Hydrogen isotopes in leaf and tree-ring organic matter as potential indicators of drought-induced tree mortality

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Abstract

The oxygen and hydrogen isotopic composition ($\delta\ ^{18}O$, $\delta\ ^{2}H$) of plant tissues integrates hydrological, physiological, and metabolic functions differently, which may allow disentangling reasons of tree mortality. To test this, we performed a greenhouse study and determined predisposing fertilization and lethal drought effects on $\delta\ ^{18}O$ and $\delta\ ^{2}H$ values of plant water and organic matter (OM) in leaf and woody tissues of living and dead saplings of five European tree species. Additionally, we measured physiological and metabolic traits. Compared to controls, drought reduced leaf gas-exchange, predawn water potential, and stem starch concentrations and increased $\delta\ ^{18}O$ and $\delta\ ^{2}H$ values of leaf and twig water in all tested species. These drought-induced changes generally caused an ^{2}H-enrichment in leaf and tree-ring OM, but a low and heterogenous $\delta\ ^{18}O$ response. $\delta\ ^{2}H$ values of tree-ring OM were correlated with those of leaf and twig water across treatments and species. In contrast, the predisposing fertilization had generally no significant effect on any isotopic, physiological, and metabolic traits. We propose that the ^{2}H-enrichment in the dying trees is related to (i) the plant water isotopic composition, (ii) metabolic processes shaping leaf non-structural carbohydrates , (iii) the use of carbon reserves for growth, and (iv) species-specific physiological adjustments. This stress imprint on $\delta\ ^{2}H$ but not on $\delta\ ^{18}O$ suggests that the further could be used as a proxy to understand mechanisms of drought-induced tree mortality.

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