

CPT 507
PLANT PROTECTION
(NEMATODOLOGY SECTION)

BY

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SYNOPSIS

- Characteristics & classification of PPN in tropics
- Important PPN of arable and permanent crops in the tropics
- Principles and methods of nematode control and management

INTRODUCTION

- Food and economic crises
- Climate change and global agriculture
- Nigerian Agriculture and the economy
- Covers 94m ha, 91m ha arable, < 30% under cultivation

INTRODUCTION

- Some fundamental questions
 - Resource endowment a blessing?
 - Have we been able to feed ourselves?
 - Why the dwindling agricultural production statistics
 - Why food problems? (social, climate, biotic, political)
 - How long will it take to be self sufficient in food production?
 - What are the solutions?
 - What role does nematodes play in limiting food production?

What are nematodes & where do they live?

- nematodes are worm-like organisms (animals) which can be found in the soil, salt and fresh water, plant and animal parts.
 - Animal parasites nematodes (Helminths)
 - Egs. Intestinal worm (*Ascaris lumbricoides*)
 - The guinea worm (*Dracunculus medinensis*)
 - The eye worm (*Onchocerca volvulus*)
 - *Wucheria malayi* responsible for Elephantiasis
 - The heart worm (*Dirofilaria spp.*)

What are nematodes & where do they live?

- Nematodes (those in the soil, fresh water, salt water, and plant parts)

They consist of the following groups:

- Free-living nematodes (saprophytes)
- Predaceous nematodes
- Entomogenous/entomophagus nematodes, and
- Plant-Parasitic nematodes.

Nematode Types

- **Free-Living nematodes**
(a. k. a. Saprophytic nematodes)
 - Feed on decaying matter as well as their products in the soil
 - Constitute no threat to crop plants

Eg Rabditida

Nematode Types

- **Predaceous nematodes**

- Prey or predate other microorganism such as bacteria, fungi and even nematodes.
- Microbivorous nematodes or microbial-feeding nematodes.
 - fungivores or fungivorous nematodes (e.g. Anguinidae, Aphelenchidae, Tylencholaimidae)
 - bacterivores or bacterivorous nematodes (e. g. Alaimidae, Plectidae, Leptolaimidae, Rhabditidae)
- Play vital roles in food web (nutrient recycling) as secondary decomposers
- Beneficial to agriculture especially organic agriculture.

Nematode Types

- **Entomogenous nematodes**
 - The entomogenous group consists of nematodes that parasitize insects.
 - Useful tool in biological control of insects (e.g. *Zonocerus variegatus*) by *Mermis* spp. of nematode.
- **Plant-Parasitic groups**
 - Phytonematodes
 - They are thread-like, non-segmented, microscopic, stylet-bearing organisms which inhabit the rhizosphere of plants
 - Interacts with the plants
 - Leading to reduction in growth and economic yield.

Some important data

- 500,000 nematodes spp. have been predicted
 - 15,000 spp. Described & classified
 - 2,200 spp. are plant parasitic (10 or 15%)
 - 95 to 98% RKN {Mi (52%), Mj (31%), Ma(7%)}
 - Others 2 to 5 %
 - 12,800 spp. non parasitic (85 %)
- 485,000 spp. yet to be described

Some vernacular/common names of nematodes

Common Name	Scientific Name
Root knot or gall nematode	<i>Meloidogyne</i> spp.
Root Lesion nematode	<i>Pratylenchus</i> spp.
Cyst nematode	<i>Heterodera</i> & <i>Globodera</i> spp.
Dagger nematode	<i>Xiphinema</i> spp.
Burrowing nematode	<i>Radopholus similis</i>
Stem nematode	<i>Ditylenchus</i> spp.
Banana root lesion nematode	<i>Pratylenchus coffeae</i>
Citrus nematode	<i>Tylenchulus semipenetrans</i>
Pin nematodes	<i>Paratylenchus</i> spp.
Yam nematodes	<i>Scutellonema bradys</i>

