EGU24-6272, updated on 25 Jan 2025
https://doi.org/10.5194/egusphere-egu24-6272
EGU General Assembly 2024

Long-Term Effects of Silphium perfoliatum on Soil Pore Dynamics and Organic Carbon Accumulation

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Perennial bioenergy crops like *Silphium perfoliatum* (cup plant) are a promising alternative to currently used energy crops such as maize because of their positive feedbacks on various soil properties including carbon sequestration, edaphon activity and erosion control. This study investigates the long-term impact (over 10 years) of the cup plant on soil organic carbon and soil structural parameters in comparisons to a to a nearby ploughed reference site.

We employed tension infiltrometers to measure water infiltration rates at two soil depths (5 and 45 cm). Following this, 100 cm³ aluminum soil cores were extracted for X-ray computed tomography at a resolution of 35 µm. The image analysis, enhanced by machine learning, classified structures including roots, particulate organic matter (POM), biopores, and two types of soil matrix: dense and loose, the latter indicating higher carbon content or more pores slightly below image resolution. The dataset was complimented by the determination of total carbon content and the root length distribution with RhizoVisionExplorer.

The results indicate significant differences in pore structure, primarily in the topsoil, where the cup plant site showed a greater volume of biopores than the reference site. In contrast, the subsoil differences were less marked. Organic carbon content analysis demonstrated a notable increase in the upper soil layer (10-15 cm) at the cup plant site, contributing to a higher soil organic carbon stock than the reference site. However, this effect diminished with depth, becoming negligible at 50-55 cm. In the topsoil, extensive bioturbation/biomixing was observed, as indicated by the darker, more loosely structured soil matrix, which often had the shape of biopores. This bioturbation, which mixed particulate organic matter (POM) into the soil, significantly enhanced soil organic carbon, as evidenced by linear regression analysis.

These findings underscore the substantial impact of the perennial cup plant in enhancing soil structure and carbon content, particularly in the topsoil.