

Plant Nematology

2nd Edition

Edited by
Roland N. Perry and
Maurice Moens

Contents

The Editors	xi
Contributors	xv
Preface to the First Edition	xix
Preface to the Second Edition	xxi

PART I TAXONOMY, SYSTEMATICS AND PRINCIPAL GENERA

1 Structure and Classification	3
<i>Wilfrida Decraemer and David J. Hunt</i>	
1.1. Introduction	3
1.2. General Morphology	7
1.3. Life Cycle Stages	29
1.4. Feeding Groups	31
1.5. Classification of Plant-parasitic Nematodes	32
1.6. Common Morphometric Abbreviations	37
2 Molecular Systematics	40
<i>Sergei A. Subbotin, Lieven Waeyenberge and Maurice Moens</i>	
2.1. Phylogenetics and Phylogenomics	41
2.2. Species Concepts and Delimiting Species in Nematology	42
2.3. Phylogenetics and Classification	43
2.4. Molecular Techniques	44
2.5. Genes used for Molecular Systematics	52
2.6. Microsatellites	57
2.7. DNA Bar Coding	57
2.8. Phylogenetic Inference	57
2.9. Reconstruction of Historical Associations	62
2.10. Databases	63
2.11. Examples of Molecular Phylogenies	64
3 Root-knot Nematodes	73
<i>Gerrit Karssen, Wim Wesemael and Maurice Moens</i>	
3.1. Introduction to Root-knot Nematodes	74
3.2. Life Cycle and Behaviour	74
3.3. Host Response to Parasitism	77
3.4. Post-infection Biology	80
3.5. Effect on Plant Growth and Yield	82
3.6. Survival	83

3.7. Cytogenetics	84
3.8. General Morphology	84
3.9. Principal Species	91
3.10. Biochemical and Molecular Identification	102
3.11. Interactions with Other Plant Pathogens	103
3.12. Management and Control	105
4 Cyst Nematodes	109
<i>Susan J. Turner and Sergei A. Subbotin</i>	
4.1. Introduction to Cyst Nematodes	110
4.2. Life Cycle and Behaviour	111
4.3. General Morphology of the Subfamily Heteroderinae	116
4.4. Genera and Principal Species	120
4.5. Pathotypes and Races	135
4.6. Biochemical and Molecular Diagnosis	137
4.7. Interactions with Other Plant Pathogens	139
4.8. Management	141
5 Migratory Endoparasitic Nematodes	144
<i>Larry W. Duncan and Maurice Moens</i>	
5.1. Introduction to Migratory Endoparasitic Nematodes	145
5.2. The Pratylenchids: Lesion, Burrowing and Rice Root Nematodes	146
5.3. Anguinids and the Stem and Bulb Nematode, <i>Ditylenchus dipsaci</i>	162
5.4. Plant-parasitic Aphelenchs	166
6 Ectoparasitic Nematodes	179
<i>Wilfrida Decraemer and Etienne Geraert</i>	
6.1. Introduction	180
6.2. Definition of Ectoparasites/Ectoparasitism	180
6.3. Classification	181
6.4. Tylenchina (Chromadorea, Chromadoria)	181
6.5. Enoplea	193
6.6. Biochemical and Molecular Diagnostics	212
6.7. Ectoparasitic Nematodes as Vectors of Plant Viruses	213
6.8. Management	214

PART II NEMATODE BIOLOGY AND PLANT-NEMATODE INTERACTIONS

7 Reproduction, Physiology and Biochemistry	219
<i>Roland N. Perry, Denis J. Wright and David J. Chitwood</i>	
7.1. Reproduction and Development	220
7.2. Musculature and Neurobiology	224
7.3. Biosynthesis	227
7.4. Respiration and Intermediary Metabolism	230
7.5. Osmotic and Ionic Regulation and Excretion	233
7.6. Survival Strategies	235

8	Behaviour and Sensory Perception	246
	<i>Roland N. Perry and Rosane H.C. Curtis</i>	
8.1.	Sense Organs or Sensilla	247
8.2.	Undulatory Propulsion	249
8.3.	Random Movement	255
8.4.	Movement in Response to Stimuli	259
8.5.	Nematode Feeding and Movement within Plant Tissue	266
8.6.	Other Types of Movement and Behaviour	273
9	Molecular Aspects of Plant-Nematode Interactions	274
	<i>Godelieve Gheysen and John T. Jones</i>	
9.1.	Nematode Parasitism of Plants	275
9.2.	Invasion and Migration	277
9.3.	Wound and Defence Responses of the Plant	281
9.4.	Suppression of Host Defences and Protection from Host Responses	283
9.5.	Molecular and Cellular Aspects of the Development of Nematode Feeding Cells	285
9.6.	Nematode Signals for Feeding Site Induction and Other Processes	292
9.7.	Comparisons Between Cyst and Root-knot Nematodes	295
9.8.	Resistance and Avirulence Genes	296
 PART III QUANTITATIVE NEMATOLOGY AND MANAGEMENT		
10	Plant Growth and Population Dynamics	301
	<i>Corrie H. Schomaker and Thomas H. Been</i>	
10.1.	Introduction	302
10.2.	Relationships of Nematodes with Plants	302
10.3.	Predictors of Yield Reduction	303
10.4.	Different Response Variables of Nematodes	305
10.5.	Stem Nematodes (<i>Ditylenchus dipsaci</i>)	305
10.6.	Root-invading Nematodes	307
10.7.	Effect of Nematicides	319
10.8.	Validation of the Model	321
10.9.	Population Dynamics	322
11	Distribution Patterns and Sampling	331
	<i>Thomas H. Been and Corrie H. Schomaker</i>	
11.1.	Introduction	331
11.2.	Practical Application	332
11.3.	Horizontal Distribution	333
11.4.	Vertical Distribution	356
12	International Plant Health – Putting Legislation into Practice	359
	<i>Sue Hockland, Renato N. Inserra and Lisa M. Kohl</i>	
12.1.	Introduction and Terminology	360
12.2.	Historical Considerations	362
12.3.	International Phytosanitary Frameworks	364

