

<b>COURSE CODE:</b>	CPT 503
<b>COURSE TITLE:</b>	Principles of Nematology
<b>NUMBER OF UNITS:</b>	2 Units
<b>COURSE DURATION:</b>	Three hours per week

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### COURSE DETAILS:

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<b>Other Lecturers:</b>	

### COURSE CONTENT:

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

### COURSE REQUIREMENTS:

This course is compulsory for all students in Crop Protection Department. The affected students are, therefore suppose to participate in all the course activities and score a minimum of 75 % attendance to be able to sit for the final examination.

### READING LIST:

1. Dropkin, V. H. *Introduction to Plant Nematology*. John Wiley & Sons, Inc. 1980
2. Mai, W. F., and H. H. Lyon. *Pictorial Key to Genera of Plant-Parasitic Nematodes* Cornell University Press, 1975
3. Adesiyan, S. O., Caveness, F. E., Adeniji, M. O., and B. Fawole. *Nematode Pests of Tropical Crops*, Heinemann Educational Books 1990
4. Caveness, F. E. A glossary of nematological terms. International Institute of Tropical Agriculture, 1984

### LECTURE NOTES

- ✓ Nematodes are microscopic, wormlike animals that live saprophytically in water or soil or as plant or animal parasites. They are the most numerous multicellular organism outnumbering even insects in species number.
- ✓ They inhabit all ecological niches, from the top of the mountain to the bottom of the ocean. Even particles of dust carry nematodes. In terms of global distribution 50 % of nematodes inhabit marine water, 35 % live in fresh water and soil while the remaining 15 % are found in animal tissues including humans. Of the soil/freshwater nematodes, 10 % parasitizes plants.
- ✓ Plant-parasitic nematodes otherwise called phytophagous or phytonematodes are economically important to Agriculture because they attack virtually all cultivated crops species be it garden crops, ornamentals, arable, tree or plantation crops. They can be destructive to crops globally, causing serious economic losses to the crop.
- ✓ Most of the important PPN are found in the tropics particularly on the African continent because of the favourable climatic condition.
- ✓ In addition to crop damage, some species of plant-parasitic nematodes are vectors of important plant viruses. However, some are useful in biological control of insects pests and other pathogens affecting crop production and food supply. They also interact with other pathogens to cause mirage of untold damages and severe losses to crops.

### **Economic importance of nematodes**

Nematodes are considered to be economically important either as crop yield reducing factors, bio-control agents or vectors of other pathogenic organisms.

#### **1. Crop Loss**

- ✓ Phytonematodes are major production constraints of most of the crops grown in the tropics. Many are economically important in various crops in Africa. However, there are variations in the nematodes species attacking crops from country to country, from region to region and from state to state. Up to 4300 species of nematodes are parasitic on plants.

- ✓ Through their feeding activities nematode pests kill cells or remove content thereby causing mild to severe damages on the crop and its products resulting in yield and/or harvest losses. In economic terms these losses may be enormous depending on the level of infestation of production fields and the prevailing soil conditions.
- ✓ Nematodes can feed on roots, buds, flowers, stems, resulting damage of affected part by the invading nematode leading to yield loss. 1 to 100 % loss (average = 10 %) are common culminating to a staggering \$ 80 – 100 m worth of damage to crops globally.
- ✓ Majority of plant-parasitic nematodes belong to the group known as endoparasites. They include *Meloidogyne* spp.(root-knot nematodes), *Pratylenchus* spp. (root lesion nematodes) and *Heterodera* spp. (the cyst nematodes), which ranks the world's top three plant-parasitic nematodes. Other plant-parasitic nematodes constituting problems to tropical agriculture include; *Globodera* (cyst nematodes), *Ditylenchus* (stem and bulb nematodes), *Tylenchulus* (Citrus nematodes), *Xiphinema* (dagger nematodes), *Radopholus* (burrowing nematodes), *Rotylenchulus* (reniform nematodes), *Helicotylenchus* (spiral nematodes, *Belonolaimus* (sting nematodes, and *Scutellonema* (spiral yam nematode).
- ✓ In Africa they cause 20-100% losses to cowpea, okra, cotton, tomato, tobacco, banana, maize, sorghum, rice, soybean, and sugarcane. It should be noted that a single plant-parasitic nematode may have wide host range; attacking several cultivated crops and several plant-parasitic can attack a single plant. It is therefore possible to discuss crop losses on the basis of nematode or crop type. Nematode damage leads to low or high losses, sometimes a total crop failure.

**A. ARABLE CROPS**

**1. CEREALS**

**i RICE (*Oryza sativa*)**

- ✓ Rice is the most important staple food in the tropics. It is however parasitised by plant-parasitic nematodes. Rice yield losses resulting from plant-parasitic nematode attack are estimated at 10%. Major nematode pest of economic importance in rice production in Nigeria include *Aphelenchoides besseyi*, *Criconemella*, *Meloidogyne incognita*, *Hoplolaimus* spp., *Hirschmanniella* spp., *Paralongidorus*, *Pratylenchus*, *Heterodera* and *Xiphinema ifacolum*.
- ✓ Root-knot nematodes (rkn), *Meloidogyne* spp. particularly *M. graminicola* and *M. incognita* are responsible for root-knot disease of rice characterized by terminal or sub-terminal galls. At inoculum level of 1000-5500 eggs/juveniles *Meloidogyne* per plant correlates with 40-89% rice grain yield loss. Significant reduction in growth and grain yield is more severe in upland rice than lowland rice
- ✓ *Pratylenchus* spp. Particularly *P. zae* and *P. indicus* are responsible for root lesion disease responsible for significant damage of upland rice. They are migratory endoparasites which through their feeding activities destroys root cortex which hampers root growth.

