

Integrated Management of Fruit Crops and Forest Nematodes

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Integrated Management of Fruit Crops and Forest Nematodes

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PREFACE

This series originated during a visit of prof. K. G. Mukerji to the CNR Plant Protection Institute at Bari, Italy, in November 2005. Both editors convened to produce a series of five volumes focusing, in a multi-disciplinary approach, on recent advances and achievements in the practice of crop protection and integrated pest and disease management.

This fourth Volume deals with management of nematodes parasitic of tree crops, and includes a section on tropical fruit crops and commodities, as well as a second section on tree crops from more temperate areas. The latter also includes a chapter updating the current knowledge about the pine wood nematode, *Bursaphelenchus xylophilus*. Volume 4 flanks Volume 2 of this IMPD series, which focused on management of vegetable and grain crops nematodes.

Nematodes are a very successful, diversified and specialised animal group, present in nature in any ecological niche. Among nematode species, only a reduced number feeds on plants, of which a few species cause severe economic impacts on crop productions. Plant parasitic nematodes represent an important concern for a broad range of agricultural productions and systems, worldwide. This statement explains the attention devoted in last decades to nematodes, and the research and technical efforts invested for their control. As for other disciplines included in plant protection, nematology is now in a mature stage in which the initial optimism deriving from the widespread use of chemicals and fumigants lent space to a more pragmatic, comprehensive and integrated vision of control and management, including traditional approaches like resistance-based management or innovative approaches like biocontrol or use of natural compounds.

A wide literature already covers chemical or biological control of nematodes, but there is still a need for a more holistic vision of management, accounting for different experiences and solutions, developed worldwide. In this series we attempted to fill this gap aiming at providing an informative coverage for a broad range of agricultural systems which coexist in the world today, focusing on solutions fitting the corresponding background economies. Chapters are mainly organized and centered on crops and/or regional problems, ranging from nematodes of tropical crops like banana, cocoa and coffee, to species affecting more widespread crops like citrus. Regional aspects are described in chapters dealing with tropical fruit or commodity productions (Venezuela, Mexico, Nigeria) or with export-oriented cropping systems (Chile). Chapters in Section 2 review nematodes and related management options for more temperate crops, i.e. *Prunus* spp., grapevine, pistachio and olive nematodes, with a chapter on the management options for virus-transmitting nematode species. Emphasis was also given to long-term technological solutions, updating the actual knowledge on the application of resistant germplasm in several of the cited crops.

In the first chapter, the integrated management of banana nematodes is reviewed, starting from the botanical and economical backgrounds of this crop. Dessert banana crops for export and the geographic distribution of associated nematode species are revised. Concepts definition and applications are then discussed, in the light of integrated nematode management. Damage and economic

importance of main nematode species and control strategies are reviewed, with reference to nematicide use. The search for alternatives to chemical control are then illustrated, with basic studies on nematode biology for the different species. Nematode problems of banana crops in Africa, Asia, Oceania and America are reviewed, focusing on the occurrence, importance and potential damage caused by main species. Current management options, including the production and dissemination of clean planting material, the application of cultivated fallow and alternate cropping systems, as the use of mulching and fertilisers, are then reviewed. Future and common strategies and plant health measures applied are revised, with emphasis on the search for sources of resistance to the burrowing nematode *R. similis*, the lesion nematode *Pratylenchus* spp., root-knot *Meloidogyne* spp. and the spiral nematode *Helicotylenchus multicinctus*. The nematode tolerance, the production of new synthetic banana hybrids and their response to nematodes are also examined. Finally, resistance and plant defence mechanisms are reviewed, followed by transgenic resistance, biological control and antagonistic microorganisms, induction of suppressiveness and available improvements for cultural practices.

In the following chapters, problems and solution applied on a regional scale for management of nematodes of fruit and commodity crops follow, illustrating some case-studies ranging from South to Central America and West Africa. A comprehensive review of the main nematode species of tropical fruit crops is given in Chapter 2, describing the case-study of Venezuela. In the following chapter, concepts in management in export-oriented, fruit production systems in Chile are reviewed, focusing on the conservation of soil fertility by means of irrigation and fertilization, placing nematodes management options in a more general view of root and plant protection, as well as soil fertility conservation. In Chapter 4, the broad diversity of coffee cropping systems of Mexico is analysed, with a review of the main properties and problems of natural or mountain systems, including traditional polyculture and specialized systems, commercial polyculture and sunlight system. The main phytosanitary aspects of these coffee cropping systems are reviewed, focusing on nematodes and related investigations.

Nematode problems of cocoa production systems in West Africa are revised in Chapter 5. After discussing the production, climatic requirements, cultivation techniques and practices, the main nematode species attacking cacao are reviewed, with data on their geographic distribution, damage and symptoms. Apart of root-knot nematodes, other nematode parasites and related disease complexes are examined. The options for management and control in cacao are then reviewed, focusing on the integrated approach to nematode control, the use of resistant planting material, the production of nematode-free seedlings in nurseries, the use of nematicides in the field, and of organic amendments and biological control.

In the following chapter the status of nematodes management in citrus orchards is reviewed. This chapter deals with the citrus nematode, *Tylenchulus semipenetrans* and the related slow decline symptoms. Other nematode species of citrus are also examined, including *Radopholus similis* and *R. citri*, *Pratylenchus* spp., *Belonolaimus longicaudatus*, *Meloidogyne* spp., *Hemicycliophora* spp. and dorilaimid species. Data are provided on their biology and ecology, on the interactions with other soil organisms, biotypes, rootstock resistance, economic

importance and crop loss prediction. Management, sampling and extraction techniques are also reviewed, together with sanitation practices and exclusion, as well as cultural practices, use of fumigants and nematicides.

