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SCIENTIFIC AND METHODOLOGICAL FOUNDATIONS FOR TEACHING NEMATODE DISEASES IN VEGETABLE AND MELON CROPS IN THE SOUTHERN REGIONS OF UZBEKISTAN

Begali Kholiqnazarov
PhD in Biological Sciences, Associate Professor
Termez State Pedagogical Institute
E-mail: Begali1959Xoliqnazarov@gmail.com

Abstract

This article discusses the biology, epidemiology, diagnostic methods, and scientific-methodological foundations for teaching nematode diseases affecting vegetable and melon crops in the southern regions of Uzbekistan. An educational concept based on agrotechnical, biological, and integrated management measures against nematode diseases is analyzed. The paper also examines strategies for developing students' theoretical knowledge and practical skills within the higher education system, as well as organizational approaches to laboratory and field training.

Keywords: Nematodes, vegetable crops, melon crops, teaching methodology, educational activities.

Introduction

Nematodes are species of roundworms (phylum *Nematoda*) that live as parasites in soil and plants and are considered among the most destructive diseases affecting vegetable and melon crops worldwide. Their activity causes root

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deformation, growth inhibition, and significant reductions in crop yield. In the southern regions of Uzbekistan, warm climatic conditions, deep groundwater levels, and favorable agroecological environments increase the risk of nematode epidemics. Therefore, teaching this topic in higher education institutions based on modern scientific methods requires well-grounded scientific and pedagogical approaches.

Nematodes are cylindrical, unsegmented, multicellular organisms, mostly microscopic in size. They are among the most widely distributed organisms on Earth, inhabiting soil, water environments, and living organisms, including plant tissues. Plant-parasitic nematodes are especially important due to the serious economic damage they cause to agricultural crops.

Plant-parasitic nematodes mainly infest plant root systems, stems, leaves, and sometimes seeds and fruits. By penetrating vascular tissues and sucking cellular sap, they negatively affect plant physiological processes and suppress growth and development.

The nematode life cycle consists of several successive stages:

- egg stage;
- larval stages (I, II, III, and IV instars);
- actively motile form;
- juvenile nematode;
- sexually mature stage;
- adult nematode.

Depending on environmental conditions, the life cycle usually lasts 2–6 weeks. The second larval stage is considered the infectious stage for most plant-parasitic nematodes, during which they penetrate plant tissues.

Most nematodes exhibit two life forms:

1. free-living soil form;
2. parasitic form living within plant tissues.

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This characteristic demonstrates their high ecological adaptability. Nematodes are highly sensitive to environmental factors such as soil temperature, moisture, oxygen content, and organic matter composition and respond rapidly to changes. Nematodes develop most actively at temperatures between 10–30 °C, while high soil moisture increases their mobility and infectivity. Some species can enter an anabiotic state under unfavorable conditions (drought or low temperature), maintaining viability for long periods.

Biologically, nematodes possess high reproductive potential; a single female may lay thousands of eggs, enabling rapid population growth and the emergence of epiphytotic outbreaks.

In summary, the morphological simplicity, short life cycle, high adaptability, and reproductive capacity of nematodes classify them as dangerous plant parasites requiring scientifically based control strategies.

The high temperature and relatively elevated humidity typical of southern regions create favorable agroecological conditions for the active development and mass spread of phytonematodes. Particularly in areas practicing intensive agriculture, economically harmful nematode species are widespread and negatively affect crop growth and productivity.

The most common phytonematode species in southern regions include:

- **Meloidogyne spp.** (root-knot nematodes), commonly affecting vegetable crops such as tomato, forming root galls, causing morphological deformation, and disrupting nutrient uptake.

- **Pratylenchus spp.**, migratory endoparasitic nematodes that penetrate internal root tissues, damage cellular structures, and increase plant susceptibility to secondary phytopathogenic infections.

- **Heterodera** and **Globodera spp.** (cyst nematodes), which form cysts in root systems and severely limit plant water and mineral nutrition.

