

CPT 503: Principles of Nematology

By

Dr. J. J. Atungwu

Room 211, COLPLANT Building,
University of Agriculture, Abeokuta

CPT 503 (Principles of Nematology) is a 2 units elective course offered in Crop Protection Department since 2003/2004 session

ABOUT THE COURSE

- Life cycles and economic importance of PPN of arable and permanent crops
- Population dynamics of nematodes and their distribution in space and time
- Host-Nematode interactions and density dependent factors

COURSE SYNOPSIS

- Extraction and identification of from soil under bush fallow, from different monocrops and crop mixtures
- Estimating nematode populations from soil samples
- **Extraction of nematodes from plant tissues and calibration**
- **Symptom expression by nematode infected crops**

OUTLINE FOR PRACTICAL

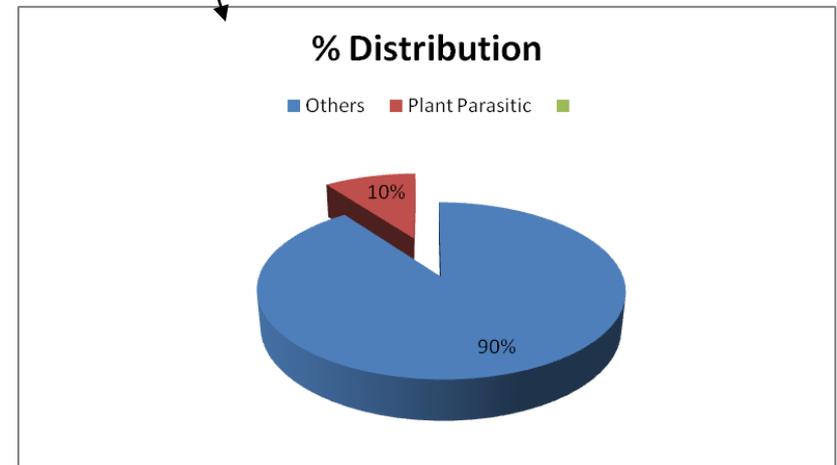
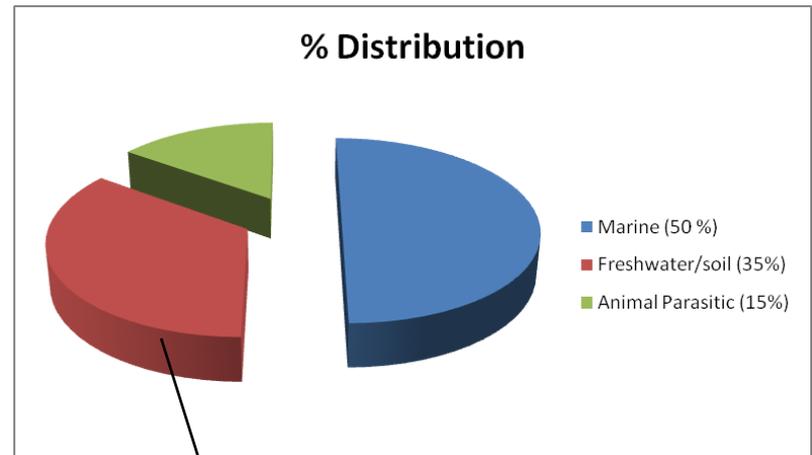
INTRODUCTION

- ❑ **Historical Perspectives**
- ❑ Collecting and processing soil and plant materials
- ❑ Outlining microscopic techniques
- ❑ Identification and classification
- ❑ Symptom and diagnosis of infection
- ❑ Nematode ecology, species, genera, morphology, host, biology and life cycles, eggs, infective stages, non parasitic stages, population dynamics

Overview/Historical Perspectives

- What are nematodes?
- Where do they live?
- Global distribution

- Proportion of Plant-parasitic nematodes to other freshwater/soil nematode types



Historical Perspectives (1)

- 1743-*Anguina tritici* discovered by Needham
- 1855 – *Meloidogyne* spp. by Berkeley
- 1857 – *Ditylenchus dispaci* (stem nema) by Kuhn
- 1859 – *Heterodera schachtii* by Schacht
- 1871– *H. schachtii* re-described by Schmidt
- 1891 – *Aphelenchoides fragariae* (foliar nematodes) by Ritzema-Bos

