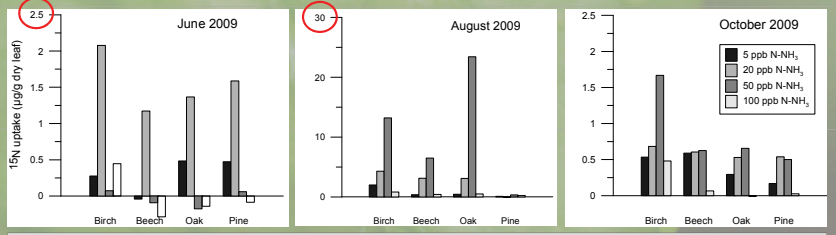
Vertical slice of a beech leaf (400 x)

SEM of an oak leaf (2500 x)

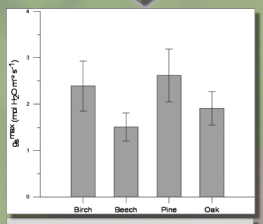
- Plant N uptake was calculated per unit biomass to account for the differences in treated leaf mass among tree species. Differences between means were analysed with ANOVA and Tukey tests.
- Leaf anatomy, stomatal characteristics and conductance were determined simultaneously.

RESULTS

- ^{15}N-NH_3 uptake patterns differed significantly for the three treatment dates. In June, highest uptake was observed at 20 ppb (4 times ambient levels), while for the experiment of August this was at 50 ppb (10 times ambient levels) and that of October 5 ppb.
- Birch and pine showed highest uptake in June, followed by a distinctive increase in uptake of the deciduous species in August and a decrease towards October. Uptake of pine needles did not differ significantly between the three dates.

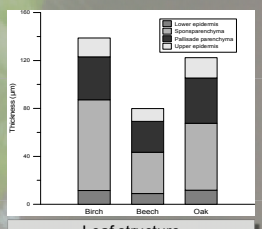


^{15}N-uptake by leaves after addition of ^{15}N-NH_3



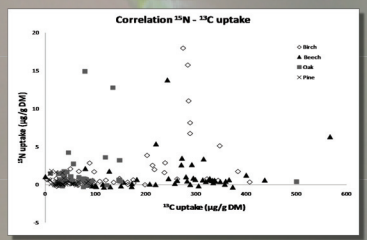
Maximal stomatal conductivity g_s^{max}

- Maximal stomatal conductance for H_2O is highest for birch and pine
- Thickness of parenchyma layers indicate that the anatomy of birch leaves is more optimized for gas exchange compared to the other deciduous species



Leaf structure

^{15}N uptake is weakly but significantly ($r = 0.231$; $p<0.05$) correlated with ^{13}C uptake, indicating that other factors than photosynthesis also play a role in determining NH_3 fluxes to the leaves of forest species.



Relation between ^{15}N and ^{13}C uptake

CONCLUSION

^{15}N-NH_3 foliar uptake patterns differ significantly between tree species, treatment dates and NH_3 concentration. These patterns can be partially explained by leaf photosynthetic and transpiration properties.

ACKNOWLEDGEMENTS:
Sandy Adriaenssens and Jeroen Staelens are funded by the Research Foundation Flanders (FWO)

REFERENCES: Rennenberg & Gessler (1999). Water, Air and Soil pollution 116:47 - 64

UNIVERSITEIT GENT
ISOFYS
Dpt. Forest and Water Management
Laboratory of Forestry