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Volumes published since 1997 are listed at the end of this book.

Springer-Verlag Berlin Heidelberg GmbH
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Root Ecology

With 72 Figures, 2 in Color, and 27 Tables

Springer
Preface

The early vascular plants that invaded the land had a very simple morphology. Typically consisting of a rhizomatous axis with vertical aerial axes placed on top, they had a low degree of organ differentiation. Unlike the situation experienced by their aquatic ancestors, the source of water and mineral nutrients was located in the soil. To aid the uptake of these resources, these primitive plants possessed only rhizoids, root hair-like outgrowths from the rhizomatous axis providing some anchorage and increasing the surface area by which the plants had contact with the soil (Mogie and Hutchings 1990).

Much has happened since. In the course of evolution, a great variety of root systems developed that have overcome the many physical, biochemical and biological problems encountered in soil. It is the variety of advanced mechanisms by which roots have adapted to life in soil and the complex role of roots within the soil ecosystem that make roots a fascinating object of scientific study. This volume gives an overview of our current understanding of these mechanisms and roles, and suggestions for how to further deepen our insight into the ecology of roots.

We now know that roots are as extensive and important to plant growth and fitness as the plant’s aboveground structures. However, roots have been rightfully coined the “the hidden half” (Waisel et al. 1996) because an appreciation of their significance has come rather late. The ignorance of the crucial role of roots for plant life has gradually disappeared as more information on the functioning of roots has seen the light of day. Recent scientific progress has depended strongly on sophisticated methodologies. Novel techniques continue to be developed (Smit et al. 2000) and so, in this volume, a number of chapters have sections on methods. This is an expression of an innovative field of research and much more is likely to be revealed in the future. Particular challenges are detailed in the “Summary and Prospects” sections that every chapter (except the opening chapter) concludes with.

The volume starts with an overview of the form and function of roots and the many problems that they encounter by life in soil (Chap. 1), introducing many of the topics that are discussed in more detail in the chapters that follow. Chapter 2 describes the spatial distribution of roots, including the
responses to heterogeneous soils that are interpreted in terms of foraging for nutrients and water. Chapter 3 deals with root distribution in time, by reviewing the knowledge on turnover of roots in various ecosystems and their implications for ecosystem processes.

The following five chapters provide physiological background to the basic functions of roots, including carbon in- and output (Chap. 4) and water and solute movement (Chap. 5), and the physiological and morphological solutions that roots have developed to cope with three major abiotic stresses, i.e. hard soil structure (Chap. 6), drought (Chap. 7) and flooding (Chap. 8). The carbon balance in roots largely determines the growth of a root system, and is therefore crucial not only for our understanding of root proliferation, but also for the role of roots as carbon source for the soil ecosystem (Chap. 4). The allocation of such carbon compounds and the transport of nutrients taken up by the roots depend on a carefully controlled hydraulic balance (discussed in Chap. 5). Nutrient and water uptake, two prime tasks of a root system, may be severely hampered if a root cannot penetrate the bulk soil (Chap. 6), encounters low soil water potential (Chap. 7) or low oxygen concentrations (Chap. 8). The regulatory control of the anatomical and morphological changes that enable roots to overcome such adverse conditions is greatly similar among stresses, and based on key plant hormones such as ethylene and abscisic acid. Additionally, specific biochemical pathways add to the resistance of the roots to these extreme habitats (Chaps. 7 and 8).

The volume concludes with six chapters on biotic interactions emphasising the complex soil ecosystem that roots influence and, vice versa, influences the roots. Roots have evolved symbiotic interactions with mycorrhiza (Chap. 11), rhizobia (Chap. 12) and soil bacteria (Chaps. 12 and 13) that assist in the capture of soil resources such as nitrogen and phosphorus that are often in short supply. Roots compete for these resources with other roots (Chap. 9) and with soil microorganisms (Chap. 12) and are an important food source for a variety of soil herbivores (Chap. 14). Many of the biotic interactions involve the exudation of organic substances (Chap. 10) and release of gases, such as oxygen in flooded soils (Chap. 13). In this way, roots possess an array of intriguing mechanisms by which they manipulate the soil environment and its biota, facilitating the growth of soil bacteria that promote plant growth or suppress diseases (Chap. 12), stimulate microbial processes that accelerate soil nutrient cycling (Chap. 13), or provide a chemically hostile environment for competitor plants (Chap. 10).

