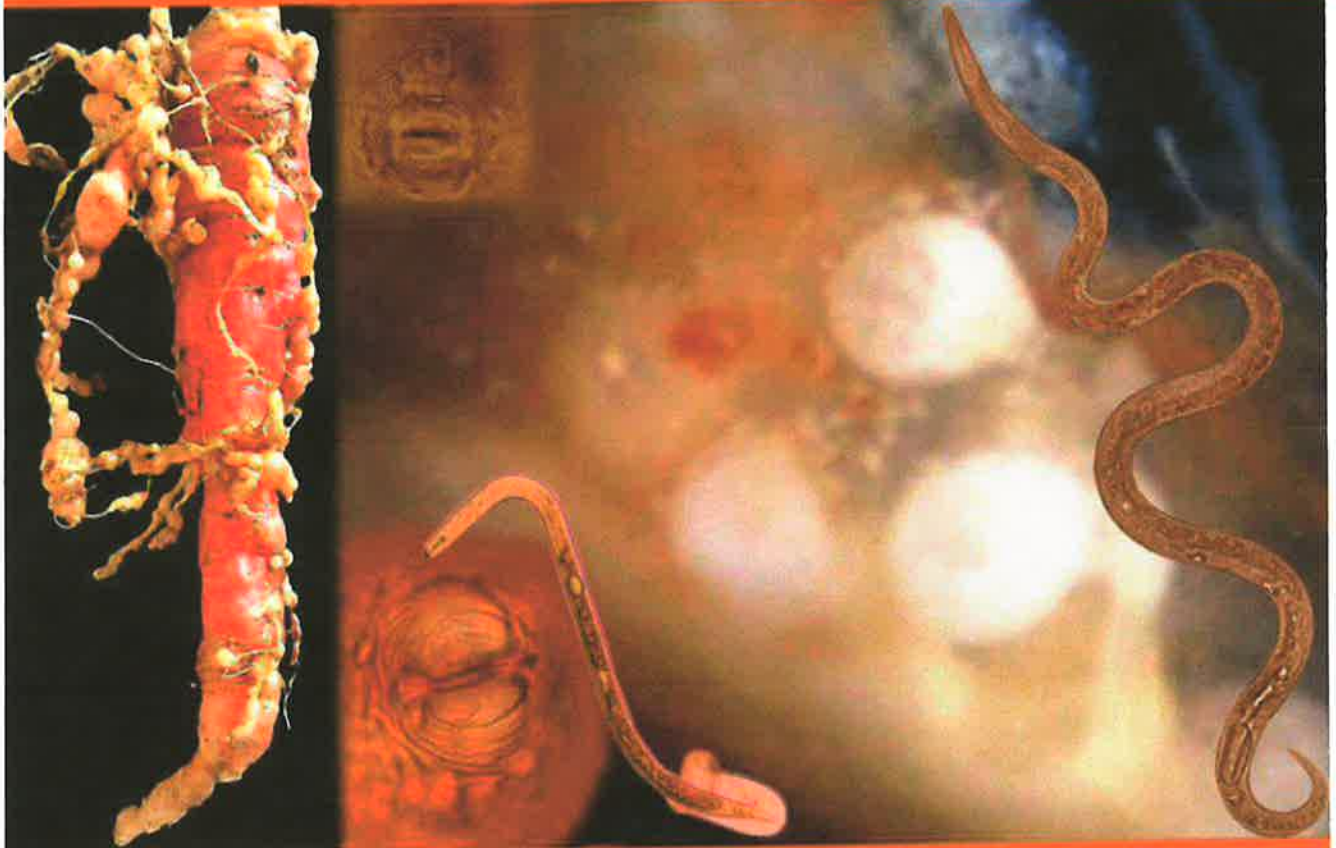


# Textbook of Plant Nematology



**Manzoor Hussain Soomro**

**Erum Iqbal**

**Firoza Kazi**

**1<sup>st</sup> Edition**

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Office of PSN,  
National Nematological Research Centre,  
University of Karachi, Karachi-75270, Pakistan

Tel: +92-021-99261387

Email: [info@pjn.com.pk](mailto:info@pjn.com.pk)

Website: [pjn.com.pk](http://pjn.com.pk)

