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Fertilization shapes rhizosphere and bulk soil prokaryotic communities in agroecosystems

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The rhizosphere is a narrow zone of soil adjacent to the roots of living plants that is directly influenced by the root exudates. A multitude of biotic and abiotic factors are assumed to affect the structural and functional diversity of microbial communities in the rhizosphere. While a key role of root exudates in shaping the rhizosphere microbiome is well known for natural ecosystems, fertilization becomes an essential factor determining both soil properties and rhizosphere microbial communities in agroecosystems. The extent to which both factors contribute to microbial communities is not yet fully understood. In this study, we assessed the influence of plant- (species and development stage) and fertilization-related (mineral and organic systems) factors on the abundance, biomass and composition of rhizosphere and bulk soil prokaryotic communities.

Soil samples were collected from the bulk soil and the rhizosphere of maize, potato, and white mustard under two fertilization treatments within a long-term micro-field experiment. For seven years, mineral fertilizers (N180P180K180) or fresh cattle manure (50 t/ha) were applied annually. The abundances of archaeal and bacterial 16S rRNA gene and transcript copies were estimated using RT-PCR. Total and active prokaryotic communities were analyzed via high-throughput sequencing on the Illumina MiSeq platform of 16S rRNA gene libraries.

The long-term application of organic fertilizers led to a significant increase in the microbial abundance and biomass. Organic fertilization was also followed by a large number of introduced microbial species whose high population increased strongly microbial diversity and affected the prokaryotic community structure in both the rhizosphere and bulk soil. Mineral fertilizers had almost no positive effect on the microbial abundance, but significantly reduced microbial diversity and the total number of species. Fertilization led to the convergence of the rhizosphere and bulk soil microbial communities in agroecosystems. Our findings suggest that fertilization is the most important factor in determining the abundance and diversity of total and active prokaryotic communities in both the rhizosphere and bulk soil. Thus, the traditional concept of the key role of plants in shaping microbial community composition in the rhizosphere which is valid for non-cultivated plant species was not confirmed for agricultural ecosystems and should be revised.