Described by Hiltner over a century ago (1904), the rhizosphere is defined as the fraction of soil influenced by plant root activities. This dynamic, complex interface where soil, plant roots and microbes interact is a major hotspot of microbial activity, where numerous subtle molecular processes, as well as multiple feedback events take place. Rhizosphere investigations at the microscopic scale have driven spectacular academic advances in the fields of soil sciences or plant-microbe interactions. They bear promises in terms of environmentally-friendly procedures such as bioremediation or ecological engineering. The long recognized role of rhizosphere processes in plant nutrition and health, and more generally in plant adaptation to stress conditions, is now becoming central for designing sustainable management practices of agricultural and forest ecosystems. The rhizosphere, however, must also be considered and investigated at a much larger scale than its own, especially as a location where important steps of both carbon and nitrogen cycles occur, with obvious links with global changes. Major advances in understanding the rhizosphere have been achieved over the last two decades. Combined expertise in plant biology, microbial ecology and soil sciences and design of research strategies including the latest innovative methods in these fields opens exciting prospects for the future.

Reprinted from Plant and Soil, Vol. 321, nos 1-2
Plants and Soil

Cover caption:

Background photograph: Fababeans (Vicia faba L.) grown in the long-term P-fertilizer field trial at Aizeville (INRA Toulouse), exhibiting roots with N₂-fixing nodules, abundant roots hairs and adhering soil, i.e. key players and features in the rhizosphere of legumes (photograph by P. Hinsinger).

Left insert photograph: In situ detection of gfp-tagged Pseudomonas sp. DSMZ 13134 cells on root surface of barley (Hordeum vulgare L.) using the CLSM (confocal laser scanning microscope LSM510, Carl Zeiss, Jena, Germany). Two-day old seedlings were inoculated with a bacterial suspension (10⁶ cells per seedling). Plants were grown for two weeks in agricultural soil in pots in a greenhouse before analysis of the root colonization. Auto-fluorescent soil particles can be seen in the upper right corner (courtesy of K. Buddrus-Schiemann, Helmholtz Zentrum München, Neuherberg, Germany).

Right insert photograph: In situ detection of bacterial cells on the root surface of potato (Solanum tuberosum L.) grown under field conditions four weeks after planting. Fluorescence in situ hybridization (FISH) was performed using the oligonucleotide probe EUB-338-mix labeled with Fluos. Bacterial cells appear with the CLSM as green fluorescent signals and a clay particle can be seen as redish auto-fluorescence (courtesy of K. Buddrus-Schiemann, Helmholtz Zentrum München, Neuherberg, Germany).

© Springer Science + Business Media B.V., 2010
No part of this work may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording or otherwise, without written permission from the Publisher, with the exception of any material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work.

Printed on acid-free paper.
springer.com
Contents

Editorial
Rhizosphere: so many achievements and even more challenges
Y. Dessaux · P. Hinsinger · P. Lemanceau 1–3

Review Articles
Carbon flow in the rhizosphere: carbon trading at the soil–root interface
D.L. Jones · C. Nguyen · R.D. Finlay 5–33

Nitrogen-fixing bacteria associated with leguminous and non-leguminous plants
C. Franche · K. Linström · C. Elmerich 35–59

Biochemical cycling in the rhizosphere having an impact on global change
L. Philippot · S. Hallin · G. Börjesson · E.M. Baggs 61–81

Plant-microbe-soil interactions in the rhizosphere: an evolutionary perspective
H. Lambers · C. Mougel · B. Jaillard · P. Hinsinger 83–115

Rhizosphere: biophysics, biogeochemistry and ecological relevance
P. Hinsinger · A.G. Bengough · D. Vetterlein · I.M. Young 117–152

Plant root growth, architecture and function
A. Hodge · G. Berta · C. Doussan · F. Merchán · M. Crespi 153–187

The rhizosphere zoo: An overview of plant-associated communities of microorganisms, including phages, bacteria, archaea, and fungi, and of some of their structuring factors
M. Buée · W. De Boer · F. Martin · L. van Overbeek · E. Jurkevitch 189–212

Rhizosphere fauna: the functional and structural diversity of intimate interactions of soil fauna with plant roots
M. Bonkowski · C. Villenave · B. Griffiths 213–233

Plant-driven selection of microbes
A. Hartmann · M. Schmid · D. van Tuinen · G. Berg 235–257

Rhizosphere microbiota interferes with plant-plant interactions
A. Sanon · Z.N. Andrianjaka · Y. Prin · R. Bally · J. Thioulouse · G. Comte · R. Duponnois 259–278

Molecular communication in the rhizosphere
D. Faure · D. Vereecke · J.H.J. Leveau 279–303

Acquisition of phosphorus and nitrogen in the rhizosphere and plant growth promotion by microorganisms
A.E. Richardson · J-M. Barea · A.M. McNeill · C. Prigent-Combaret 305–339

The rhizosphere: a playground and battlefield for soilborne pathogens and beneficial microorganisms
J.M. Raaijmakers · T.C. Paulitz · C. Steinberg · C. Alabouvette · Y. Moënne-Loccoz 341–361

Rhizosphere engineering and management for sustainable agriculture
P.R. Ryan · Y. Dessaux · L.S. Thomashow · D.M. Weller 363–383

Rhizosphere processes and management in plant-assisted bioremediation (phytoremediation) of soils
W.W. Wenzel 385–408
Novel approaches in plant breeding for rhizosphere-related traits
M. Wissuwa · M. Mazzola · C. Picard 409–430

Strategies and methods for studying the rhizosphere—the plant science toolbox
G. Neumann · T.S. George · C. Plüssard 431–456

Sampling, defining, characterising and modelling the rhizosphere—the soil science tool box
J. Luster · A. Göttlein · B. Nowack · G. Sarret 457–482

Molecular tools in rhizosphere microbiology—from single-cell to whole-community analysis
J. Sørensen · M. Haubjerg Nicolaisen · E. Ron · P. Simonet 483–512

Iron dynamics in the rhizosphere as a case study for analyzing interactions between soils, plants and microbes
P. Lemanceau · P. Bauer · S. Kraemer · J.-F. Briat 513–535