We would like to end this preface with some words of thanks to the people who made this volume possible. First, and most importantly, we are grateful to the authors for their willingness to put their ideas into this volume, resulting in the creation of particularly challenging chapters. We also owe the many referees that have helped the authors to further improve their original contributions. Kees Blom, Professor in Experimental Plant Ecology at the University of
Nijmegen, initiated this project and selected and invited the various authors. His current position as Vice Chancellor has prevented him from completing his task as an editor, but we acknowledge his indispensable input into the early phases of the project. We finally thank Jose Broekmans for her assistance in the final stages of formatting and checking the final manuscript.

Hans de Kroon
Eric J.W. Visser

Nijmegen, January 2003

References

Contents

1 Constraints on the Form and Function of Root Systems 1
D. Robinson, A. Hodge and A. Fitter

1.1 Introduction ............................................. 1
1.2 Problems Associated with Life in Soil .................. 2
1.2.1 Physical Problems .................................... 2
1.2.2 Chemical Reactivity .................................. 3
1.2.3 Biological Activity .................................. 3
1.2.4 Heterogeneity ......................................... 4
1.3 Evolutionary Solutions .................................. 4
1.3.1 Penetration of Soil Pores ......................... 5
1.3.2 Heterotrophy ......................................... 5
1.3.3 Hierarchical Branching ................................ 5
1.3.4 Long-Distance Transport .............................. 8
1.3.5 Maintenance Costs .................................. 8
1.3.6 Dehydration Risk ................................... 9
1.3.7 Compensation for Unpredictable Water and Nutrient Supplies .......................................... 10
1.3.8 Conflicting Design Requirements ..................... 10
1.4 Emergent Properties .................................... 11
1.4.1 Topology ............................................. 11
1.4.2 Size ................................................... 15
1.4.3 Depth .................................................. 19
1.4.4 Anchorage ............................................ 20
1.4.5 Rhizosphere ......................................... 21
1.4.6 Mycorrhizas .......................................... 23
1.4.7 Specialised Morphologies .............................. 24
1.4.8 Global-Scale Processes ............................... 25
1.5 Concluding Remarks .................................... 26
References .................................................. 27
Distribution of Roots in Soil, and Root Foraging Activity

M.J. Hutchings and E.A. John

2.1 Introduction ........................................ 33
2.2 Plant Rooting Patterns in the Vertical and Horizontal Dimensions ......................... 35
2.3 Segregation of Root Systems ......................... 40
   2.3.1 Segregation of Root Systems in the Vertical Dimension .......................... 40
   2.3.2 Segregation of Root Systems in the Horizontal Dimension ...................... 42
2.4 Foraging by Roots ..................................... 44
   2.4.1 Root Foraging Responses to Spatial Heterogeneity in Availability of Soil-Based Resources .......... 45
   2.4.2 Morphological vs. Physiological Plasticity: Responses to Total Resource Supply and to the Spatial and Temporal Patterns of Resource Provision .......... 49
   2.4.3 Patterns of Root Placement in Heterogeneous Environments and Their Consequences .......... 50
2.5 Summary and Prospects .............................. 55
References .............................................. 56

Turnover of Root Systems

W.K. Lauenroth and R. Gill

3.1 Introduction ........................................ 61
3.2 Overview of the Structure of Root Systems .................................................. 62
   3.2.1 Conifers and Woody Dicots ........................................... 63
   3.2.2 Herbaceous Dicots .................................................. 63
   3.2.3 Monocots ......................................................... 64
3.3 Methods of Assessing Root Turnover ......................................................... 64
   3.3.1 Direct Estimates of Root System Turnover Coefficients Based on $^{14}$C Turnover .......... 65
   3.3.2 Indirect Estimates of Root System Turnover Coefficients ....................... 66
      3.3.2.1 Biomass ...................................................... 66
      3.3.2.2 Ingrowth Cores ........................................... 66
      3.3.2.3 Nitrogen Balance .......................................... 66
      3.3.2.4 Minirhizotrons .......................................... 67
3.4 The Growth, Life Span, and Death of Roots ............................................... 68
   3.4.1 Effects at the Individual Root Level ........................................... 68
      3.4.1.1 Water and Nutrients ....................................... 68
      3.4.1.2 Soil Temperature .......................................... 69
      3.4.1.3 Root Diameter ............................................ 69
      3.4.1.4 Root Symbionts ........................................... 70
   3.4.2 Morphological vs. Physiological Plasticity: Responses to Total Resource Supply and to the Spatial and Temporal Patterns of Resource Provision .......... 49
   3.4.3 Patterns of Root Placement in Heterogeneous Environments and Their Consequences .......... 50
   3.5 Summary and Prospects .............................. 55
References .............................................. 56
Herbivory

