Nematode Problems in Crops and their Management in South Asia

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Edited by

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FOREWORD

A MAJOR ADDITION

The book, *Nematode Problems in Crops and their Management in South Asia*, is a new state-of-the-art book, devoted to plant parasitic nematodes as major pests of food and cash crops in South Asia. The book is both timely and extremely important for all those working to improve soil and plant health. It will definitely be a valuable resource for nematologists studying the impact of plant parasitic nematodes on food production in this region of the world, but also for those working internationally on nematodes and crop health. Nematodes are often called the *unseen enemies* of crop production, because their damage usually goes *unseen*. These soil-borne parasites play a significant and often underestimated role in the yield gap that is now impacting food production in South Asia and elsewhere in the world.

The challenge of developing suitable nematode management programs in a region where over 200 million farmers produce food for 1.5 billion humans, on small to moderate size farms is massive. This book will help those working in plant health management to improve crop yield by upgrading their understanding of nematode problems and by outlining management solutions to insure healthy crops for healthy food.

Plant parasitic nematodes are part of what I have called the “thirty percent food-give-away” or that portion of agricultural production that farmers unwillingly make available to nematodes, insects, fungi and other pests. This is food not available for human nutrition because of a lack of knowledge or access to management options. Nematodes cause an estimated 10% loss in agricultural output or over US$150 billion per year on a worldwide basis. Losses are probably greater in South Asia where production is already stagnating on the small parcels of land farmed, by growers who have limited access to improved plant protection technology.

It is estimated that the world needs to increase food production by at least 2% every year to ensure an adequate food supply for the world’s growing population. The 10% lost to nematodes is therefore, important for food

security. This book gives information needed for nematode management that will lead to better yields and a healthier environment in South Asia.

The first question I asked myself when reviewing the book was - will this new book make a difference?

Firstly, I am convinced that this book will have a major impact on how nematology is conducted in the future in South Asia. The information in the book will also make a difference, because it presents the science of nematology as it exists across all the countries making up the South Asia.

Second, the editors, R. K. Walia and M. R. Khan, are highly respected nematologists. They have effectively used subtitles in the chapters, to improve the structure and clarity of the information supplied. In addition, the authors and co-authors of the chapters are all highly qualified experts for the topics covered.

Third, the breakdown of the book into 5 sections has produced a holistic coverage of the science of nematology - past, present and future. The first section outlines accomplishments made on the distribution, diagnosis and education in India and includes a chapter on the interaction with private industry. The next section supplies the reader with, what I believe, is the first review of the present status of nematology in the five countries making up South Asia. I began my career in nematology in 1970 at G.B. Pant University in Pantnagar, Uttarakhand, and would have profited greatly, having a book of this quality as a resource for my research.

Fourth, the 42 chapters that follow, present up-to-date information on major nematode problems across all major crops and include major tools for integrated nematode management. Many of the nematode-crop interrelationships in these chapters are presented for the first time in such detail.

And fifth, the last section contains chapters that are concerned with new scientific developments including: biotechnical, pesticide, drone, automation, and artificial intelligence technologies that need to be urgently researched to improve nematode management across all farming systems in South Asia.

As populations in South Asia increase in size, a major challenge for nematologists will be the development of nematode management approaches for the fragmented, under financed and ever decreasing size of small family farms in South Asia. Nematode management for these

farmers will require developing innovative approaches that produce more from less and this at a time when climate change will alter how food is produced.

Integration of current and new technologies will be important in improving nematode management programs regardless of farm size. Remote sensing, for example, could be used to demonstrate the negative impact of nematodes over large areas. Information of this type can be used to convince policymakers that the *unseen enemy* is an important limiting factor in agriculture in South Asia and generate funding for research programs. The book ends with a powerful epilogue that outlines visions for the future and the need for action plans to improve the science of nematology in the future.

I want to congratulate the editors and chapter authors, for an excellent book that I believe will make a difference in both: food production, environmental health, and human well-being in South Asia.

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PREFACE

Why this book, when many recent dedicated reference books are already doing the rounds? We have many reasons to justify our attempt. First and foremost, to focus on the region where nematodes cause tremendous crop losses, yet most growers are still ignorant about them. Initially conceived for India alone, but later we realized that the adjacent geographies are no different and have common nematological concerns. The second major reason is to present crop-region-specific nematode problems and build-up a field-oriented practical knowledge base along with currently available solutions. A major chunk of the book is devoted to this aspect that runs into five sections (iii-vii) including 43 chapters covering cereal crops, agronomic cash crops, vegetables, fruits, spices, and condiments etc.

