

# Handbook of Methods Used in Rhizosphere Research

## Online Edition

A multi-authored product of COST action 631 (**UMPIRE** – *U*nderstanding and *M*odeling of *P*rocesses *i*n the *R*hizosphere *E*nvironment)

### Framework, Objective

Investigating the rhizosphere where plant roots, microbes and soil interact intensively, is inherently interdisciplinary involving soil chemistry and physics, plant physiology and soil micro- and molecular biology. Each of these disciplines operate with their own jargon and their own methods. Therefore, there is a large need for better communication between the disciplines and for cross-disciplinary education with respect to methodology. Furthermore, rhizosphere processes inherently occur on a microscale and influences of roots, microbes and soil chemistry are often difficult to distinguish. Modelling is therefore needed to understand fundamental processes occurring at a microscopic scale and to scale these up to understand their contribution to element fluxes and processes occurring at the macroscopic and ecosystem level. Based on these considerations, one of the deliverables of COST action 631 was to compile a handbook of methods used in rhizosphere research, and make it available to the broader rhizosphere community. Another objective was to build a bridge between researchers who work experimentally and those who focus on modelling.

### Content

The result of this effort is a collection of standardized method and model descriptions covering important aspects of rhizosphere research:

Chapter 1 deals with the question how to define a rhizosphere. In particular, sub-chapters treat growth systems, root growth and morphology, as well as the sampling of rhizosphere soil and soil solution.

Chapter 2 is devoted to the occurrence and bioavailability of elements and ions in the soil and their uptake into plants. Methods are described for localization and total analysis of elements in plant and fungal tissue, and for the quantification of total elemental and ionic contents as well as elemental speciation in the soil solid phase and in soil solution.

Chapter 3 covers the fluxes and transformations of organic carbon in the rhizosphere. Sub-chapters deal with the collection and identification of root exudates, isotopic and biosensor methods to trace carbon fluxes and turnover in soils, and the characterization of soil organic matter and xenobiotics.

The general theme of chapter 4 is the occurrence, identity and activity of microorganisms in the rhizosphere. In particular, microbial growth and visualisation of bacteria and fungi, enzyme activities, as well as the molecular identification and functional analysis of single species and communities are treated in sub-chapters.

The last chapter, chapter 5, gives an overview of models that have been used or have a potential to be used in rhizosphere research. This includes water and nutrient uptake models, soil chemical speciation and transport models, root architecture models and combinations thereof. In addition, a link is included to a web model data base.

### Concept

The concept of the handbook is based on two components. Firstly, method sheets are one to two page descriptions of a method or a method adaptation and the practical experience with it by individual researchers or research groups. They include information not normally contained in the literature, such as: in which systems a method has been used

successfully so far, in which systems the method has not been used at all, and in which systems the use of the method has proved unsuccessful. In addition, potential pitfalls and a list of do's and don'ts are included as well as links to detailed protocols if available. The method sheets mainly cover the expertise within the COST 631 community. Some gaps, however, were filled with expertise from other research groups. Secondly, summaries of methods for a given group of parameters have been written by experts in the field, who were also responsible for compiling the respective method sheets. They discuss groups of methods in a broader, critical perspective. In particular, they compare advantages and disadvantages of methods against each other and give brief introductions to important groups of methods that are not covered by method sheets.

The handbook offers a unique collection of proven methods covering a wide range of areas of rhizosphere research. We have attempted to include both "tried and tested", traditional methods, as well as newer techniques which are still being developed and refined. We hope the collection of methods will be useful to early career scientists, as well as established scientists seeking information outside their main areas of subject specialisation. The handbook offers a good starting point for aiding communication in interdisciplinary rhizosphere studies, however we are aware that it cannot replace the detailed information available in many excellent textbooks and web based method collections dealing with the analyses of plant and soil material or the characterization of microorganisms, and it has not been our intention to duplicate these existing sources of information. A selection of basic references is given below. More specialised textbooks or review articles are cited in the respective chapter summaries.

#### *Plant analysis:*

Harborne, J.B. 1998. *Phytochemical Methods - a Guide to Modern Techniques of Plant Analysis*. Chapman & Hall, London.

Kalra, Y.P. 1998. *Handbook of Reference Methods for plant analysis*. 1998, CRC Press, Boca Raton.

Smit, A.L.; Bengough, A.G.; Engels, C.; van Noordwijk, M.; Pellerin, S.; van de Geijn, S.C. (eds.). 2000. *Root Methods: A Handbook*. Springer, Berlin.

#### *Soil and soil solution analysis:*

Sparks, D.L. (ed.). 1996. *Methods of Soil Analysis; Part 3, Chemical Methods*. Soil Science Society of America Book Series No. 5, Soil Science Society of America, Madison WI.

*Standard Methods for the Examination of Water and Wastewater*. 17<sup>th</sup> Edition, 1989, American Public Health Association, Washington, DC.

#### *Microbial analysis:*

Alef, K.; Nannipieri, P. 1995. *Methods in Applied Soil Microbiology and Biochemistry*. Academic Press, London.

Kowalchuk, G.A.; de Bruijn, F.J.; Head, I.M.; Akkermans, A.D.L.; van Elsas, J.D. (eds). 2004. *Molecular Microbial Ecology Manual*. Second Edition. Springer

Norris, J.R.; Read, D.; Varma, A.K. 1994. *Techniques for Mycorrhizal Research*. Methods in Microbiology, Academic Press Inc., San Diego, CA.

Varma, A. 1998. *Mycorrhiza manual*. Springer-Verlag, Berlin.

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## Recommended form of citations:

### *Handbook:*

Luster, J., Finlay, R. (eds.) 2006: Handbook of Methods used in Rhizosphere Research – Online Edition. [<http://www.rhizo.at/handbook>]

### *Summaries:*

Name(s) Chapter Editor(s) 2006: Summary Chapter Title. In: Luster, J., Finlay, R. (eds.) Handbook of Methods used in Rhizosphere Research – Online Edition. [<http://www.rhizo.at/handbook>]

### *Method Sheets:*

Name(s) Author(s) 2006: "Method" OR "Parameter" by "Method" entry from sheet. In: Name(s) Chapter Editor(s) (eds.) Chapter Title. In: Luster, J., Finlay, R. (eds.) Handbook of Methods used in Rhizosphere Research – Online Edition. [<http://www.rhizo.at/handbook>]

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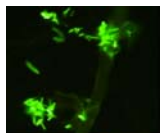
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### *Do you wish to update an existing method sheet ?*

Please send the revised contribution to the responsible chapter editor (e-mail addresses see above) and both of the editors ([joerg.luster@wsl.ch](mailto:joerg.luster@wsl.ch), [roger.finlay@mykopat.slu.se](mailto:roger.finlay@mykopat.slu.se)).

## Print Edition of the Handbook



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### **Handbook of Methods Used in Rhizosphere Research**

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