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MARSCHNER REVIEW

Harnessing the rhizosphere microbiome through plant breeding and agricultural management

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Abstract
Background The need to enhance the sustainability of intensive agricultural systems is widely recognized One promising approach is to encourage beneficial services provided by soil microorganisms to decrease the inputs of fertilizers and pesticides. However, limited success of this approach in field applications raises questions as to how this might be best accomplished.
Scope We highlight connections between root exudates and the rhizosphere microbiome, and discuss the possibility of using plant exudation characteristics to selectively enhance beneficial microbial activities and microbiome characteristics. Gaps in our understanding and areas of research that are vital to our ability to more fully exploit the soil microbiome for agroecosystem productivity and sustainability are also discussed.
Conclusion This article outlines strategies for more effectively exploiting beneficial microbial services on agricultural systems, and calls attention to topics that require additional research.

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Introduction

Agricultural productivity rests on a foundation of microbial activity, much of which takes place in soil. The soil has long been understood to harbor enormous microbial diversity (Torsvik et al. 1990), and contemporary research has reinforced this fact (Roesch et al. 2007). There is a growing appreciation of the genetic potential and the functional importance of the soil microbiome (Morales and Holben 2011). Within a given soil type, resident plants exert selective forces on this enormous pool of biodiversity, shaping and restructuring microbial communities in the rhizosphere [reviewed in (Berg and Smalla 2009)]. At the same time, plants are also sensitive to microbial activity, and may experience either enhanced or compromised performance depending on the activities of associated microbes. This dynamic, two-way exchange of effects between plants and soil microbes is significant in agricultural systems, and enhancing our ability to manipulate or direct these interactions could offer progress toward sustainability through development of crop varieties that selectively enhance beneficial functions within the soil microbiome. However, significant gaps in our understanding of the forces that influence the structure and functioning of plant-associated soil microbial communities pose an obstacle to realizing this goal. In this article, we review