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Trade-off in allocation between growth, storage and defense: what matters most?

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Studies on carbon allocation have a long history in plant science and recent observations of climate-induced vegetation mortality have sparked hot debates on how plants allocate carbon in a changing climate. In particular, whether allocation to storage and defense is driven by the balance between carbon supply via photosynthesis and carbon demand for growth as predicted by carbon-nutrient balance hypothesis (CNBH), or occur at the expense of growth thus leading to trade-off in allocation; and how allocation patterns change during organ ontogeny (e.g. young vs old) and across organ types (e.g. leaf vs stem vs root) in different plant species types (e.g. herbaceous vs. woody plants).

To resolve these questions, we carried out a series of glasshouse and field manipulation experiments. Peppermint (Mentha x piperita L.), winter wheat (Triticum aestivum L.) and Norway spruce (Picea abies L.) were exposed in glasshouse experiments to drought and carbon limitation, whereas field-grown grass species (Dactylis glomerata, Taraxacum officinalis, Trisetum flavescens) to a combination of drought, warming and elevated CO_2 conditions. We assessed the whole-plant carbon balance (assimilation, respiration, growth, non-structural carbohydrates (NSC) and secondary metabolites (SM)) and investigated trade-offs between growth, storage and defense.

In the glasshouse experiments, carbon limitation significantly decreased NSC and growth while SM showed a diverse response; concentrations of phenolic compounds were significantly reduced in wheat but constant in spruce. Monoterpenes production, however, remained constant in peppermint and spruce as newly-assimilated carbon was allocated even under carbon limitation. These results reflect that allocation to SM is not a function of carbon availability as predicted by CNBH. We also observed organ-specific responses in allocation trade-offs, where young leaves showed a high allocation priority for SM. By contrast, drought stress resulted in NSC accumulation but had no effects on SM production, likely via increasing need of NSC for osmoregulation. In the field manipulations, we observed increases in leaf SM production in response to drought, warming and/or elevated CO_2 in Dactylis glomerata and slight increases in Taraxacum officinalis, while SM decreased in Trisetum flavescens.

Our experiments provide insightful data on trade-offs between growth and defense under environmental stress which may substantially influence plant responses under rapidly changing climate. More field investigations are required, though, to corroborate results from such factorial investigations.