Oxygen consumption and carbon dioxide production in a large physical model of the vadose zone

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The soil-zone carbon cycle is a primary control on mobility of contaminants in the vadose zone, because it links soil moisture, microbial activity, soil water pH buffering, and chemical retardation. To examine the potential effect of CO_2 production and transport on contaminant fate at the Idaho National Engineering and Environmental Laboratory, we conducted a set of ^{14}C, ^{3}H, and U transport experiments in a model unsaturated zone comprised of a 2.5-m high x 1-m diameter homogeneous soil column with a steady-state unsaturated flow field. Results from the carbon-cycle analysis are reported herein. Soil temperature in the column varied with room temperature, ranging from a low of ~18 C during the winter of 2001, to a high of ~32 during the following summer. CO_2 and O_2 concentrations were monitored for two years and gas and liquid transport parameters were characterized via tracer tests. To calculate CO_2 production rates in the column over time, we solved the gas flow and transport equations for each week of the experiment. Taking each week's starting concentration profile as the initial condition, we used an iterative least squares fitting approach to solve for a depth-dependent production term that provided the best fit to the end-of-week concentration profile. Subsisting only on the ~0.5% organic carbon content of the local sediments used, the native microbial communties respired at a near-constant rate throughout the experiment, except during periods of dramatic temperature increase. The mean integrated CO_2 production rate during the experiment was ~0.05 moles m^{-3} day^{-1}, and production generally decreased slightly with depth in apparent response to decreasing O_2 availability. Monitoring data collected during the experiment provided several means of calculating gas fluxes and production/consumption rates in the column that generally compared favorably. In contrast, attempts to independently calculate the production rate from expressions relating microbial activity to temperature, water content and other factors were only moderately successful and generally suggested that current models of CO_2 production in the vadose zone still need improvement.

Responses of ectomycorrhizal fungi to mineral substrates

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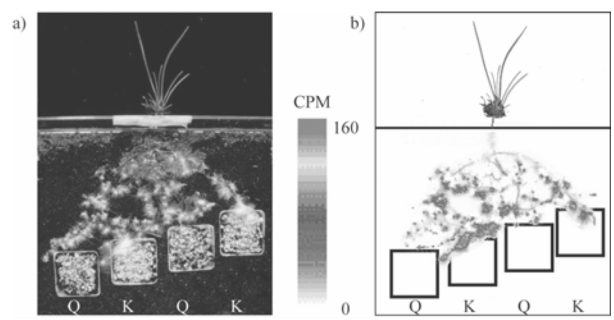
Growth in mineral soil

Ectomycorrhizal fungi mediate nutrient cycling in boreal forest ecosystems. We have demonstrated that as many as half of the ectomycorrhizal taxa colonising root tips in a boreal forest podzol may be primarily associated with mineral soil horizons (Rosling *et al.* 2003).

Mycelia transport of carbon to mineral substrates

Distribution of ^{14}C-labelled assimilates from pine seedlings colonised by *Heboloma crustuliniforme* was studied in flatbed microcosms (a) with patches of pure minerals potassium feldspar (K) and quartz (Q). The shoots were pulse labelled with 0.74 Mbq $^{14}CO_2$ after 15 weeks.



Distribution of the label was measured using electronic autoradiography (b) and destructive harvesting followed by liquid scintillation spectroscopy (Rosling *et al* 2004a). We demonstrated that at least 10 times more carbon was allocated to patches with K compared to those with Q.

Conclusion

Some ectomycorrhizal fungi only proliferate in certain mineral substrates. Carbon is transported from the host tree to the colonised minerals via mycorrhizal hyphae. Other experiments (Rosling *et al.* 2004b) suggest that local acidification around the hyphae may also be influenced by the composition of the mineral substrate.

References

Rosling A. *et al.* (2003). *New Phytol*. **159**, 775-783.
Rosling A. *et al.* (2004a). *New Phytol*. **162**, 795-802.
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