Some vernacular/common names of nematodes

Common Name	Scientific Name
Red ring nematode	<i>Rhadinaphelenchus cocophilus</i>
Rice white tip nematode	<i>Aphelenchus besseyi</i>
Ring nematode	<i>Criconemoides</i> spp.
Cob's spiral nematode	<i>Helicotylenchus multicinctus</i>
Bulb nematode	<i>Ditylenchus dipsaci</i>

Characteristics of PPN

- Stylet (protrusible, hard, sharp, spear shaped structure on the cephalic region)
 - Function to:
 - Rupture egg shell during hatching
 - Puncture and penetrate plant cell during infection
 - Suck cell content during feeding
 - May or may not possess stylet knob
 - Stomatostylet (Order: Tylenchida)
 - Odontostylet (Order: Dorylaimida)

Characteristics of PPN

- **Morphology and anatomy** (external and internal structures)
 - Size 0.25 to 0.30mm long and 0.05mm wide
 - Mostly cylindrical in shape, tapering at the two ends
 - Usually filiform but female in some loose worm shapeEgs. *Meloidogyne*, *Heterodera*, *Globodera*
 - _ Complex organisational structure like higher animals
 - Feeding and digestive organs
 - Reproductive organs, sexes separate
 - Circulatory system
 - Excretory system
 - No respiratory organs because exchange of gases is directly from the atmosphere

Characteristics of PPN

- **Morphology and anatomy (Cont'd)**
 - Body plan is simple
 - Triploblastic (three layered skin)
 - Cuticle (moults 4 times as the nematode grows)
Colourless and transparent
 - Annulated
 - Smooth
 - Serpentine movement

Characteristics of PPN

- **Morphology and anatomy (Cont'd)**
 - Hollow body (Pseudocoelumate)
 - Tube within tubes
 - Alimentary canal runs from stylet to anus
 - Oesophagus (Pharynx) links stylet with intestine for food movement

Characteristics of PPN

- **Morphology and anatomy (Cont'd)**
 - Sex organs (gonads) are also & threadlike
 - Female gonad
 - Ovary (Eggs develop from germ cell in the ovary)
 - uterus (Fertilisation of eggs take place here)
 - vulva (vagina) (Copulation)
 - Male gonad
 - Testes (Sperms are produced here)
 - Spicule (sperms are deposited via spicule into the vagina via vulva)

Characteristics of PPN

- **Morphology and anatomy (Cont'd)**
 - **Life cycle and reproduction**
 - Six stages (egg, J1, J2, J3, J4, Adult)
 - Moults (4 times)
 - Egg production potentials 250 to 25,000/generation or cycle
 - A cycle is 28 to 30 days in tropics
 - Polycyclic nematode diseases of plants
 - Reproduction is by:
 - amphimixis (male + female) the most common
 - Parthenogenesis (male not involved)
 - Hermaphroditism (both sexes present in an individual)

Classification of plant parasitic nematodes

- Why classify?
 - Knowing each nematode enhances the understanding of its biology and control
 - Approaches in classification are changing
 - Integration of morphology and molecular approaches (DNA sequencing)
- Taxonomy = Science of classification

What is Classification?

- Theory and practice by which kinds of nematodes are delimited to avoid chaotic accumulation of species (the basic entity)
- Principles of classification
 - Morphology
 - Anatomy
 - Physiology
 - Ecology
 - Genetics
 - Biogeography

Classification system

- De Ley (2002) Developed new classification system based on:
 - Molecular Biology
 - Morphological analysis
- Pictorial and non pictorial identification keys
- The key uses all kinds of characters
- Taxonomic characters (stylet etc)

Classification and Identification

- Classification = Ordering of nematodes into groups on the basis of their relationship
- Identification = the assignment of unidentified nematodes into the correct taxon once classification has been established
 - Micro taxonomy (fewer characters are used)
 - Macro taxonomy (many characters are involved)

Example:

- Kingdom: Animalia
 - Phylum: Nematoda
 - Order: Tylenchida
 - Family: *Meloidogynidae*
 - » Genus: *Meloidogyne*
 - » Species: *Meloidogyne incognita*