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As a result of their phytopathogenic effects, plant physiological processes weaken, vegetative and generative development slows, and crop productivity declines significantly both quantitatively and qualitatively. Therefore, developing and implementing scientifically based phytosanitary measures against nematodes is highly important for southern regions.

Teaching Methodology of Nematode Diseases

The main objective of teaching nematode diseases is to develop students' knowledge, skills, and competencies related to nematode biology, distribution patterns, diagnostic methods, and scientifically grounded control systems. Achieving this goal requires fostering scientific thinking, analytical ability, comparative analysis, and practical decision-making competencies.

Teaching methodology is organized based on a systematic, step-by-step, and integrative approach linking theoretical knowledge with practical activities. When studying nematode biology, their morphology, developmental stages, and host relationships are explained using scientific literature, microscopic observations, and schematic models, with special emphasis on developing students' observation skills and biological thinking.

Problem-based learning elements are applied in teaching disease epidemiology. Students analyze distribution factors, ecological relationships, and outbreak patterns of nematode diseases through practical examples, statistical data, and case studies, thereby developing analytical thinking and scientific reasoning skills.

Modern diagnostic methods are taught through laboratory training, instrumental analysis techniques, and innovative diagnostic technologies. Students learn early disease detection, proper laboratory analysis, and scientific interpretation of results. The use of information and communication technologies enhances teaching effectiveness.

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Integrated disease management forms an important component of the teaching methodology. Agro-technical, biological, chemical, and organizational measures are scientifically justified and interconnected. Practical assignments and independent work help students develop professional competencies applicable in real agricultural practice.

Thus, nematode disease teaching methodology systematically integrates theoretical and practical learning, promotes scientific thinking, and strengthens professional preparation.

Organization of the Educational Process

The educational process is organized systematically to ensure balanced formation of theoretical knowledge, practical skills, and professional experience through interconnected stages.

Lectures

Lecture sessions provide fundamental theoretical knowledge in nematode pathology, including structural organization, scientific directions of the field, morphological and biological characteristics of nematodes, classification criteria, and ecological factors influencing nematode distribution and population dynamics.

Laboratory Training

Laboratory classes link theory with practice and develop research competencies. Students learn to collect soil and root samples, observe nematodes microscopically, identify species based on morphological features, and document results through photographic analysis. The use of internationally recognized scientific protocols improves educational quality.

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Field Practice

Field practice strengthens professional training by allowing students to observe nematode diseases under real production conditions. During internships, students identify nematode-related diseases, assess crop productivity using specific indicators, and analyze the effectiveness of applied agrotechnical methods, thereby developing practical problem-solving abilities.

General Conclusion

The conducted analysis shows that the warm and relatively dry climatic conditions of southern Uzbekistan create favorable environments for the spread of nematode diseases in vegetable and melon crops. Root-knot nematodes (*Meloidogyne spp.*) particularly cause serious yield losses and reduce agricultural product quality.

Research results demonstrate the necessity of integrating theoretical knowledge with practical activities such as observation, experimentation, and diagnostics in teaching nematode diseases. Interdisciplinary integration, research-oriented assignments, and modern pedagogical technologies effectively contribute to developing students' professional and ecological competencies.

Considering regional characteristics, improving curriculum content, and applying local experience and advanced agro-technologies enhance education quality.

Based on the research findings, the following scientific-methodological recommendations are proposed:

1. Adapt teaching content on nematode diseases to the agro-climatic characteristics of southern Uzbekistan.
2. Expand the implementation of practice-oriented teaching methods (field observations, laboratory analyses, case studies, project work).
3. Integrate STEM and environmental education elements to develop students' research and critical thinking skills.

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4. Develop specialized methodological manuals, electronic resources, and multimedia materials for teachers in nematology.
5. Strengthen cooperation between higher education institutions and agricultural research institutes.
6. Systematically introduce educational components aimed at developing phytosanitary culture and ecological responsibility among students.

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