Historical Perspectives (2)

- 1941 – 1990 New era in Nematology:
 - a) 1941 – *Heterodera rostochiensis* (Golden nematode) by Canon
 - b) Assessment of *Globodera rostochiensis* (formerly *Heterodera*) damage on potato in Europe with funding support by Government to avoid spread (=quarantined) to USA
 - c) 1943 – Carter discovered D-D Nematicide
 - d) 1953 – *Rhadopholus similis* (burrowing nematode) linked to spreading decline in citrus in Florida
 - e) 1958 – Hewit et al linked nematodes to virus transmission

Historical Perspectives (3)

- Crop-nematode interrelationship well documented
- Well informed nematode disease diagnosis
- 1960 – 1988 – Caveness documented 82 species of PPN in 49 Genera to occur in Nigeria
- Notwithstanding, there has been slow progress of the development of Nematology in Africa/developing countries

ECONOMIC IMPORTANCE OF PPN (1)

✓ **Plant-parasitic**

nematodes/phytophagous/phytonematodes are economically important to Agriculture.

✓ **They attack virtually all cultivated crops be it garden crops, ornamentals, arable, tree or plantation crops.**

✓ **They can be destructive to crops globally**

✓ **Most of the important PPN are found in the tropics particularly on the African continent because of the favourable climatic condition.**

Economic Importance of PPN

- **Crop Loss:**

- Nematodes can feed on roots, buds, flowers, stems, etc
- All crops are affected by one nematode or the other
- Crop damage
- Reduced crop yield/crop loss
- 1 to 100 % loss (average = 10 %)
- \$ 70 worth of damage to crops globally



LEGUMES (11)

3) Soybean (*Glycine max*)

Root-knot disease !!!!



ECONOMIC IMPORTANCE OF PPN (2)

- ✓ **Some species of PPN are vectors of important plant viruses.**
- ✓ **They also interact with other pathogens to cause mirage of untold damages and severe loses to crops.**
- ✓ **However, some are useful in biological control of insects pests and other pathogens affecting crop production and food supply.**



Root disease

Galled *C. olitorius*

Healthy *C. olitorius*



NEMATODE DIAGNOSIS

- i. Visit field and make observations
- ii. Take soil & plant samples
- iii. Determine soil nutrient status
- iv. Extract nx from soil & plant tissue
- v. Identify the nx using appropriate keys
- vi. Determine population densities of nx
- vii. Raise pure culture of culprit nx
- viii. Inoculate healthy seedlings & observe symptoms
- ix. Re-Isolate nx if same symptom appears
- x. Write diagnostic report and make recommendations

Note: Mis-diagnosis can be very costly.

SOME TERMINOLOGIES IN NEMATODOLOGY (1)

- ❑ **Nematology** – study of nematodes
- ❑ **Nematodes** – Microscopic, wormlike animals that live saprophytically in water or soil or as plant or animal parasites
- ❑ **Principles** – ideology, standard, rule, tenet, assumptions
- ❑ **Parasite** – organism which derives part or all its nutrition from another organism called **Host**
- ❑ **Pathogen** - an organism able to cause disease in a particular host or range of hosts

SOME TERMINOLOGIES IN NEMATODOLOGY (2)

- ❑ **Obligate parasite** – parasite which can only grow in living host
- ❑ **Pest** – any organism or group of organisms that causes damage to, or destruction of, another organisms
- ❑ **Inoculum** – Material containing organism to be introduced to a host or a medium
- ❑ **Moult** – shedding or casting off of cuticle
- ❑ **Life cycle** – the stage or successive stages in nematode growth and development occurring between appearance and disappearance of the stages
- ❑ **Juvenile** – Life stage of nematode between adult and embryo
- ❑ **In vitro** – Outside the host
- ❑ **In vivo** – Inside the host

SOME TERMINOLOGIES IN NEMATODOLOGY (3)

- ❑ **Pathogenecity** – Ability to cause disease
- ❑ **Perineal pattern** – cuticular folds and annules around the tail, anus, phasmids and vulva in *Meloidogyne* females
- ❑ **Annulation** - series of tranverse depressions on the cuticles of a nematode
- ❑ **Cuticle** – membraneous on outer/external wall of epidermis made up of wax or cutins for protection of nematodes against chemical and physical dangers