Host reaction to nematodes/factors

- **Nematode crop interactions**
 - Resistant
 - Tolerant
 - Susceptible
 - Hypersusceptible
- **Environmental factors**
 - Temperature
 - Soil
 - Microbes
- **Host nutrition**

Nematode-plant interactions

- **Crop damage by nematodes**

- Physical injury

- Enzymatic/Physiological/Chemical changes

GENERAL NEMATODE DISEASE SYMPTOMS

- Above ground.
 - **Chlorosis (depigmentation i.e yellowing of foliage)**
 - **Necrosis (complete drying & death of plant cell/tissue)**
 - **Stunting (reduction in growth due to shortened internodes)**
 - **Patchiness (crop failures, staggered growth)**
 - **Inter-veinal chlorosis (stripping of green tissues between veins which turns yellow while the veins remain greenish)**

GENERAL NEMATODE DISEASE SYMPTOMS

- Above ground.
 - Snapping
 - Toppling
 - Dieback – progressive necrosis of branch terminals particularly of trees and other plants
 - Sudden death

GENERAL NEMATODE DISEASE SYMPTOMS

- Below ground.
 - **Root knot – pronounced localised swelling of root tissue resulting from hypertrophy and hyperplasia incited by nematode feeding activities.**
 - **Lesion – an injury, wound, or morbid change in plant structure (a localised spot of infected tissue)**
 - **Necrosis – Death of cells surrounded by living tissue, especially en mass.**

Nematode-plant interactions

- **Crop loss**

- Economic threshold level

- Crop loss assessment

- Direct (Experimentation & surveys)

- Indirect (Literature review, expert testimony)

Important nematodes of crops

- **Nematode basis**
- **Crop basis**
 - **Legumes** eg. Cowpea, Soybean, Groundnut, (Protein)
 - Soybean (40%) } RKN disease caused by *Meloidogyne* spp.
 - Cowpea (25%)
 - **Tuber Crops** (CHO) Yam, cassava, sweet potato, carrot
 - Dry rot of yam caused by *Scutellonema bradys*
 - RKN disease caused by Mi
 - Root lesion disease caused by *Pratylenchus* spp.

Important nematodes of crops

– Plantation crops

- Toppling disease of Plantain caused by *Radopholus similis*

– Cereals

• Maize

- Root lesion disease of Maize caused by *Pratylenchus safeansi*
- RKN disease caused by Mi

• Rice

- White tip disease caused by *Aphelenchoides besseyi*
- RKN disease caused by Mi

Important nematodes of crops

– **Cocoa**

- RKN disease caused by *Meloidogyne incognita*
- Die back caused by Mi (progressive necrosis of branches while the trunk is alive)
- Sudden death caused by Mi (Green leaves turn yellow, brown and finally dry up but remain hanging even after the death of the plant)

NEMATODE POPULATION AND DISEASE MANAGEMENT

Principles of nematode management

- **Avoidance** - Avoidance of the pest/pathogen involves selection of geographical areas with low/zero initial inoculum (pl. inocula)
- **Eradication** - deals with elimination of pest/pathogen from the crop or the area after establishment
- **Exclusion** - is a principle aimed at preventing the spread of pest/disease

Principles of nematode management

- **Protection** - s aimed at killing the pest/pathogen before it invade the crop
- **Resistance** - is genetic or innate ability to prevent, reduce or tolerate pest/disease organism
- **Therapy/treatment** – application of treatment to diseased plants

Methods of nematode management

- Cultural
- Physical
- Chemical
- Biological
- Host-Plant resistance
- Integrated nematode management
- Organic protection system, and
- Biotechnology

Cultural Method

- Any agronomic practice adopted consciously or unconsciously by farmers to improve crop yields. Although, its effectiveness on nematodes may be difficult to verify, there are evidence that cultural practices can also achieve good crop protection against nematodes. Examples include:
 1. **Nematode-free planting materials**. Infested or infected seeds and plant materials, such as tubers, rootstocks, cutting and grafts, can infect an entire crop. Using healthy and clean seeds or planting materials is the best starting point in nematode management.

