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Stress differentially impacts reserve pools and root exudation: implications for ecosystem functioning and carbon balance

Simon Landhäusser, Justine Karst, Erin Wiley, and Jacob Gaster
University of Alberta, Renewable Resources, Edmonton, Canada (simon.landhausser@ualberta.ca)

Environmental stress can influence carbon assimilation and the accumulation and distribution of carbon between growth, reserves, and exudation; however, it is unclear how these processes vary by different stress types. Partitioning of carbon to growth and reserves in plants might also vary between different organs. Roots reserves are of particular interest as they link the plant with the soil carbon cycle through exudation. Simple models of diffusion across concentration gradients predict the more C reserves in roots, the more C should be exuded from roots. However, the mechanisms underlying the accumulation and loss of C from roots may differ depending on the stress experienced by the plants. In a controlled study we tested whether different types of stresses (shade, cold soil, and drought) have differential effects on the distribution, abundance, and form (sugar vs. starch) of carbohydrates in seedlings, and whether these changes alone could explain differences in root exudation between stress types.

Non-structural carbohydrate (NSC) concentration and pool sizes varied by stress type and between organs. Mass-specific C exudation increased with fine root sugar concentration; however, stress type affected exudation independently of reserve concentration. Seedlings exposed to cold soils exuded the most C on a per root mass basis followed by shade and drought. Through 13C labeling, we also found that depending on the stress type, aspen seedlings may be less able to control the loss of C to the soil compared with unstressed seedlings, resulting in more C leaked to the rhizosphere.

The loss of C beyond that predicted by simple concentration gradients might have important implications for ecosystem functioning and carbon balance. If stressed plants lose proportionally more carbon to the soil, existing interactions between plants and soils may decouple under stress, and may include unexpected C fluxes between trees, soils and the atmosphere with a changing climate.