Root elemental content drives shifts in belowground carbon storage

Background/Objective

- There is wide interest in breeding or engineering plants for increased control of soil organic matter levels and soil carbon storage. However, the critical plant traits affecting soil carbon storage are less well understood than the environmental drivers of soil organic carbon (SOC).

Approach

- Soils (0–15 cm) and roots were sampled under 23 *P. trichocarpa* genotypes (n=3 each) in a CBI common garden established in Clatskanie, OR in 2009.
- Soils were fractionated into particulate and mineral-associated organic matter (MAOM).
- Roots were analyzed for nitrogen, lignin, and elemental content.
- Analysis included heritability estimation and LASSO regression.

Results

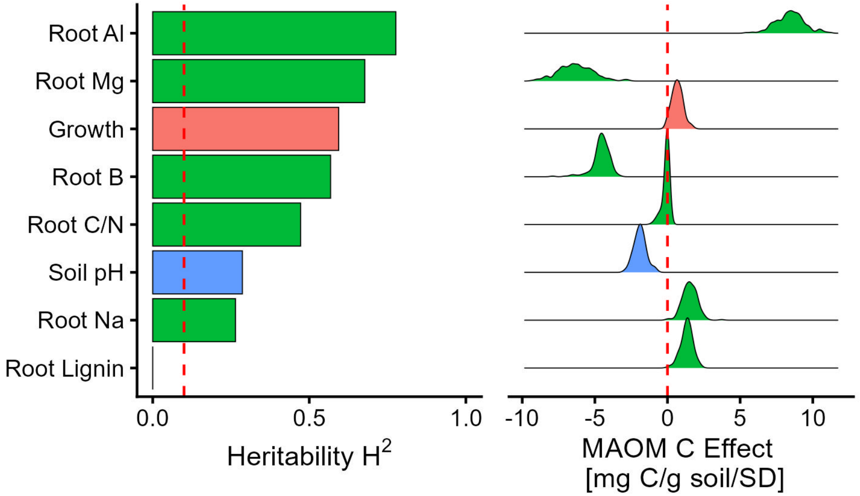
- Total soil carbon concentration was not heritable across the 23 sampled genotypes, but stocks (total carbon mass per area) of the MAOM-C fraction were heritable ($H^2 = 0.24$).
- Root nitrogen and lignin were only weakly associated with soil carbon. In contrast, root concentrations of aluminum, magnesium, and other elements were highly heritable and strongly associated with soil carbon.
- There is preliminary evidence that soil carbon stocks under different poplar genotypes have diverged at rates of 1–8 T C ha^{-1} $year^{-1}$ since this common garden was established.

Significance/Impacts

- Root elemental content may be an important target for breeding to manage soil carbon.
- In contrast, older process-based models used for bioenergy system assessment (e.g., DayCent) have limited value for guiding plant bio-design for enhanced soil carbon storage.
- Long-term common gardens are an underutilized resource for studying soil carbon storage and plant controls on biogeochemistry more broadly.

Field, J. *et al.* *GCB* (2025) 31, e70450, doi: 10.1111/gcb.70450

13-year-old Clatskanie common garden



Heritability and effect of select plant traits on soil MAOM-C