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Carbon and Nitrogen dynamics in deciduous and broad leaf trees under drought stress

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Climate change is projected to lead to an increased frequency and duration of severe drought events in future. Already within the last twenty years, however, drought stress related forest mortality has been increasing across the globe. Tree and forest die off events have multiple adverse effects on ecosystem functioning and might convert previous carbon sinks to act as carbon sources instead and can thus intensify the effect of climate change and global warming.

Current predictions of forest's functioning under drought and thus forest mortality under future climatic conditions are constrained by a still incomplete picture of the trees' physiological reactions that allows some trees to survive drought periods while others succumb. Concerning the effects of drought on the carbon balance and on tree hydraulics our picture is getting more complete, but still interactions between abiotic factors and pest and diseases as well as the interaction between carbon and nutrient balances as factors affecting drought induced mortality are not well understood. Reduced carbon allocation from shoots to roots might cause a lack of energy for root nutrient uptake and to a shortage of carbon skeletons for nitrogen assimilation and thus to an impaired nutrient status of trees. To tackle these points, we have performed a drought stress experiment with six different plant species, 3 broad leaf (maple, beech and oak) and 3 deciduous (pine, fir and spruce). Potted two-year-old seedlings were kept inside a greenhouse for 5 months and 3 levels of drought stress (no stress (control), intermediate and intensive drought stress) were applied by controlling water supply. Gas exchange measurements were performed periodically to monitor photosynthesis, transpiration, stomatal conductance. At the pinnacle of drought stress, we applied isotopic pulse labelling: On the one hand we exposed trees to $13CO_2$ to investigate on carbon dynamics and the allocation of new assimilates within the plant. Moreover, we labelled the soil with 15N nitrate by injecting nitrate solution into the soil without strongly changing the water content for investigating nitrogen uptake and distribution along different compartments of the plant soil continuum.

We observed a distinct difference in the carbon and nitrogen dynamics and allocation pattern between broad leaf and conifer seedlings.

Broad leaf species showed a lower reduction of CO_2 assimilation under drought and still allocated significant amounts of the new assimilates to the roots. Especially in maple and oak the belowground transfer of assimilates was kept at high levels even under severe drought stress, while there was a reduction in assimilation transport in beech. Instead, only small amounts of 13C labelled new assimilates arrived in the roots of conifers in the drought treatments.

In the deciduous species 15N taken up the roots was more intensively allocated to aboveground tissues compared to conifers under control conditions, which retained the largest amounts within the fine roots.

15N uptake was reduced in the drought treatments in all species assessed. There was, however, no clear relation of this reduction to changes in 13C allocation to the roots. We thus cannot conclude that the reduction of nitrogen uptake is due to reduced transport of new assimilates belowground. We thus need to assume that carbon storage is sufficient to provide energy and carbon for nitrogen uptake and assimilation at least over the short-term. During longer drought periods, however, depletion of carbon stores might adversely affect the nutrient uptake and balance of trees.