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"Competing pathways for equitable food systems transformation: Trade-offs and synergies"

Root-soil-contact influences on maize root growth, nutrient uptake, and nitrogen-cycling microorganisms in the rhizosphere

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Abstract

The rhizosphere is enriched with microorganisms, including plant growth promoters and drivers of biogeochemical cycles. Root-soil interactions cover a wide range of biological and physicochemical processes with direct effects on plant growth. Therefore, approaching the rhizosphere in response to root-soil contact is an important strategy to improve crop growth and productivity to fulfil global food demand. Root hairs are an important root trait that ensures root-soil contact. Knowledge of the influence of root-soil contact on plant performance and microbial rhizosphere processes is limited. In this study, we explored the heterogeneity of the maize root system in response to reduced root-soil contact. Contact was modulated by artificial soil pores or the absence of root hairs. We determined the influences on root growth, nutrient uptake, and microbial abundance with a special focus on N-cycling microorganisms. Growth of the *Zea mays root hairless 3* (*rth3*) mutant was comparatively studied with its corresponding wild-type for 21 days in a climate chamber. Root-pore utilisation was characterised by endoscopic analysis. Shoot nutrient contents were quantified by CHNS analyzer and nitric acid digestion followed by flame AAS and ICP-OES analysis. A qPCR analysis targeting the *16S rRNA, amoA*, and *nirK* genes was carried out to quantify the abundance of bacteria, archaea, nitrifiers, and denitrifiers respectively. Root-growth behaviour inside the pores varied depending on the genotype and root type, though both genotypes tended to grow into the pores. Wild-type plants showed significantly higher shoot and root growth than the mutant. Artificial pores did not significantly affect nutrient uptake, suggesting compensation for missing root-soil contact by reducing biomass, while maintaining biomass nutrient levels. The wild-type harbored a higher abundance of bacteria and archaea in the rhizosphere than the root-hairless mutant. Likewise, the abundance of nitrifiers was significantly affected by root-soil contact, resulting in the highest abundance under complete root-soil contact. Both archaea and denitrifiers preferred the pore walls over the bulk soil, suggesting an anaerobic and nitrate-rich environment on the pore walls. Taken together, proper regulation of root-soil contact by reducing soil artificial porosity and selecting genotypes with higher root surface area is worth enhancing plant growth performance.

Keywords: Denitrifiers, microorganisms, nitrifiers, rhizosphere

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