Section (ii) deals exclusively with the current status of nematological problems of major crops in South Asian countries (India, Pakistan, Bangladesh, Sri Lanka, Afghanistan). We could not find a local active nematologist to write about nematodes in Nepal and Bhutan.

Teaching, research and extension, the three pillars of our science, constitute the first section. The current status of teaching nematology at various levels, the journey of the "All India Coordinated Research Project on Nematodes" and its applied research contributions, and the necessity of taking nematology to Public-Private-Partnership mode are also discussed in this section.

The last section covers upcoming technologies like biotechnology, drones, artificial intelligence, newer and greener chemical molecules etc.

The book begins with an out of the box prologue sharing the little-known things about parasites of human beings that should be interesting to the readers. The volume closes with a concluding chapter on futuristic directions as an epilogue.

The selection of contributors is solely based on the authors having real and field experience. All the crop-oriented chapters have been kept short and crisp with only the most essential literature citations. Unlike exhaustive reviews, most of these chapters are focussing on a particular regional problem.

We are thankful to the galaxy of contributors, both young and stalwarts of nematology of the region; but for their cooperation and timely actions this project would not have been completed on time.

The book was conceived about two years ago in the guest house of G.B. Pant University of Agriculture & Technology where myself and Matiyar Rahaman Khan stayed for an event. This book is inspired by a recent contribution 'Integrated Nematode Management – State-of-the-Art and Visions for the Future' edited by Richard A. Sikora and his co-editors. We could not find a better person than Richard to write a foreword for this South Asian version of his book.

We sincerely believe that the readership spanning across academia, corporate sector, farming community, public sector officials, and NGOs engaged in agriculture will find it useful.

Editors

PROLOGUE

NEMATODE PARASITES OF HUMANS: SOME LITTLE-KNOWN FACTS

RAMAN K. WALIA

Introduction

Nematodes can be grouped into two broad categories: the free-living and the parasites. The free-living nematodes are all microscopic and are microbivorous or saprophytic. They are omnipresent in all types of water bodies and terrestrial habitats, including those covered with snow permanently.

The parasitic category has attracted the attention of mankind since time immemorial. The first nematodes to be discovered were large-sized and easily visible parasites of human beings and domesticated animals. These have been the subject of study under the branch of science, Helminthology or Parasitology. The parasites of animals resemble those infecting humans but are studied as a discipline of Veterinary sciences, Veterinary Parasitology. The parasites of crop plants and invertebrates (mainly insect pests of crops) and free-living nematodes are microscopic and are studied under a separate science called Nematology (Fig. 1).

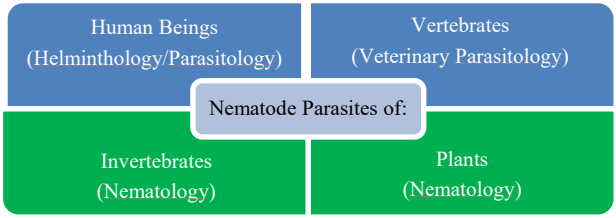

Figure 1. Kinds of nematode parasites and branches of study

The purpose of this article is to apprise the readers of some interesting and little facts about parasites of human beings. Some of these features are well known socially, but their linkage to nematodes may not be known to people in general and even some nematologists.

Vedic references: The oldest written records

Nematode parasites of human beings have been known since the advent of mankind. A peep down the history of Nematology reveals mention of nematode parasites of humans in the ancient scriptures like the *Vedas* from India (6000–4000 BC), 'Huang Ti Nei Ching' (The Yellow Emperor's Classic of Internal Medicine) from China (ca. 2700 BC), Ebers' Papyrus from the Mediterranean and the middle east (1553–1550 BC), Old Hebrew writings (Agatharchides 180 BC), Greek writings by Hippocrates (400 BC), and Aristotle (350 BC), etc.

