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The soil structure roots encounter affects root activity and the fate of carbon in the rhizosphere

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Carbon inputs into soil take place primarily through rhizodeposition and root decay. Spatial inaccessibility of organic matter to organisms, i.e., physical protection, is a key factor for stabilizing such carbon in soils. Protection is governed by soil structure, i.e., the spatial arrangement of solids and voids, thus, differences in root distribution and in their rhizosphere physical properties influence carbon sequestration. This structure, in turn, is affected by roots, which explore the soil by rearranging existing soil particles and thus may compact the rhizosphere, especially, when the soil does not contain a well connected macropore system.

Here we conducted a split root experiment to determine how plant roots grow into soil depending on the structure they encounter and how this affects the fate and distribution of SOM. Soil cores, with four different structures, either intact or destroyed by sieving, from monoculture switchgrass and prairie systems were incorporated into containers planted with Panicum virgatum L. (Switchgrass) and Rudbeckia hirta L. (Black-eyed Susan), plants with contrasting root characteristics.

The cores were X-ray µCT scanned before and after plant growth, enabling explorations of the feedback interactions between roots and soil structure through analysis of pore size distributions, root distributions, and rhizosphere physical properties. To assess the fate of the plant-derived C, the plants were labelled by $^{14}CO_2$; and presence of ^{14}C in roots, rhizosphere, and rhizoplanes was examined. The cores were incubated for 30 days and $^{14}CO_2$ and CO_2 respiration was measured. Soil solution from pores of different sizes was collected by centrifugation and analyzed for ^{14}C. This enabled to investigate the fate and distribution of carbon in correlation to the interactions of roots and structure derived from image analysis.

Results suggest root soil contact as a universal driver that stimulates greater allocations of photo assimilated C (^{14}C) to roots and to their immediate surroundings. When roots were growing into the dense soil matrix, greater ^{14}C was detected within the roots, rhizosphere, and rhizoplane. In addition, more ^{14}C was found as DOC. Although most of this carbon was released fast, in total more ^{14}C also remained in the soil after the 30 day incubation. While the majority of roots from Black-Eyed-Susan grow into the dense soil matrix, Switchgrass roots, in contrast, preferentially grew into macropores (especially into switchgrass created biopores). When that happened, roots and rhizosphere had low quantities of freshly assimilated C (i.e., ^{14}C), yet, surprisingly more ^{14}C

was found at greater distances from the roots in microsamples, which may be linked to mycorrhizae.

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