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## PREFACE

*“Take a handful of soil, from the top of mountains and the depths of the seas. Extract the living organisms in some water, and among the other forms of life you will find elongate, threadlike, active animals. These are nematodes”*; wrote Victor H. Dropkin in his erstwhile 1980 book; *“Introduction to Plant Nematology”*. Thus, the nematodes of different kinds are found across the environments and habitats. Plant parasitic nematodes are of considerable importance worldwide and are costly impediments to crop production & productivity; their devastating effects on crops have major economic and social impacts. Phytoparasitic nematodes are one of the most abundant, highly diversified and ecologically significant groups with wide host range and geographical distribution. The feeding action of plant parasitic nematodes, not only results in mechanical and physical injury to the tissues causing disturbance and distortion in plant growth process, leading to production losses but also affects the quality and marketability of the produce especially of root and tuber crops. This ultimately leads to food insecurity worldwide. In developing countries including Pakistan, nematode problems coupled with secondary infections, are serious and complex as climatic conditions and crop culture practices favour the activities and reproduction of these destructive parasites. However, there are some nematode species that play a beneficial role in the ecosystem, though; more research is required to learn about them.

Considering the importance of diversity and roles of nematodes in the ecosystem, and the fact that plant nematology is taught in degree programmes at various universities, not a single textbook of the subject has been produced in Pakistan. Thus, a dire need of such a textbook has been felt for quite some time for the benefit of students specializing in the subject at graduate and postgraduate levels. Therefore, this book has been designed to cover the course outline of *“Plant Nematology”*, approved by the National Regulator- the Higher Education Commission (HEC) of Pakistan for B.S. and M.S. (Plant Pathology) degree programmes.

The book contains 16 chapters covering the latest information on the major fundamental and advanced aspects of plant parasitic nematodes. The book includes; basic introduction, global and local historical development of nematology, as well as its importance in agriculture. It explains the techniques for the study of nematodes including their morphology, anatomy, structure and systematics; and the outline classification of the nematode fauna of Pakistan. The textbook also provides for taxonomy of important parasitic nematode genera along with their parasitism and habitat. It has a chapter on the most important nematodes; root-knot, cyst, and some other important species; their life cycles, diseases caused by them, as well as disease symptoms, etiology and their management. Nematode-microbe interaction, nematode population dynamics and crop/yield loss assessment, also make part of the book. Exclusive chapters on nematodes as vectors of plant viruses, entomopathogenic nematodes and molecular nematology are also included in the book.

The authors hope that this “Textbook of Plant Nematology” with a touch of Pakistan perspective, would serve as a major guide book for students of Plant Nematology, Plant Pathology, Plant Protection, Microbiology, Environment, and Agriculture as a whole. Though the intended audiences of the book are students and researchers; the extension personnel, growers and those working in crop production and crop protection, would also benefit.

We have tried our best to put in the book, all the needed and available authentic scientific information of nematology, but to err is human, and we take the responsibility of any error or omission. However, the book can be improved in future edition(s). Thus, we would appreciate receiving any views, comments and constructive criticism as well as suggestions for improvement of the contents and quality of the book in future editions.

We dedicate this book to the initiators of the science of Nematology in Pakistan but especially to the two dedicated Pakistani Nematologists, who got this science recognized in Pakistan, established Pakistan Society of

Nematologists (PSN) and the National Nematological Research Centre (NNRC), i.e., Dr. M.A. Maqbool (1941-2016) and Prof. Dr. Shahina Fayyaz (1959-2020), who not only assisted Dr. Maqbool in all his endeavours, but further strengthened the NNRC, the PSN, and the Pakistan Journal of Nematology (PJN).

We are very grateful to the two outstanding champions of agricultural research for writing the Forewords to the book; a living legend and developer of Pakistan's National Agricultural Research System and the Founder Chairman of Pakistan Agricultural Research Council (PARC)- Dr. Amir Muhammed, and Dr. Zafar A. Handoo, a very senior Nematologist at the US Department of Agriculture, ARS, Beltsville, MD, USA. Dr. Handoo also kindly reviewed the book and advised on many technical aspects of the manuscript.

Finally, the financial support of Pakistan Science Foundation to Pakistan Society of Nematologists for publication of the book, is acknowledged.

