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How root-fungal interaction stabilizes soil organic matter? a mechanical explanation.

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Boreal forest ecosystems are one of the world's largest terrestrial carbon (C) sinks, storing significant amount of C in soil organic matter (SOM). The fate of boreal forest SOM is uncertain due to lack of mechanical understanding of its formation and decomposition. Gaining the knowledge about processes driving SOM transformations would let to predict future C stocks, and to mitigate climate change through increased C sequestration.

Soil microorganisms, especially mycorrhizal fungi may act in SOM decomposition but also in SOM formation providing large input of C and nitrogen (N), limiting nutrient in boreal forest ecosystems. It was suggested that half of C stored in boreal forest humus may originate from fungal mycelium and that roots are providing the most recalcitrant plant-derived C. However, studies on fungal necromass (FNM) showed rather fast decomposition rate. Thus, the role of fungi in SOM formation is unresolved.

Here, through combined laboratory and field experiments we demonstrate a novel mechanical explanation for increased stability of FNM. Considering that tannins, plant polyphenolics abundant in plant roots, may create complexes with proteins and chitin, two main N-containing compounds from FNM, we hypothesized that complexation of FNM with root tannins is a mechanism to create more stable SOM. We have proved it using three experiments. In laboratory experiment, we placed in soil microcosms with mycorrhizal pine 15N-labelled FNM vs 15N-labelled FNM-tannin complexes. We observed that degradation and uptake of 15N was significantly faster from FNM than from FNM-tannins. To study if such mechanism can exist also at field scale, we followed with two three-year long experiments, where we added homogenized humus or FNM to mesh bags of different mesh size: 1mm (allowing fungal and root ingrowth), 50μm (limiting root but not fungal ingrowth) and 1μm (limiting root and fungal ingrowth). Mesh bags were buried in soil at Hyytiälä forestry field station (SMEAR II, southern Finland, 61°84'N, 24°26'E) and harvested after 1, 2, or 3 growing seasons. In experiment with FNM-containing bags we observed decreased decomposition rate if FNM was accessed by roots due to complexation of FNM by tannins from roots. In a second field experiment, with humus-containing bags, we observed build-up of stable SOM only if the humus was accessed by roots, providing tannins. Moreover, production of greenhouse gases was not enhanced in the presence of roots, although SOM-turnover was the fastest there. It suggests that mycorrhizal plants using tannins switch SOM decomposition into more organic N-orientated route than saprotrophs lacking tannins.

In conclusion, through combined laboratory and field experiments we demonstrate that FNM-tannin interaction decelerates FNM decomposition building up more stable SOM. Our findings support the need to understand mechanisms behind plant-microbial-soil interactions to predict feedback of boreal ecosystems to climate change.