SOME TERMINOLOGIES IN NEMATOTOLOGY (4)

- ❑ **Resistance** – Ability to retard or withstand effect of invading pathogen. i.e. prevent reproduction/development of the organism
- ❑ **Susceptible** – Inability of the host to defend itself against or to overcome the effects of invasion by pest/pathogen
- ❑ **Symptom** – a visible or detectable abnormality arising from disease/infection
- ❑ **Sterilisation** – a process of rendering a substrate devoid of devoid of all living organisms
- ❑ **Pasteurisation** – Process of selectively killing specific organism leaving others alive

LIFE CYCLE OF PPN



LIFE CYCLE OF PLANT-PARASITIC NEMATODES (1)

❑ WHY STUDY LIFE HISTORY ?

❑ To formulate efficient and effective mgt strategies

❑ How?

❑ Through:

❑ The knowledge of the vulnerable stage of the nematode – avoid?

❑ Estimation of the number of generations/population per growing season

❑ The knowledge of life habit (sedentary/migratory endoparasite) – contact/systemic xcal?

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (2)

❑ BASIC STAGES IN LIFE CYCLE

❑ In spite of the many different types of nematodes, the basic life cycle is similar across the various species

❑ Plant-parasitic nematodes have a simple life cycle of six basic stages.

❑ Production of eggs by individual marks the end of the cycle. This implies that the life cycle of plant-parasitic nematode begins with egg, followed by four larval or juvenile stages, and an adult.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (3)

❑ THE EGG STAGE

❑ Temperature and moisture levels determine when the egg hatches, and the larva will not emerge from the egg until the environment is one that is favorable for survival.

In some types of nematodes, the parasite will molt for the first time while still within the egg, so it is a second-stage larva that emerges.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (4)

- ❑ **THE LARVAL (JUVENILE) STAGE**
 - ❑ Usually the embryo develops within the egg to produce the first juvenile,
 - ❑ **1ST Juvenile upon first moult produces the invasive (infective) second stage juvenile before hatching.**
 - ❑ Four moults, one each accompanies each juvenile stage.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (5)

❑ THE LARVAL (JUVENILE) STAGE

❑ Consequently, first molt produces second stage juvenile, second molt produces 3rd stage juvenile, 3rd molt, the fourth stage juvenile while adult will emerge after the fourth molt.

❑ The nematode is bigger in each successive stage than the preceding stage

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (5)

❑ THE LARVAL (JUVENILE) STAGE

❑ the Parasitic larval

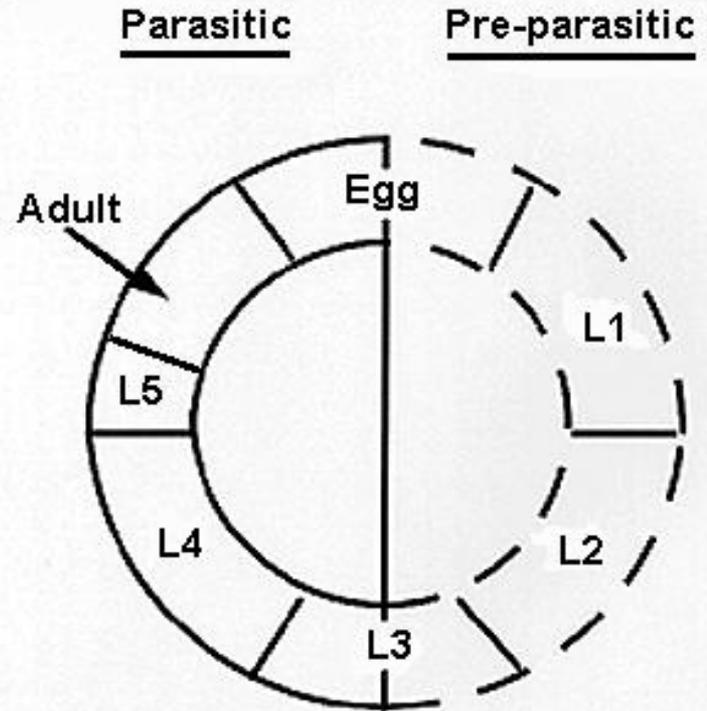
In many types of parasitic nematodes, the larva will infect its host following its second molt, M2. The infection occurs when the nematode is in the L3 stage of its development.