 Effects at the Whole-Plant Level

 Elevated CO₂

 Pathogens and Herbivores

 Field Estimates of Root Turnover
 and Net Primary Production

 Forests

 Temperate

 Boreal

 Tropical

 Grasslands

 Temperate

 High Latitude

 Tropical

 Shrublands

 Temperate

 High Latitude

 Tropical

 Relationship of Root Turnover to Environmental Factors

 Summary and Prospects

 References

 The Control of Carbon Acquisition by and Growth of Roots

 J.F. FARRAR and D.L. JONES

 Introduction

 Production of Carbohydrate in Source Leaves

 Import of Carbohydrates by Roots: the Phloem Path

 Import of Carbohydrates by Roots: Phloem Unloading and Short-Distance Transport

 Fibrous Roots

 Storage Roots

 Is There Feedback Control of Import?

 Are There Plant Growth Substances That Control Import?

 Are There Genes That Control Import?

 Carbon Fluxes Within Roots and Their Role in Growth and Import

 Flucts That Increase C Content

 Flucts That Cause Loss of C

 Turnover and Metabolism Within Roots

 Localisation and Compartmentation

 Size of Pools Relative to Fluxes
4.5.3.3 Flux to Structure (Including Maintenance) .......... 101
4.5.3.4 Localisation of Metabolism to Different Cell Types .. 102
4.6 Exudation ........................................... 103
4.6.1 How Large Is the Root Exudation C Flux? .......... 103
4.6.2 What Are the Dominant Exudate Components? ...... 104
4.6.3 Localisation of Root Exudation ................. 106
4.6.4 Mechanistic Basis of Root Exudation .......... 106
4.6.4.1 Root Exudation Regulated by C Influx ........ 107
4.6.4.2 Root Exudation Regulated by C Efflux .......... 108
4.6.5 Exudation: Conclusion ............................ 109
4.7 Integration of Fluxes .................................. 110
4.7.1 Shared Control of Carbon Flux ............. 110
4.7.2 Additional Evidence for Shared Control
of Import into Roots ................................. 111
4.7.3 Mechanisms Underlying Shared Control of Carbon Flux 112
4.7.4 What is Root 'Demand'? ............................. 113
4.7.5 The Remarkable Consequences of Darkening ...... 114
4.8 Allocation of C and Dry Weights to Roots Relative to Shoots 115
4.8.1 The Conservation of Shoot/Root Ratio .......... 115
4.8.2 The Case of Phosphate ............................ 116
4.8.3 Functional Equilibrium ............................ 117
4.9 Summary and Prospects ............................... 118
References ................................................. 119

5 Hydraulic Properties of Roots .......................... 125
M.T. Tyree

5.1 Introduction .......................................... 126
5.2 Root Structure and Possible Pathways of Water Movement 127
5.3 Driving Forces and the 'Composite Membrane' .......... 130
5.4 Methods of Measuring Hydraulic Conductances .......... 131
5.4.1 Root Chamber Methods ............................ 132
5.4.2 Nobel Method ................................. 132
5.4.3 Root Pressure Probe Method ...................... 134
5.4.4 The High Pressure Flowmeter Method ........... 136
5.5 Distribution of Hydraulic Resistances in Roots .......... 137
5.5.1 Axial Water Flow – Poiseuille's Law ............ 137
5.5.2 Radial Water Flow and Role of Endodermis and Exodermis 138
5.5.3 Experiments to Locate Major Barriers
to Water and Solute Flow ............................. 138
5.6 Models of Solute and Water Flux in Roots
(Possible Reinterpretation of Ideas) ................. 141
8 Physiology, Biochemistry and Molecular Biology of Plant Root Systems Subjected to Flooding of the Soil

