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Plant- Soil microbial interaction: molecular to ecological perspective

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Roots are ecosystem engineers and build their environment, shaping the rhizosphere for optimal functioning. The interactions between plants and soil microbes are an important focus of terrestrial ecology. The application of classical and novel in situ imaging approach in combination with stable and radioactive isotopes to trace C and N fluxes shade light on the crucial role of root exudates on nutrient acquisition in the rhizosphere depending on biotic (e.g. pathogen, plant diversity) and abiotic factors (e.g. drought, temperature and land use). High-quality and quantitative images clearly showed that extend of rhizosphere is plant specific and it depends on root morphology; nutrient limitation and pathogenic infection will enlarge the rhizosphere size and increase soil volume from which root can mine nutrient. Overlapping of zymography and 14C imaging combined with qPCR analysis showed that thirsty maize release more root exudates and stimulates microbiome to express more peptidases. Similarly, coupling imaging and analytical tools illustrate while acclimation of enzymes to temperature showed that warming, mainly selected for soil enzyme systems maintaining static substrate affinity, it can also shorten the duration of hotmoment and increased the hotspots. Similarly, land use management strategies and fertilization revealed evidence of 1) changes in enzyme systems or 2) shift in microbial community and 3) spatial (re)distribution of enzymatic hotspots. In addition, this methodological combination showed that the rhizosphere shape for all parameters corresponds to sigmoidal or diffusion curves. Sharp gradients are formed within a few days for nutrients and enzymes. Showing, despite the dynamic nature of each property, rhizosphere shape is quasi-stationary because of the opposite directions of its formation processes. Thus, smart conjugation of classical and new approaches for static imaging and dynamic visualization of soil environments will benefit soil (micro)biology by providing new insights of life in the opaque belowground. Detecting and locating (micro)organisms poised soil (micro)biology to progress from simply cataloguing organism complexity to becoming a functional system science.