The *Vedas* have been written in *Sanskrit*, the mother of all Indian languages. In the *Rig*, *Jajur* and *Atharv Vedas*, written 6000–4000 BC, there are frequent references to nematodes by the *Sanskrit* word "*Krmin*", which means worm. The indigenous medical science *Ayurveda* developed following *Atharv Veda* (3000 BC and later). Charak, an authority on indigenous medical science, recognized 20 different organisms as *Krimis* in his *Charak Samhita,* which included nematodes, arthropods, and leeches.

In the *Vedas,* two words, *Yambhan* (suppression by growth) and *Hanan* (complete eradication), have been frequently used. To accomplish these, metaphysical methods like, worship through '*Yajna*' or sacred fire, *Vedic* chants (a couple of *shlokas* from *Atharv Veda* in *Sanskrit* and their meaning in matching colour are reproduced below), and physical methods like solar treatments and herbal recipes were practiced. The use of well-known medicinal plants such as *Comiphora mukul* (exudates), *Salvadora persica* (root extract), *Andropogon maricatus* (root extract), *Acorus calamus* (rhizome), and *Jasmine sambac* (root extract) is mentioned for the control of *krimis*.

HATASO ASYA BESHASO HATASAH PARIBESHASAH
ATHO YE KSHYULLAKA IBA SARBE TE KRMAYO HATAH
…….Ath.2.32.5
"As all the near and dear ones and servants of an enemy are ruthlessly killed along with it, in the same way, let all the *krmis*, their eggs and servants be killed"

DRASTAM ADRASTAM ATRUHAM ATHO KUKURUM ATRUHAM
ALGANDUN SARBAN SHALUNAM KRMIN WACASA YABHAYAMASI
…….Ath.2.31.2
"Let me kill and suppress by *vedic* chants all the visible and invisible *krmis, which cause itching and ugly sounds (in children?) and which* enter into our bodies"

The story of fiery serpents and medical logo

The Guinea worm, *Dracunculus medinensis* is about 1 m long and is present in the subcutaneous tissues causing intense pain in the limbs. It is commonly known by various names, including Dragon of Medina, Fiery Serpent, Bronze Serpent, etc. The term "Fiery Serpent" mentioned in the Bible, Number 21: 6–9 (reproduced below), is a reference to the guinea worm:

> "*And the Lord sent fiery serpents among the people, and they bit the people, and much people of Israel died."*

As the story goes, the fear of this dreaded worm forced the people to come to Moses (the King) and said:

> "*We have sinned for we have spoken against the Lord, and against thee; pray unto the Lord that he takes away the serpents from us.*"

And Moses prayed to the Lord for the people. And the Lord said to Moses:

> "*Make these fiery serpents, and set it upon a pole, and it shall come to pass that every one that is bitten, when he looketh upon it, shall live.*"

And Moses made a serpent of brass, and put it upon a pole, and it came to pass that if a serpent had bitten any man when he beheld the serpent of brass, he lived.

In ancient times, the problem caused to man by *D. medinensis* had become so serious and widespread that special schools were set up to help counter them. Here, the experts in medicine took on the task of extracting the nematode from the invaded tissues using a stick (Fig. 2). *D. medinensis* is

used both in the logo of the Order of Pharmacists – the caduceus or staff of the Greek god Hermes represented by a rod entwined by two serpents; and by doctors – the Rod of Asclepius, the god of medicine, represented by a serpent-entwined rod – as a symbol of liberation from disease (Fig. 3).

Figure 2. *Dracunculus medinensis*: Infection appears as a boil on the limbs (top left) that bursts open when the infected person comes in contact with water, the hind portion of the worm ejaculates to release eggs in water (top right); extraction of the worm by specialist by winding on a stick (bottom) (Source: (top) scientificamerican.com, (bottom) nigeriahealthonline.com)

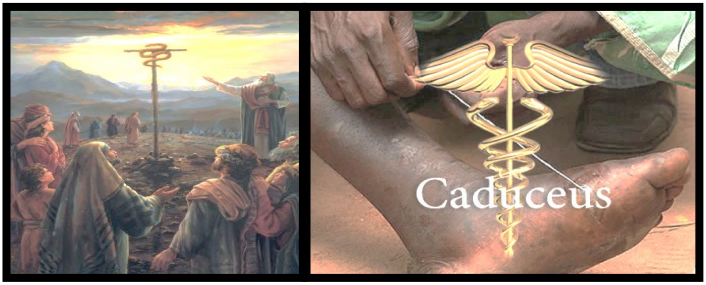

Figure 3. A single serpent entwined on a rod, the Logo of medicine (left); two serpents entwined on a rod, the Logo of the Order of Pharmacists (right) (Source: (left) churchofjesuschrist.org, (right) nigeriahealthonlione.com superimposed with cliparts.co)