M.B. Jackson and B. Ricard

8.1 Introduction .................................................. 193
8.2 Inhibition of Root Growth by Partial Oxygen Shortage ........ 193
8.3 Possible Causes of Severe Growth Inhibition and Cell Death in the Absence of Oxygen ........ 194
8.3.1 ATP Supply and Demand .................................. 194
8.3.2 Self-Injury from Products of Anaerobic Metabolism .......... 197
8.4 Hypoxic Acclimation to Anoxia ................................ 198
8.4.1 Oxygen Sensing and Signal Transduction .................... 198
8.4.2 Regulation of Gene Expression ............................. 198
8.4.3 Selective Gene Expression and Enzyme Synthesis .......... 199
8.4.4 Metabolic Basis of Improved Tolerance to Anoxia .......... 200
8.4.4.1 Sugar Transport and Degradation ...................... 201
8.4.4.2 Glycolytic and Fermentative Enzymes .................. 201
8.4.5 Cytoplasmic Acidosis .................................... 202
8.4.6 Other Routes to Tolerance .................................. 202
8.5 Aerenchyma and Avoidance of Anoxia ........................ 203
8.6 Stem Hypertrophy, Adventitious Rooting and Related Phenomena ................................. 204
8.7 Signalling by Oxygen-Deficient Roots ............................. 204
8.8 Summary and Prospects ....................................... 206
References ......................................................... 207
# Contents

## 9 Root Competition: Towards a Mechanistic Understanding
H. de Kroon, L. Mommer and A. Nishiwaki

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1 Introduction</td>
<td>215</td>
</tr>
<tr>
<td>9.2 What Traits Confer Belowground Competitive Ability?</td>
<td>216</td>
</tr>
<tr>
<td>9.3 Mechanisms of Root–Root Interactions</td>
<td>217</td>
</tr>
<tr>
<td>9.3.1 Indirect Effects Through Resource Depletion</td>
<td>217</td>
</tr>
<tr>
<td>9.3.2 Direct Chemical Interactions</td>
<td>219</td>
</tr>
<tr>
<td>9.4 Root Distributions as a Consequence of Root–Root Interactions</td>
<td>222</td>
</tr>
<tr>
<td>9.5 Belowground Competition as a Consequence of Root Distribution Patterns</td>
<td>225</td>
</tr>
<tr>
<td>9.5.1 Symmetric Competition for Space</td>
<td>225</td>
</tr>
<tr>
<td>9.5.2 Symmetric or Asymmetric Competition for Nutrients</td>
<td>226</td>
</tr>
<tr>
<td>9.5.3 The Dynamics of Competition</td>
<td>227</td>
</tr>
<tr>
<td>9.6 Summary and Prospects</td>
<td>231</td>
</tr>
<tr>
<td>References</td>
<td>231</td>
</tr>
</tbody>
</table>

## 10 Root Exudates: an Overview
Inderjit and L.A. Weston

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1 Introduction</td>
<td>235</td>
</tr>
<tr>
<td>10.2 Examples of Root Exudation</td>
<td>237</td>
</tr>
<tr>
<td>10.3 Methods of Measuring Root Exudation</td>
<td>238</td>
</tr>
<tr>
<td>10.4 Fate and Movement of Exudates in Soil</td>
<td>241</td>
</tr>
<tr>
<td>10.5 Case Study: Root Exudation by Sorghum</td>
<td>243</td>
</tr>
<tr>
<td>10.6 Influence on Inorganic Nutrient Availability</td>
<td>246</td>
</tr>
<tr>
<td>10.7 Influence on Soil Organisms</td>
<td>248</td>
</tr>
<tr>
<td>10.8 Other Roles of Root Exudates</td>
<td>248</td>
</tr>
<tr>
<td>10.9 Summary and Prospects</td>
<td>250</td>
</tr>
<tr>
<td>References</td>
<td>251</td>
</tr>
</tbody>
</table>