In Section 2, six further chapters deal with nematodes of temperate fruit crops, with a revision of forest nematodes management, mainly updating the situation for *B. xylophilus*, a major emerging problem in Europe. The integrated management of nematodes parasitic on *Prunus* spp. is reviewed in Chapter 7, dealing with root-knot, lesion, ring and dagger nematodes. The chapter focus is on management and control methods based on prevention and quarantine. Pre-planting measures are reviewed, including fallow, crop rotation, site preparation, soil solarization, biofumigation, steam application, soil fumigation, chemical control with non-fumigants nematicides, seedling treatments and resistance. Post-planting measures examined include chemical and biological control, cultural methods and integrated management.

In the following chapter, the selection and application of resistant germplasm for management of nematodes attacking grapevine is reviewed. The chapter focus is on root-knot nematodes and the GFLV vector *Xiphinema index*. For root-knot nematodes, data on their biology, ecology, symptoms and control are provided. The selection and breeding of resistant rootstocks is then reviewed, with data on resistant *Vitis* and *Muscadinia* material. The advances in breeding for resistance, as well as the genetics of resistance mechanisms and its durability are also discussed. The chapter then reviews the biology, vention and classical control methods of *X. index* and other virus vector nematodes of grapevine, focusing on the selection and breeding for *Vitis* and *Vitis* × *Muscadinia* resistant rootstocks. The resistance features of *Muscadinia rotundifolia* are then discussed, together with the properties of the *V. vinifera* × *M. rotundifolia* F₁ hybrids obtained in California and France. Data on resistance to other nematodes and rootstock control of multiple nematode pests are also provided.

Given the importance of virus-vector nematodes, the following chapter reviews the management of virus-transmitting species with special emphasis on South-East Europe. The geographic distribution and spread of main species is reviewed, focusing on vectors and virus diagnostic techniques, including vectors identification, transmission assays, molecular detection and integrated management. Concepts in prevention and quarantine are then discussed, together with the main practices available for management, like agronomic and chemical control, exploitation of nematode resistance sources available in plants, and organic management. Data on assays with organic and natural products are then discussed, together with biofumigation, use of nematicidal plants and potentials of biological control agents.

In Chapter 10 a further regional and specific agricultural issue concerning pistachio production is reviewed, in reference to nematodes management in the Middle East. Pistachio crops are important sources of nutrients and income for local producers. The distribution of pistachio nematodes and the management options available are listed, including agronomic management, use of resistant rootstocks, biological control, as well as soil solarization.

In the following chapter the situation for the pine wood nematode, *B. xylophilus*, is reviewed. Pine wilt disease (PWD), caused by *B. xylophilus*, is one of the most

severe disease affecting *Pinus* spp. in the Far East, North America and now the European Union (Portugal). In some countries, such as Japan, PWD was catastrophic, destroying native pine species at such an extent that some areas had to be totally replaced by other tree species. *Bursaphelenchus xylophilus*, endemic to North America where it causes minor damage, was introduced in Japan in the early XXth century and then spread to mainland Asia. Since its first arrival in the EU this nematode has been monitored and efforts are continuously provided to halt its spreading in the european continent. Experience from Japanese control actions include aerial spraying of insecticides to control the insect vector (the Cerambycid beetle *Monochamus alternatus*), direct injection of nematicides to the trunk of infected trees (mainly for added-value trees), slashing and burning of areas out of control, beetle traps, biological control and tree breeding programs. In Portugal, the damage, although lower than in Asia, is still significant and PWD has caused severe losses to the forestry industry. In this chapter, a brief history of PWD is provided, mapping its spread in Japan and to other East Asian nations, as well as updating the situation for Portugal. The economic impact of PWD is reviewed, in relation to the world importance of forestry and conifer production and trade. Inspection and quarantine issues are then discussed. The PWN biology and life cycle are reviewed, together with its relationship with the insect vector. Data on the taxonomy and progress using molecular biology techniques are also provided. The pine resistance and susceptibility to the nematode are also reviewed, including pathogenicity and the potentials of breeding programs. The authors also provide a comprehensive review about the control of PWN and its insect vector, with methods like insecticide spraying, nematicide injection, biological control and breeding for resistance. A discussion on the results achieved by means of management actions worldwide is also provided.

Finally, in the last chapter, the pathogenicity, geographic distribution and damage of nematodes associated with olive are revised, for species within the genera *Gracilacus*, *Helicotylenchus*, *Heterodera*, *Meloidogyne*, *Ogma*, *Pratylenchus*, *Rotylenchulus*, *Tylenchulus*, and *Xiphinema*. Research data on olive nematodes are reviewed, focusing on the effects of parasitism by root-knot nematodes, plant growth, cultivars and rootstocks susceptibility, nematodes interactions with the soil-borne pathogen *Verticillium dahliae*, replant problems and control strategies. These include chemical and biological control, solarization, use of soil amendments and organic management, biofumigation and application of nematicidal plants.

In conclusion, we acknowledge the authors for providing a broad range of data on nematode management solutions available worldwide in different agricultural systems. Thanks to the efforts and will of many nematologists studying and applying advanced solutions in their long term research efforts and field practices, we hope we were able to provide a tool useful in the deployment of environment friendly and sustainable management practices for the main crops and parasites listed. Our hope is that this volume will result useful and helpful for interested readers and students, inspiring and supporting research efforts invested in their field and laboratory work.

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