The nematodes connection to open defaecation-free (ODF) campaign: *Darwaza bund to beemari bund*

There are more than two dozen nematode parasites of human beings. However, the most common ones are in our intestines, e.g., the intestinal roundworm - *Ascaris lumbricoides*, the pinworm - *Enterobius vermicularis*, and the hookworms *Ancylostoma duodenale* and *Necator americanus*. Along with the soil trematodes and cestodes, these nematodes are transmitted from soil; collectively, these are known as Soil Transmitted Helminths (STH).

Among all these helminths, *A. lumbricoides* is the most common (Fig. 4), and about one-fourth of mankind in the world is infected with this nematode. Each female is about 15–20 cm long and lays about 2.7 million eggs daily through our faeces.

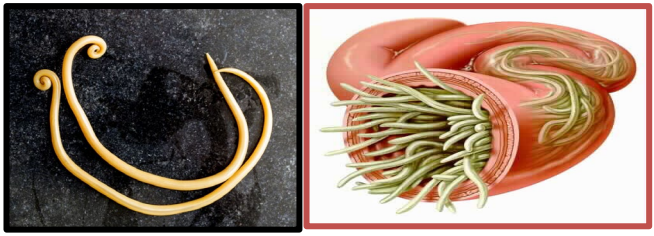

Figure 4. The intestinal roundworm, *Ascaris lumbricoides* (left); the worms blocking the intestine under heavy infection (right) (Source: MACTODE)

When people go out in the open for defecation, millions, and billions of microscopic eggs of these worms are deposited in the field soil. Any person who comes in contact with this soil directly or indirectly gets infected. To contain the spread of this worm, or STH, referred to as disease ("*Beemari*" in common parlance), the government of India has launched a massive campaign to build toilets in every household and educate the people not to go for open defecation and make the country ODF (Open Defecation-Free) through *Swachh Bharat Abhiyan* (Fig. 5).

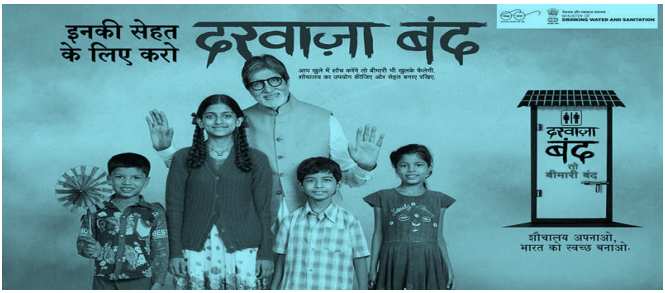

Figure 5. A TV advertisement to educate people about using toilets and avoiding helminth infection (Source: behance.net)

In ancient times, the grandparents used to forcibly administer bitter castor oil once a year to the kids, ostensibly to rid them of intestinal worms. However, now-a-days under a government scheme, all the children of the age group of 1–14 years are given "albendazole" as antinemic treatment on dedicated days (National Deworming Day) (Figs. 6,7).

Figure 6. Children being given castor oil to deworm…grandma with sugar as bribe, father threatening with handfan-stick, three kids already had - look at their expressions! One boy miserably awaiting his turn (left); Modern-day treatment in schools by giving anti-nemic tablets (Source: (left) Artist Gopulu from cover of Tamil weekly 'Ananda Vikatan', (right) Ministry of Health & Family Welfare, Govt. of India)

Figure 7. National Deworming Days on 10th February and 8th August (Source: Ministry of Health & Family Welfare, Govt. of India)

The Elephantiasis of humans (and plants)

Most people are aware of filariasis or elephantiasis in humans, more so because of social embarrassment than a disease because it causes inflammation of not only limbs but also genital organs of males and breasts in females. But not many people know that it is endemic to coastal areas; a particular mosquito species in coastal areas spreads this disease. The mosquito ingests the microfilariae of this worm present in our blood while it bites us and releases in the bloodstream of another person during biting. The disease is commonplace among poor people who fail to get treatment during the early stages of infection. A semblance of elephantiasis is apparent in root galls due to *Meloidogyne* spp. (Fig. 8).