2. **Selection of good site** (reasonably free of inoculum) is a good strategy of nematode management
3. **Ploughing the fields and burning stubble.** This method produces good seedbeds or plant beds. Turning the soil exposes nematode larva and eggs
4. **Planting susceptible trap crops.** Trap crops such as celosia can encourage penetration of nematodes but must be destroyed before the adults emerges in order to avoid egg laying.
5. **Intercropping.** The planting of different crops or varieties within the same area diversifies the available habitat and may inhibit the expansion of nematode **especially if resistant varieties are included.**

6. Crop rotation. Varying the annual crop in the same field from year to year interrupts the specific relationship between nematodes and host plants and can prevent the spread the target nematode.

For example: (i) cereals can be alternated with beans or groundnuts, sweet potatoes with cotton and cassava.

(ii) Another example of crop rotation is growing maize or sorghum for one or two seasons and planting vegetables or a root crop in the third season.

NB: Crop rotation can be an effective measure against nematodes if the rotation cycle is sufficiently long and **resistant host is included**

7. **Plant nutrition-** Well-balanced fertilizer application results in healthy plants. Organic fertilizer, which improves the physical and microbial properties of soils, is better than inorganic fertilizers.

8. **Farm/Tool sanitation/hygiene.** Sanitation in storage areas, farmyards and fields is also a principal means of preventing nematodes. The aim is at reducing initial inoculum

Physical/Mechanical Method

1. **Roguing**: Some nematode infected plants can be physically collected and then destroyed in areas where labour is cheap.
2. **The use of mechanical implements** for weeding is growing. Removal of weed removes some important alternate host hence protect high-value or small-area crops from nematode pests.

Physical/Mechanical Method

- 3. Physical barriers** - screenhouse benches, concreted floors and /or raised platforms
- 4. Flooding** is an effective way of reducing nematode population in lowland rice field

Chemical Method

- Synthetic nematicides are routinely used to control nematodes
- Quick action- The major advantage is that synthetic pesticides are quick in action. However, they have been found to have the potential to harm humans, livestock and wildlife. They can pollute the environment and destroy beneficial organisms and there is also growing concern about the increasing resistance of pests to pesticides.
- To optimize the timing and efficacy of nematicides against target nematodes and to minimize the potential detrimental effects on beneficial species, other non-target organisms and the natural environment, it is important to know their general mode of action.

Mode of action

- 1 Contact nematicides which kill the nematode in contact with it.
- 2 Systemic nematicides move through the plant's vascular system. They are absorbed by the nematodes that feed on the leaves, stems, fruits or roots of treated plants.

Biological Control

- Use of natural enemies/other organisms to control nematodes:
 - (i) *Trichoderma* spp.
 - (ii) *Dactylella* spp.
 - (iii) *Mycorrhiza*

Host-Plant Resistance

- Resistant varieties are one of the important components of nematode management and can easily be combined with other control methods.
- In the field, however, crop resistance to nematodes can eventually break down.
- Therefore, plant resistance breeding programmes continuously select new varieties to replace older ones.

Nature of resistance:

1. Horizontal resistance is polygenic resistance

2. Vertical resistance is monogenic resistance

Biotechnology

- Biotechnology is the application of molecular biology in agriculture, environment and health.
- This implies improvement of the genetic traits of the cell (of plant, animal, bacterium or fungus) by exploiting recombinant deoxyribonucleic acid (DNA) and other molecular technologies so as to develop improved methods and modified organisms.

- Biotechnology has already yielded nematode-resistant, plants in developed agriculture.

Organic approach

- Organic nematode management (OPM) describes a systems that would mimic and optimise natural processes and products (holistic).
- Encourages growth and diversity of soil fauna and flora with beneficial and/or antagonistic effects on nematode pests.
- OPM is not IPM

Integrated Nematode Management

- INM attempts to combine 2 or more methods of nematode managements