NB: In root-knot nematodes only J2 is the infective stage

This pattern is illustrated by the adjacent figure and consists of two phases, **parasitic** and **pre-parasitic**. The parasitic phase takes place inside the definitive host while the pre-parasitic phase occurs either as a freeliving phase in the external environment or inside a second host, called an intermediate host. This basic life cycle also consists of seven stages, an egg, four larval stages (L1, L2, L3, L4) and two adult stages comprising separate males and females. Sometimes the sexually immature adult stages are called L5's

In most species sexual reproduction by adult nematodes is the norm and occurs within an infected definitive host. Eggs are laid by the female and pass from this host into the external environment.

These eggs must pass through the three developmental stages (L1, L2, and L3) before the nematode is again infective for another host.



LIFE CYCLE OF PLANT-PARASITIC NEMATODES (6)

❑ THE ADULT STAGE

❑ The fourth and final molt, M4, will take place within the host (which may be an insect, plant or animal) in most species.

❑ Upon the final molt, the nematode will be an adult but not yet capable of reproduction.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (7)

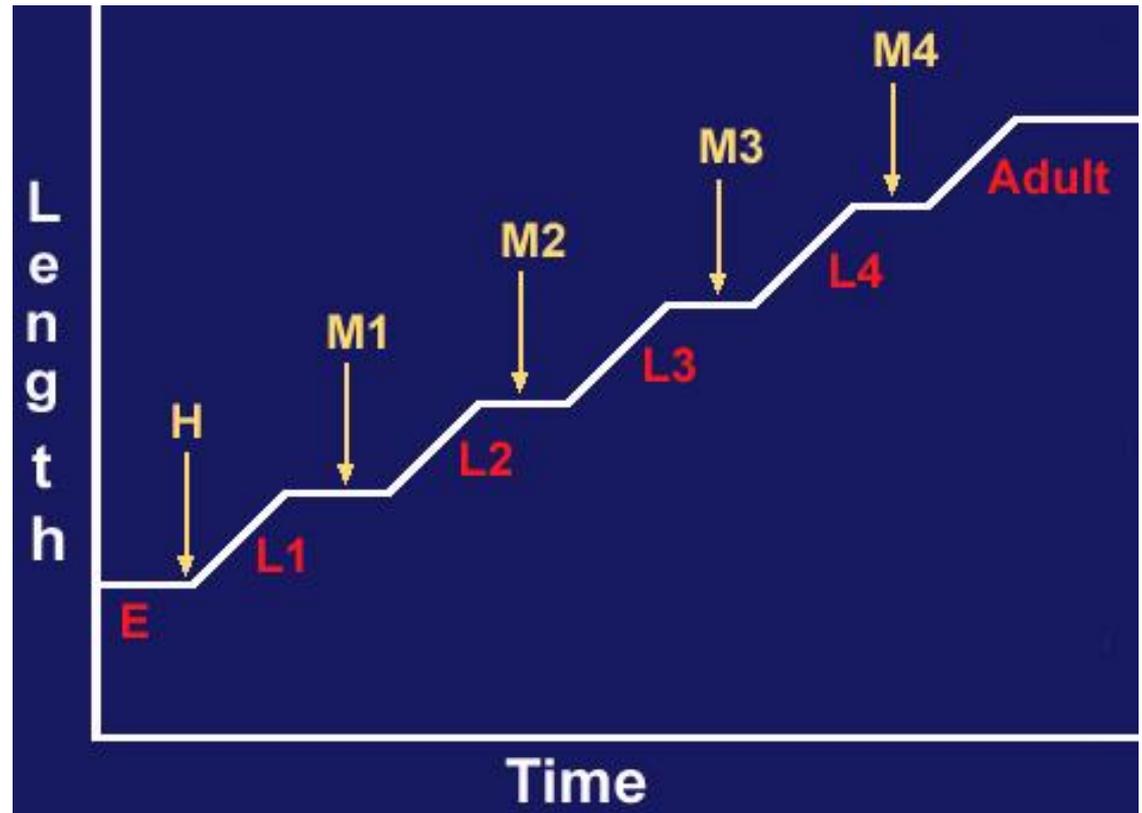
❑ THE ADULT STAGE

Reproduction

- A final phase of growth makes the adult capable of sexual reproduction
- it is only at this final phase in the nematode life cycle that genders are established
- The life cycle begins again when the adults reproduce and lay eggs.
- **These eggs usually pass from the host's body and will develop to infect another plant**

This developmental cycle can be represented by a growth curve as shown in the following figure.