## 11 Mycorrhizas
F.A. Smith, S.E. Smith and S. Timonen

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.1 Introduction</td>
<td>257</td>
</tr>
<tr>
<td>11.2 Classification and Root Structures</td>
<td>259</td>
</tr>
<tr>
<td>11.2.1 Arbuscular Mycorrhizas</td>
<td>259</td>
</tr>
<tr>
<td>11.2.2 Ectomycorrhizas and Endomycorrhizas</td>
<td>262</td>
</tr>
<tr>
<td>11.2.3 Mycorrhizas of the Ericales</td>
<td>264</td>
</tr>
<tr>
<td>11.2.4 Orchid Mycorrhizas</td>
<td>265</td>
</tr>
</tbody>
</table>
11.2.5 Surprises in Store? ........................................ 265
11.2.6 Fungus-Plant Interfaces and Interactions ............ 267
11.3 Mycorrhizal Plant Communities and Their Distribution ... 267
11.4 The Mycorrhizosphere .................................... 270
11.4.1 External Hyphae ...................................... 270
11.4.2 The Soil Environment ................................ 272
11.4.3 Bacteria Associated with Mycorrhizal Fungi ........ 272
11.5 Functional Bases of Mycorrhizal Symbioses ............ 274
11.5.1 Transfer of Nutrients and Carbon .................... 274
11.5.1.1 Individual Plants .................................. 274
11.5.1.2 Linked Plants .................................... 275
11.5.2 Non-nutritional Factors ............................... 276
11.6 Diversity in Plant Growth Responses .................... 277
11.6.1 Carbon Costs of Mycorrhizal Symbioses ............ 278
11.6.2 Growth Rates, Nutrient Demand and Mycorrhizal Responsiveness ........................................ 279
11.7 Plant-Fungal Interactions at the Community Level ........ 282
11.7.1 Plant Density, Competition and Succession .......... 282
11.7.2 The Mycorrhizal Fungal Community .................... 285
11.8 Summary and Prospects .................................. 285
References .................................................. 287

12 Signalling in Rhizobacteria-Plant Interactions .......... 297
L.C. van Loon and P.A.H.M. Bakker

12.1 Introduction ............................................. 297
12.2 Plant Growth Promotion by Rhizobacteria .............. 298
12.3 Rhizobium-Plant Interactions ............................ 303
12.4 Disease Suppression by Rhizobacteria .................. 308
12.4.1 Competition for Substrate ............................. 309
12.4.2 Competition for Iron by Siderophores ............... 309
12.4.3 Antibiosis ........................................... 311
12.4.4 Lytic Activity ...................................... 314
12.5 Rhizobacteria-Mediated Induced Systemic Resistance .. 314
12.6 Summary and Prospects .................................. 320
References .................................................. 321
13 Interactions Between Oxygen-Releasing Roots and Microbial Processes in Flooded Soils and Sediments

P.L.E. BODELIER

13.1 Introduction ............................................. 331
13.2 Methodology in Rhizosphere Microbiology .................. 334
13.3 Quantitative and Qualitative Aspects of Root Oxygen Release ............................................. 335
13.4 Interactions Between Oxygen-Releasing Roots and Aerobic Microbial Processes involved in C- and N-Cycling 339
13.4.1 Heterotrophic Bacteria .................................. 339
13.4.2 Methane-Consuming Bacteria ............................. 341
13.4.3 Nitrifying Bacteria ....................................... 344
13.4.4 Interactions Between Oxygen-Releasing Roots and Anaerobic Microbial Processes Involved in C- and N-Cycling 346
13.5.1 Denitrifying Bacteria ...................................... 346
13.5.2 Iron- and Sulphate-Reducing Bacteria ..................... 348
13.5.3 Methanogenic Bacteria ................................... 350
13.5.4 Nitrogen-Fixing Bacteria ................................. 352
13.6 Summary and Prospects ..................................... 353
References ................................................................ 355

14 Root–Animal Interactions .................................... 363

J.B. WHITTAKER

14.1 Introduction .................................................. 363
14.2 The Organisms Involved ..................................... 364
14.3 Indirect Effects of Aboveground Grazing on Roots ........ 367
14.4 Direct Herbivory on Roots ................................... 370
14.5 Interactions Between Above- and Belowground Herbivory . 374
14.6 Physiological Responses ...................................... 376
14.7 Community Responses ......................................... 378
14.8 Summary and Prospects ....................................... 380
References ................................................................ 381

Subject Index ......................................................... 387
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