



Spatial patterns of enzyme activities in the rhizosphere: Effects of root hairs and root radius

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The importance of root hairs and root radius for exudation and nutrient acquisition by plants is known mainly from nutrient solution studies. The in situ effects of root hairs and root radius on the spatial distribution of enzyme activity in the rhizosphere of various plants are unknown. Four plants with contrasting root morphology (maize, wheat, lentil and lupine) were chosen to test the effects of root hairs and root radius on the spatial distribution of β -glucosidase, cellobiohydrolase, leucine aminopeptidase and acid phosphatase. We combined zymography with enzyme kinetics to evaluate the effects of root hairs on the rhizosphere extent and on substrate turnover. The extent of enzyme activity in the rhizosphere of four plants ranged from 0.55 to 2 mm. The extent of β -glucosidase was 1.5 times broader (1.2 mm versus 0.8 mm) and the substrate turnover was 2-fold faster around wheat root regions with hairs than hairless locations. The rhizosphere extent relative to root radius and the enzyme activity per root surface area were plant and enzyme specific: the rhizosphere extent was 1.5-2 times broader and the enzyme activity was 2-8-fold higher in wheat (with thin roots and long root hairs) compared to maize, lentil and lupine. The rhizosphere extent of acid phosphatase (1.1-2.0 mm) was 1.5-2-fold broader than that of other enzymes (0.5-1.0 mm). For the first time, we showed that the rhizosphere extent relative to root radius was 20-100% broader and enzyme activity per surface area was 4-7-fold higher around thin roots (wheat) than around thick roots (maize). Moreover, the rhizosphere extent relative to root radius was 10-30% broader and enzyme activity per root area was 2-7 times higher around roots with long and dense hairs (lupine) than around roots with short and sparse hairs (lentil). We conclude that root hairs and root radius shape the rhizosphere: root hairs contributed more to the rhizosphere extent, while root radius more strongly affected the enzyme activity per root surface area.