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Rhizosphere hotspots: root hairs and warming control microbial efficiency, carbon utilization and energy production

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Among the factors controlling root exudation, root hair proliferation and warming strongly influence exudate release, microbial substrate utilization and enzyme activities. The interactions of these two factors are important but poorly known in the rhizosphere. To clarify these interactions, two maize varieties – a wild type with root hairs and a hairless mutant – were grown at 20 and 30 °C for 2 weeks. We applied a unique combination of zymography to localize hotspots of β-glucosidase with microcalorimetry and substrate-induced respiration from soil sampled in hotspots. This approach enabled monitoring exudate effects on microbial growth strategy, enzyme kinetics (V_{max} and K_m), heat release and CO_2 production in the hotspots in response to warming.

Root hair effects on enzyme activity and efficiency were pronounced only at the elevated temperature: i) β-glucosidase activity of the wild type at 30 °C was higher than that of the hairless maize; ii) temperature shifted the microbial growth strategy, whereas root hairs (i.e. C input) promoted the fraction of growing microbial biomass; iii) K_m and the activation energy for β-glucosidase under the hairless mutant was lower than that under wild maize. These results suggest that microorganisms inhabiting hotspots of the wild type synthesized more enzymes to fulfill their higher energy and nutrient demands than those of the hairless mutant. In contrast, at higher temperature the hairless maize produced an enzyme pool with higher efficiencies rather than higher enzyme production, enabling metabolic needs to be met at lower cost. These changes in enzyme kinetics and metabolic shifts confirmed evolutionary theory on tradeoffs of enzyme structure–function and thermal–substrate under warming at the soil hotspot level. We conclude that, if microbial and enzymatic activities are stimulated by more substrate input under warming, then this shift in the microbial community and in enzyme systems to a lower efficiency could offset C losses.