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More than just CO$_2$-recycling: corticular photosynthesis as a mechanism to reduce the risk of an energy crisis induced by low oxygen

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Abstract:

Reassimilation of internal CO$_2$ via corticular photosynthesis (PS$_{cort}$) has an important effect on the carbon economy of trees. However, little is known about its role as a source of O$_2$ supply to the stem parenchyma and its implications in consumption and movement of O$_2$ within trees. PS$_{cort}$ of young Populus nigra (black poplar) trees was investigated by combining optical micro-optode measurements with monitoring of stem chlorophyll fluorescence.

During times of zero sap flow in spring, stem oxygen concentrations (cO$_2$) exhibited large temporal changes. In the sapwood, over 80% of diurnal changes in cO$_2$ could be explained by respiration rates (Rd(mod)). In the cortex, photosynthetic oxygen release during the day altered this relationship. With daytime illumination, oxygen levels in the cortex steadily increased from subambient and even exhibited a diel period of superoxia of up to 110% [% air sat.]. By contrast, in the sapwood, cO$_2$ never reached ambient levels; the diurnal oxygen deficit was up to 25% of air saturation.

Our results confirm that PS$_{cort}$ is not only a CO$_2$-recycling mechanism, it is also a mechanism to actively raise the cortical O$_2$ concentration and counteract temporal / spatial hypoxia inside plant stems.

Keywords: bark photosynthesis, CO$_2$ fluxes, corticular photosynthesis, hypoxia, stem CO$_2$-recycling, superoxia, xylem sap