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Soil zymography – A novel technique for mapping enzyme activity in the rhizosphere

Marie Spohn
Germany (marie.spohn@uni-bayreuth.de)

The effect plant roots on microbial activity in soil at the millimeter scale is poorly understood. One reason for this is that spatially explicit methods for the study of microbial activity in soil are limited. Here we present a quantitative in situ technique for mapping the distribution of exoenzymes in soil along with some results about the effects of roots on exoenzyme activity in soil. In the first study we showed that both acid and alkaline phosphatase activity were up to 5.4-times larger in the rhizosphere of Lupinus albus than in the bulk soil. While acid phosphatase activity (produced by roots and microorganisms) was closely associated with roots, alkaline phosphatase activity (produced only by microorganisms) was more widely distributed, leading to a 2.5-times larger area of activity of alkaline than of acid phosphatase. These results indicate a spatial differentiation of different ecophysiological groups of organic phosphorus mineralizing organisms in the rhizosphere which might alleviate a potential competition for phosphorus between them.
In a second study cellulase, chitinase and phosphatase activities were analyzed in the presence of living Lupinus polyphyllus roots and dead/dying roots (in the same soils 10, 20 and 30 days after cutting the L. polyphyllus shoots). The activity of all three enzymes was 9.0 to 13.9-times higher at the living roots compared to the bulk soil. Microhotspots of cellulase, chitinase and phosphatase activity in the soil were found up to 60 mm away from the living roots. 10 days after shoot cutting, the areas of high activities of cellulase and phosphatase activity were extend up to 55 mm away from the next root, while the extension of the area of chitinase activity did not change significantly. At the root, cellulase and chitinase activity increased first at the root tips after shoot cutting and showed maximal activity 20 days after shoot cutting. The number and activity of microhotspots of chitinase activity was maximal 10 days after shoot cutting and decreased thereafter. In conclusion, the study showed that fresh root detritus stimulates enzyme activities much stronger than living roots, probably because of the high pulse input of C and N from dying roots compared to slow continuous release of rhizodeposits.
Taken together, soil zymography is a very promising novel technique to gain insights the effects of roots on the spatial and temporal dynamic of exoenzyme activity in soil.

References

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