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Identification of spatial biochemical pattern in the rhizosphere by linkage between rhizodeposition and enzyme activities

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Understanding the photoassimilate allocation into the roots and localization of the released organic substances from the roots is an important prerequisite for characterizing the spatial and temporal distribution of enzyme activities, nutrient mobilization and the interactions between plants and microorganisms. This is necessary for interpretation of the spatial and temporal pattern of the rhizosphere. Root hairs play a critical role in the root exudation and nutrient acquisition. Enzymes, produced by both roots and microorganisms, are the main biochemical drivers of SOM decomposition. Two maize varieties contrasting in root morphology – with root-hairs (wild type) and root-hair less (rth3 mutant) - were chosen to test the effect of root morphology on the spatial distribution of β-glucosidase activity and estimate the extent of rhizosphere for root exudates. To obtain this spatial pattern, we combined 2 imaging methods: 1) Zymography for spatial distribution of β-glucosidase activity; 2) Radioisotope imaging to assess root-derived 14C release (14C imaging). Coupling of soil zymography with 14C imaging revealed that extent of the rhizosphere for β-glucosidase in maize with root hairs was broader. This confirmed that ample quantities of easily available sugars released from root hairs stimulated the activity of microorganisms for nutrient mobilization and organic matter decomposition in the rhizosphere. The images of rhizosphere extensions for enzyme activity and root exudates showed overlapping of more than 50%. For the first time, we visualized and quantified the percentage of root hairs contribution to the normalized rhizosphere extension for exudation and enzymatic activity. This confirms the remarkable role of hair roots on enzymatic mobilization of nutrients and emphasize on the importance of expression of enzymes as a nutrients mining strategy for plants. In conclusion, we found the length of hair roots plays a critical role on formation, localization of exudation and enzymes spatial distribution and their activity per root area in the rhizosphere.