An (**L1**) develops inside the egg, hatches (**H**), grows rapidly then molts (**M1**) to an **L2**. This second stage larva also shows a rapid spurt of growth followed by a second molt (**M2**) to a third stage larva (**L3**) the infective stage for many nematode species. This (**L3**) grows then molts (**M3**) inside the host to an **L4**. This final larval stage grows and undertakes a final molt (**M4**) to an immature **adult (L5)**. These L5's pass through a final growth phase to become sexually mature adult males and females



LIFE CYCLE OF PLANT-PARASITIC NEMATODES (8)

❑ **BUT**

However depending on the host parasite relationship :

- ✓ sedentary endoparasite,
- ✓ migratory endoparasite and
- ✓ ectoparasites

..... there may be possible modifications to the typical life cycle demonstrated so far

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (9)

❑ **SEDENTARY ENDOPARASITES**

Sedentary endoparasitic phytonematodes include *Anguina tritici* *Tylenchulus semipenetrans* *Heterodera spp.* and *Meloidogyne spp.*

➤ 2nd Stage infective juvenile hatches from the egg and find feeding site within the root. J2 will moult to J3 which will continue to feed and enlarge as its reproductive system begins to develop.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (10)

- At this stage the nematode develop to either male or female.
- Male will emigrate from the root for the female to develop to become **sacchate and sessile in the root.**
- Third moult will occur and J4 will emerge and develop further through the 4th moult to become adult.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (11)

- As the nematode become sessile, plant cells around the head of the invading nematode enlarge to form nurse or giant cells.
- Adult female continue to develop within the giant cell.
- Adult females will begin to lay eggs which will be held in gelatinous matrix at the posterior end of the body.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (12)

- ❑ The egg mass may be within the root or partly or wholly exposed on the root surface.
- ❑ The gelatinous matrix will dissolve to release the eggs into the soil and the life cycle begins all over again.
- ❑ The eggs are usually oblong in shape and brownish in colour.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (13)

- ❑ It takes 23 – 30 days to complete its life cycle depending on temperature (27°C)
- ❑ **It takes up to 57 days at 20 °C.**
- ❑ Reproduction is parthenogenetic
- ❑ **Two or several generations can occur in the life of the host depending on the span of the crop.**
- ❑ Note that female sedentary plant-parasitic nematodes are permanently immobile while adult males are temporally sedentary and vermiform

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (14)

❑ MIGRATORY ENDOPARASITES.

Migratory endoparasitic nematodes include *Aphelenchoides spp*, *Pratylenchus spp.*, *Ditylenchus*.

❑ Except the egg, any stage of life cycle of this group of nematodes can move into, through and out from the host tissues.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (15)

- ❑ Female usually lays in soil or in root tissue eggs singly .
- ❑ **Eggs will hatch to larvae within 4-8 days. The larva will undergo four molts the first in the egg to become adult within the feeding period,**
- ❑ Completion of the one generation varies depending especially on temperature, being 4 weeks at 27 – 30 °C or 14 weeks at 5 – 10 °C on the same crop.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (16)

- ✓ It begins with J2 penetrating the host root, J2 then feeds and molt to J3, which continue to feed and moult to J4.
- ✓ The feeding J4 moults to adult female and male. Eggs are laid and first stage juvenile moults within the egg and J2 hatches from the egg and re-infect the tissue.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (17)

ECTOPARASITES.

➤ Ectoparasitic nematodes are generally migratory. Although some have very long stylets that enable them to feed deeper in the root, most feed superficially at or very near the root tip or even on root hairs.

➤ Genera of nematodes belonging to this category include, *Trichodorus*, *Xiphinema*, *Longidorus*, *Helicotylenchus*, *Paratylenchus*, *Hemicycliophora* etc.

