Volatile isoprenoids reduce ozone damage and increase ozone uptake in plants exposed to high atmospheric ozone°

Silvano Fares *, Francesco Loreto *,
*CNR – IBAF (National Research Council – Institute of Agro-environmental and Forest Biology),
Monterotondo Scalo (Rome), ITALY.
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Introduction:

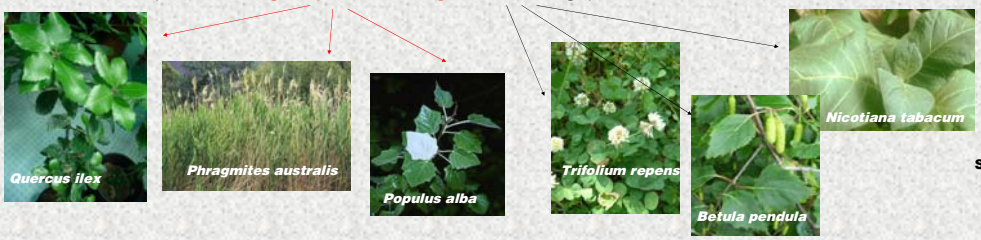
Volatile isoprenoids may defend plants against oxidative stress (Velikova et al. 2005) and their emission may be elicited by oxidative stresses (Loreto et al. 2004). Ozone atmospheric concentration increased over the last decades (Fowler at al. 1999). Ozone is one of the most dangerous gaseous compound, being toxic for animals and plants. Ozone episodes are widespread in polluted urban areas and ozone may also be transported or even formed over rural areas by photochemical reactions of anthropogenic NOx and biogenic volatile organic compounds (BVOCs). Plants are able to capture ozone from the air (Altimir et al. 2004) and this has a double, contrasting effect. On one hand, plants uptake contributes to remove ozone from the air. On the other hand the ozone taken up is phytotoxic (Zheng et al. 2002). Ozone may be taken up by plants through stomatal apertures and through cuticle adsorption. Irrespective of the diffusion mechanism, an ozone gradient between the concentration in the air and inside leaves must be present to drive the ozone flux.

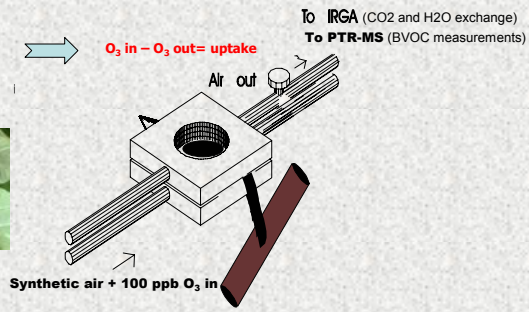
We have investigated whether volatile isoprenoids, by reacting with ozone, are responsible for this gradient, therefore driving ozone uptake, and at the same time reducing ozone damage.

Material and methods:

Leaves of different species enclosed in glass cuvettes that were tested to minimize ozone uptake, were fumigated with synthetic air containing 100 ppb of ozone and no other contaminant. The ozone uptake was calculated by measuring the difference between the ozone concentration in the air entering and leaving the cuvette

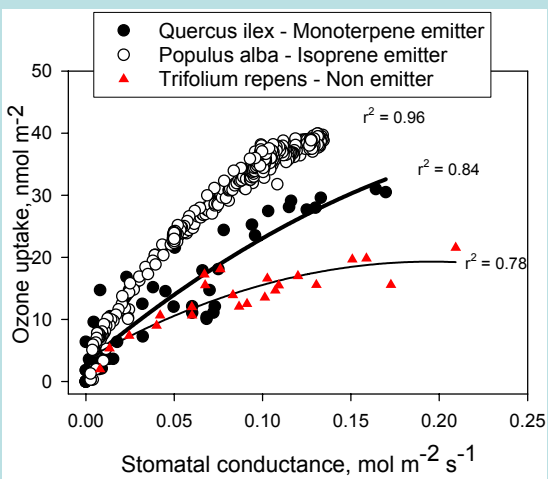
The research was performed on **high isoprenoid emitting** and **low-emitting** species





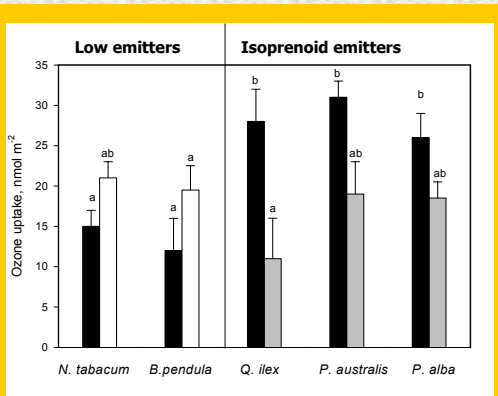
The foliar damage caused by ozone, expressed in terms of necrosis, reduction of photosynthesis and fluorescence was observed. In some experiments, plants were exposed to different temperatures (20-30-35 ° C) and to variable light intensities (from 0 to 1000 μmol m^{-2}-s^{-1}) to induce different stomatal opening, ozone uptake, and emission of isoprenoids. An inhibitor of volatile isoprenoids (Fosmidomycin) was also used to inhibit isoprenoid production by plants.

Results and Discussion



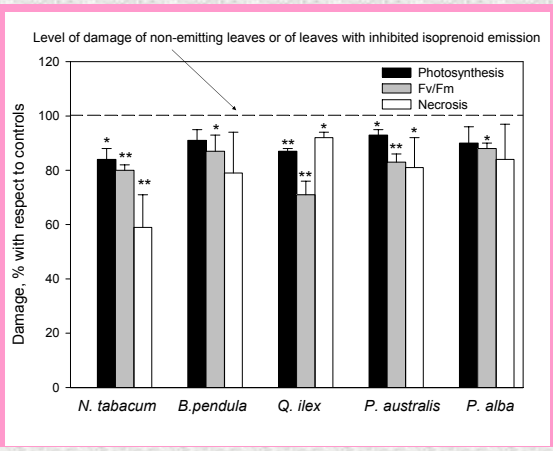
Ozone uptake predominantly depends on stomatal conductance both in isoprenoid-emitting and non-emitting species. The non-stomtal component appears minimal, as shown by the very low residual uptake at no stomatal conductance.

At high stomatal conductance ozone uptake became less dependent on stomatal conductance, indicating that the ozone gradient between air and leaf mesophyll is lower under these conditions, i.e. that ozone starts to be accumulated in the mesophyll. Perhaps ozone is not scavenged anymore efficiently at this high rates of uptake.



Ozone is taken up more in isoprenoid-emitting species than in non-emitting species, at similar stomatal conductance (0.1 mol m^{-2} s^{-1}). When isoprenoid emission is inhbited in isoprenoid-emitting species ozone uptake drops. When isoprene is exogenously fumigated to non-emitting species, ozone uptake increases.

Gas phase reactions outside the leaf are likely minimal due to the short reaction time between gases in the cuvette, and removal of ozone may largely occur inside leaves.



Exogenous or endogenous isoprenoids, despite incrementing ozone uptake (see above) reduce the damage in all plant species.

The stomatal uptake of ozone includes a detoxification and is not a suitable index of damage, at least in high isoprenoid-emitting leaves.

References

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Silvano Fares – silvano.fares@ibaf.cnr.it