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Is growth reduction in defoliated trees a consequence of prioritized carbon allocation to reserves?

Guenter Hoch (1), Sandra Schmid (1), and Sara Palacio (2)

(1) University of Basel, Department of Environmental Sciences - Botany, Basel, Switzerland, (2) Pyrenean Institute of Ecology (IPE-CSIC), Jaca, Spain

Tissue concentrations of carbon reserve compounds are frequently used as proxies for the carbon balance of trees, but the mechanisms regulating the formation of carbon reserves are still under debate. It is often assumed that carbon storage in trees is largely a consequence of surplus carbon supply (reserve accumulation). In contrast, carbon storage might also occur against prevailing carbon demand from other sink activities, like growth (reserve formation), in which case carbon reserve pools might increase even at carbon limitation, and thus, cannot be used as indicators for a tree's carbon supply status. Such a situation might be severe defoliation by herbivores. Especially in evergreen tree species, it has been shown that natural and experimental defoliation leads to a reduction of growth that is proportional to the lost leaf area. Compared to this strong effect on growth, carbon reserve pools (i.e. sugars, starch and storage lipids) of defoliated trees often exert only a temporary decrease immediately after defoliation, while tissue concentrations of carbon reserves return to those of undefoliated trees by the end of the growing season.

Within a recent experiment, we investigated, if the growth decline in trees following early season defoliation is the consequence of prioritized carbon allocation to carbon reserves over growth. To test this hypothesis we grew seedlings of evergreen Quecus ilex and deciduous Quercus petraea trees under low (140 ppm), medium (280 ppm) and high (560 ppm) CO_2 concentrations and completely defoliated half of the seedlings in each CO_2 treatment at the beginning of the growing season. In undefoliated control trees, CO_2 had a significant positive effect on the seasonal growth in both species. Defoliation had a strong negative impact on growth in the evergreen Q. illex, but less in the deciduous Q. petraea. In both species, the growth reduction after defoliation relative to undefoliated controls was very similar at all three CO_2 concentrations. Non-structural carbohydrate (NSC) concentration, decreased significantly in all investigated tissues of both species during the middle of the growing season under low CO_2 concentrations and after defoliation at all CO_2 concentrations, but increased to similar levels across all treatment combinations by the end of the growing season. We conclude from these results, that growth decline after defoliation is not related to carbon limitation, but trees growing under low CO_2 concentrations preferentially allocate photoassimilates to carbon storage during the second half of the season. The implications of this study for our understanding of carbon storage regulation in trees will be discussed.