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Spatial distribution of enzyme activities in the rhizosphere

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The rhizosphere, the tiny zone of soil surrounding roots, certainly represents one of the most dynamic habitat and interfaces on Earth. Activities of enzymes produced by both plant roots and microbes are the primary biological drivers of organic matter decomposition and nutrient cycling. That is why there is an urgent need in spatially explicit methods for the determination of the rhizosphere extension and enzyme distribution. Recently, zymography as a new technique based on diffusion of enzymes through the 1 mm gel plate for analysis has been introduced (Spohn & Kuzyakov, 2013).

We developed the zymography technique to visualize the enzyme activities with a higher spatial resolution. For the first time, we aimed at quantitative imaging of enzyme activities as a function of distance from the root tip and the root surface in the soil.

We visualized the two dimensional distribution of the activity of three enzymes: β-glucosidase, phosphatase and leucine amino peptidase in the rhizosphere of maize using fluorogenically labelled substrates. Spatial-resolution of fluorescent images was improved by direct application of a substrate saturated membrane to the soil-root system.

The newly-developed direct zymography visualized heterogeneity of enzyme activities along the roots. The activity of all enzymes was the highest at the apical parts of individual roots. Across the roots, the enzyme activities were higher at immediate vicinity of the roots (1.5 mm) and gradually decreased towards the bulk soil. Spatial patterns of enzyme activities as a function of distance from the root surface were enzyme specific, with highest extension for phosphatase. We conclude that improved zymography is promising in situ technique to analyze, visualize and quantify spatial distribution of enzyme activities in the rhizosphere hotspots.

References

Spohn, M., Kuzyakov, Y., 2013. Phosphorus mineralization can be driven by microbial need for carbon. Soil Biology & Biochemistry 61: 69-75