LIFE CYCLE OF PLANT-PARASITIC NEMATODES (18)

- ❑ All the six basic stages of development of nematodes are well represented in ectoparasites.
- ❑ However, the female lays egg while free in the soil and not in or on the host.
- ❑ These multiple stages do not initiate feeding as the case with migratory and sedentary

**Population dynamics of
nematodes and
their distribution in space
and time**

NEMATODE POPULATION DYNAMICS (1)

- ❑ Farmers need to know the risk or otherwise of nematodes to their crops. Will the population be low (small/insignificant crop loss) or high (dangerous)?
- ❑ Pathogenicity – damage caused by nematode
- ❑ Population growth – rate of increase. What factor could cause or influence nematode population growth? Seasonal growth?

NEMATODE POPULATION DYNAMICS (2)

❑ COMMUNITIES - This refers to the total array (collection/group) of organisms (birds, insects, mammals, etc) living in one type of environment (location/area).

❑ **Energy pathway** – this there is the web of interconnections among organisms in the in which energy flows e.g. when a tree dies it is decomposed to humus in the soil by activities of various organisms

NEMATODE POPULATION DYNAMICS (3)

- ❑ Nematodes play a significant part in the web of energy transfer both as consumers of living plant cytoplasms and as consumers of fungi, bacteria, mites, insects, and nematodes themselves (each other)
- ❑ **They will in turn be consumed by decomposers and predators.**
- ❑ Therefore, they not only are pests but importantly are consumers of fungi and bacteria

NEMATODE POPULATION DYNAMICS (4)

□ Plant and animal communities vary from agricultural fields being fewer (with large population of some species) to undisturbed (virgin) land.

□ It should be noted that the diversity of the communities usually reverts back after leaving a cultivated land to fallow for some time.

□ Species types are usually regulated to maintain equilibrium

NEMATODE POPULATION DYNAMICS (5)

❑ **Populations** - Communities are usually complex in nature. However, populations of each species of the interacting organisms behave in a predictable manner.

❑ After the population rises to the highest level a particular force (another organism antagonistic to it or unfavourable environmental conditions) will act against it to reduce the population.

❑ Such that An equilibrium is therefore maintained

NEMATODE POPULATION DYNAMICS (6)

- ❑ **Similarly, nematode population responds to the same forces or organisms**
- ❑ **Some times it rises other times it reduces**
- ❑ **Population at a given time depends on the:**
 - 1) Biotic Potentials of the species – which is the capacity of the nematode species to reproduce under optimal conditions without restraint imposed by the environment

NEMATODE POPULATION DYNAMICS (6)

2) Environmental resistance - imply those factors that prevents a population from growing at its full potentials rate. These factors may be:

a) **Physical factor** (soil, pH, moisture, soil composition and texture, rainfall, temperature, wind, slope, , or

b) **Biotic factors** (plants, bacteria, fungi, nematodes, insects etc

DISTRIBUTION OF NEMATODE POPULATION (1)

- IN SPACE (spatial distn) - Over the area/field
 - i. Nematodes are never uniformly distributed in the field but occur in clusters.
 - ii. Several generations occur per growing season and each new generation remain close to the point of origin because of limited movement.
 - iii. They tend to be more in the uppermost layer of the soil except for *Trichodorus* spp.

DISTRIBUTION OF NEMATODE POPULATION (2)

□ IN TIME – Seasonal Cycles

- i. Soil conditions vary from season to season
- ii. Temperature, moisture, hosts (roots) changes seasonally
- iii. Nematodes respond to the changing conditions
- iv. Nematodes are more in rainy season than dry spells**

NEMATODE-HOST INTERACTIONS (1)

- i. Nematodes are associated with many economic crops throughout the world
- ii. **The growth & development of PPN is influenced by each host crop.**
- iii. **When a susceptible host is grown year in year out PPN population increases until they reach the highest level then fluctuates around the equilibria**

NEMATODE-HOST INTERACTIONS (2)

- iv. The exact equilibrium point is dictated by the host, the nematode, and the environment**
- v. Different population levels of PPN have different effects on crop growth**
- vi. As nematode populations rises crop host will decline until the highest level after which the crop may fail completely for the nematode population to decline**

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NEMATODE-HOST INTERACTIONS (3)

vii. Some hosts may be more severely damaged than the other by certain species and populations of nematodes.

NEMATODE-HOST INTERACTIONS (4)

- Attributes of host plants:
 1. Susceptibility to injury
 2. Efficiency in raising and supporting nematode population