12.4.	Early Legislation Enacted against Plant-parasitic Nematodes	366
12.5.	International Phytosanitary Initiatives against Plant-parasitic Nematodes	367
12.6.	Phytosanitary Problems Posed by Plant-parasitic Nematodes	370
12.7.	Determining the Risk Posed by Plant-parasitic Nematodes Using Pest Risk Analysis	370
12.8.	Phytosanitary Measures for Plant-parasitic Nematodes	373
12.9.	Phytosanitary Measures and their Associated Cost: Benefits	375
12.10.	Future Challenges for the Control of Regulated Nematodes	378
12.11.	Challenges Facing Scientific Advisers and Researchers	379
13	Biological and Cultural Management	383
	<i>Nicole Viaene, Danny L. Coyne and Keith G. Davies</i>	
13.1.	Introduction	384
13.2.	Suppressive Soils	385
13.3.	Biological Control Agents	386
13.4.	Interactions with Rhizosphere Microflora	394
13.5.	Application of Biological Control Agents	395
13.6.	Integration of Biological Control with Other Control Measures	397
13.7.	Nematode-free Planting Material	399
13.8.	Sanitation	401
13.9.	Physical Soil Treatments	402
13.10.	Biologically based Practices	405
13.11.	Amendments	408
13.12.	Time of Planting	410
13.13.	Other Control Practices	410
14	Nematode Resistance in Crops	411
	<i>James L. Starr, Alexander H. McDonald and Abiodun O. Claudius-Cole</i>	
14.1.	Introduction	411
14.2.	Concepts of Resistance	412
14.3.	Inheritance and Mechanisms of Resistance	414
14.4.	Virulence in Nematodes	418
14.5.	Origins and Functions	423
14.6.	Exploitation	424
14.7.	Successes and Opportunities	434
15	Genetic Engineering for Resistance	437
	<i>Amanda Cottage and Peter Urwin</i>	
15.1.	Genetic Engineering for Resistance: General Introduction	438
15.2.	Genetic Engineering for Nematode Resistance: Use of Natural Resistances	439
15.3.	Targets in the Early Nematode-Plant Interaction for Engineered Resistance	442
15.4.	Genetic Engineering to Target the Nematode Directly	444
15.5.	Targeting the Nematode Feeding Site	450

15.6. Stacked Defences	457
15.7. The Research Approach to Engineering Nematode Resistance	457
15.8. The Future	458
16 Chemical Control of Nematodes	459
<i>Patrick P.J. Haydock, Simon R. Woods, Ivan G. Grove and Martin C. Hare</i>	
16.1. History and Development of Nematicides	459
16.2. Active Substances: Chemical Groups and Modes of Action	463
16.3. Formulation and Application	464
16.4. Nematicides in the Environment	471
16.5. Human Safety	475
16.6. Naturally Occurring Nematicides	477
References	481
Glossary	523
Index	533

Plant Nematology

2nd Edition

Edited by Roland N. Perry and Maurice Moens

Plant-parasitic nematodes devastate crops worldwide, having major economic and social impacts. Control is imperative, necessitating a broad understanding of nematode biology and ecology. This textbook describes nematodes as plant pests, covering taxonomy (classical and molecular) and genera, physiology and behaviour, plant responses, and sampling and management strategies. Fully updated throughout, it is enhanced by extensive illustrations and focus boxes, with chapters authored by international experts reviewing a wide range of current research. Providing a broad introduction that includes biological and chemical control, this comprehensive resource is essential for students of plant nematology and pathology, crop protection and applied parasitology.

Praise for the first edition

'...the book combines both an appreciation and summary of the past and current knowledge needed for students of plant nematology, while at the same time maintaining the excitement of the subject and identifying where future progress will lie...I would readily recommend the book to any students wishing to get an overview of the subject area.'

Journal of Nematology

Related titles

Parasitic Nematodes: Molecular Biology, Biochemistry and Immunology, 2nd Edition

Edited by M.W. Kennedy and W. Harnett
2013 448 pages ISBN 978 1 84593 759 1

Infectious Forest Diseases

Edited by P. Gonthier and G. Nicolotti
2013 672 pages ISBN 978 1 78064 040 2

Molecular and Physiological Basis of Nematode Survival

Edited by R.N. Perry and D.A. Wharton
2011 344 pages ISBN 978 1 84593 687 7

Integrated Pest Management: Principles and Practice

Edited by D.P. Abrol and U. Shankar
2012 512 pages ISBN 978 1 84593 808 6

For further information on these titles and other publications, see our website at www.cabi.org

CABI

Nosworthy Way
Wallingford
Oxfordshire
OX10 8DE
UK

CABI

38 Chauncey Street
Suite 1002
Boston, MA 02111
USA

ISBN 978-1-78064-153-9



Front cover image: Confocal image of a second-stage juvenile of *Globodera pallida* stained with PKH26 migrating through cells of a potato root 6 days post-infection (courtesy of Dr Vivian Blok and Dr Slawek Janakowski, The James Hutton Institute, UK).