Manzoor Hussain Soomro  
Erum Iqbal  
Firoza Kazi

## FOREWORD

Plant parasitic nematodes are recognized as one of the most important limiting factors in crop production worldwide and Pakistan is no exception. They cause billions of dollars' worth of damage to global crop production annually. Plant Nematology was initiated in Pakistan during 1952 with the first ever report of ear-cockle disease on wheat from wheat growing region of Punjab province. However, systematic research in Plant Nematology began with a PL-480 project funded by the Pakistan Agricultural Research Council (PARC) in late 1970s and this science further developed with establishment of the National Nematological Research Centre (NNRC) at the University of Karachi under auspices of PARC. It is satisfying for me as the then Founder Chairman of PARC that a small initiative in the fag end of 1970s, the NNRC became a truly National Centre and Pakistan Society of Nematologists (PSN) was established in early 1980s. PSN has continued to publish internationally recognized Pakistan Journal of Nematology (PJN) since 1983 and established the science of Plant Nematology in Pakistan so well.

I understand that Nematology forms an important part of the academic course of the undergraduate and postgraduate degree programs in agriculture and plant sciences in Pakistan. Higher Education Commission (HEC) of Pakistan has prescribed a common syllabus for Nematology course throughout Pakistan; however, there has not been even a single textbook published in Pakistan that covers the syllabus prescribed by HEC. Thus, I hope this book would serve as an important resource that fulfils the needs of the students in the universities of Pakistan and beyond. This book would also be very useful for the teaching faculty, research and extension personnel and others concerned with plant protection.

I sincerely appreciate and congratulate the authors; Prof. Dr. Manzoor Hussain Soomro, President of Economic Cooperation Organization Science Foundation (ECOSF) based in Islamabad, Patron-in-Chief of the Pakistan Society of Nematologists (PSN) and the Editor-in-Chief of PJN;

Dr. Erum Iqbal, Associate Editor of Pakistan Journal of Nematology (PJN); and Dr. Firoza Kazi, a senior scientist and nematode taxonomist associated with NNRC and PSN and an Associate Editor of PJN since long, for bringing out this comprehensive “Textbook of Plant Nematology”. Authors have extensive experience of working in Nematology. Prof. Soomro of course having served as IPM Expert in FAO-UN, Professor of Plant Protection, Chairman of Pakistan Science Foundation and lately as President of ECO Science Foundation, has made important contributions in Nematology as well as in the fields of Agriculture, Plant Protection and in promotion of science and technology in Pakistan and beyond.

I take this opportunity to encourage all experienced scientists to write books based on their local, national and international experiences, for better learning of the younger generations.

**Dr. Amir Muhammed**  
Founder Chairman of PARC  
Former President of Pakistan Academy of Sciences



## FOREWORD

Plant parasitic nematodes constitute a major constrain for agricultural crops worldwide. Significant contributions and achievements have been made in recent years globally; however, the emerging nematode problems limiting the production of major food, feed and industrial crops and their management strategies currently are big challenges across the world.

The aim of this textbook is to provide basic and advanced knowledge on plant parasitic nematodes with a global perspective. It targets practitioners, professionals, scientists, researchers, students, and other personnel working on crop protection and biosecurity about plant-parasitic nematodes.

The book entitled, Textbook of Plant Nematology, is an excellent book for students at the undergraduate and postgraduate levels, teachers of nematology/entomology/plant pathology and a perfect guide to applied plant protection practitioners, and a reference for researchers in and outside the country.

This book compiles and updates information on plant-parasitic nematodes and their alarming threat worldwide. This book is conveniently divided into 16 concise chapters with information on their identification; geographical distribution; systematics; symptoms; biology and ecology; and a detailed account of diagnostic procedures, such as sampling, isolation/detection, and identification with morphological and molecular characterization.

The stupendous effort of Prof. Dr. Manzoor Hussain Soomro, Dr. Erum Iqbal and Dr. Firoza Kazi deserve much admiration in bringing out this comprehensive and voluminous book. I am sure that its readers particularly students will find it very useful and informative.

**Dr. Zafar A. Handoo**  
Mycology and Nematology Genetic Diversity  
and Biology Laboratory, USDA, ARS,  
Beltsville, MD 20705, U.S.A.  
zafar.handoo@ars.usda.gov