**ii MAIZE (*Zea mays*)**

- ✓ Nearly 120 species of phytonematodes associates with maize worldwide. However 13 species in 14 genera are found in Nigeria. Four species of *Pratylenchus* namely *Pratylenchus brachyurus*, *P. zae*, *P. scribneri* and *P. sefaensis*; three of *Meloidogyne*; *M. incognita*, *M. javanica* and *M. arenaria*, three of *Hirschmanniella*; *Hirschmanniella spinicaudata*, *H. oryzae* and *H. imamuri*, and *Helicotylenchus* spp occur in maize fields in Nigeria.
- ✓ *M. incognita*, *M. javanica* and *M. arenaria* also presents important constraints to economic production of maize in the tropics especially Nigeria.

- ✓ A threshold population is 2,000 eggs/second-stage juvenile. Symptoms include marked stunting, chlorosis and patchy growth of maize in the field. Small or large terminal or sub-terminal root galls may develop as a result of root-knot nematode infection.
- ✓ However, it is not always all the time that typical galls are formed on the roots. The overall effect of root-knot nematodes of maize is reduction in growth and grain yield.
- ✓ The three species of *Hirschmanniella* earlier listed are pathogenic on maize. It should be noted that because of interactions between all listed nematodes crop loss assessment by any single nematode specie is usually difficult, except in controlled experimental situation.

**iii SORGHUM (*Sorghum bicolor*)**

- ✓ This is the world's fifth most important crop. In Nigeria it is grown for food and fodder and it can be processed into alcoholic and non-alcoholic beverages and ethanol. To date, more than 115 species of plant-parasitic nematodes have been associated with sorghum throughout the world.
- ✓ However, species of *Meloidogyne*, *Pratylenchus* and *Tylenchorhynchus* are of major economic constraints to sorghum production.

**iv SUGARCANE (*Saccharum officinarum*)**

- ✓ Up to 275 species of plant-parasitic nematodes associates with sugarcane worldwide. However, important nematodes of economic magnitude in Nigeria and elsewhere in the tropics include *Heterodera sacchari*, *Meloidogyne* spp., *P. zae* and *Hirschmanniella* spp. *H. sacchari* is the most damaging on sugarcane. This nematode specie was responsible for the desertion of 100 hectares of Bacita sugar Estate sugarcane plantation in 1966.
- ✓ In Nigeria, sugarcane infected by *H. sacchari* would have necrotic roots leading to reduced cane yield of up to 70%
- ✓ *M. incognita* and *M. javanica* are the two species of root-knot nematodes that causes economic loss of sugarcane in the Tropics. They can reduce cane yield

for about 20%. Affected plants are restricted from normal tillering. *P. zae* is parasitic on sugarcane causing necrotic cortex and stunted growth of the crop. *P. brachyurus* damage both cortical cells and the vascular bundle.

## 2. LEGUMES

### i COWPEA (*Vigna unguiculata*)

- ✓ Over 24 species of plant-parasitic nematode do associate with cowpea. However, those with established economic consequences on cowpea production include the root-knot nematodes (*Meloidogyne spp.*), *Rotylenchulus reniformis* and *Hoplolaimus seinhorsti*. The root-knot nematodes are the most reported.
- ✓ *M. incognita* reduced cowpea grain yield by 25-69%. Although *M. incognita* is the most preponderant, *M. javanica* and *M. arenaria* are also damaging on cowpea. A yield loss of up to 15% of cowpea grains is attributable to *R. reniformis*.

### ii GROUNDNUT (*Arachis hypogaea*)

- Groundnut is grown for its oil and protein (25%). Up to early independence it constitute one of the major crops grown in Nigeria for export. A 12% yield loss results from attack by plant-parasitic nematodes world-wide.
- A Yield reduction of 2% results from attack by *P. brachyurus* in Nigeria. *Aphelenchoides arachidis* affect the root, weaken pegs, attack pods and testa of groundnut. *M. arenaria* is the most important nematodes of groundnut.

### ii SOYBEAN (*Glycine max*)

- Over 100 species of plant-parasitic nematode associates with soybean.
- *Meloidogyne spp* and *R. reniformis* are the most damaging on soybean, contributing to over 10% grain yield loss. *M. incognita* has received due attention by nematologists in Nigeria.
- A yield loss of 12.9% was observed from *M. incognita* infested field at the Federal University of Agriculture (FUNAAB) in 1992.

### 3. ROOT AND TUBER CROPS

#### i YAM (*Discorea spp*)

- ✓ Over 90% of world yam is grown in Africa. Globally, 18% yield loss has been estimated from nematode attack on yams. The most important nematode pests of yams are *Scutellonema bradys*, *Meloidogyne spp*, and *Pratylenchus spp*.
- ✓ *S. bradys* causes a dry rot disease of yam tuber. It is disheartening to note that secondary infections facilitated by the nematodes are more readily investigated than the primary infection.
- ✓ *M. incognita* and *M. javanica* are particularly damaging on yam. They infect both roots and tuber. Galls resulting from *Meloidogyne* infection render the tuber unsightly with the consequent reduction in economic/market value of the tubers. *P. coffeae* also attack the tuber reducing the edible portion of the yam.

#### ii CASSAVA (*Manihot spp.*)

- ✓ *Manihot esculenta* is grown in all tropical regions. Cassava is a host to a wide range of plant-parasitic nematodes.
- ✓ pathogenicity of most nematodes on cassava remained poorly reported in literature. *M. incognita* and *M. javanica* are the most damaging on cassava. Yield loss of undocumented magnitude is associated with nematode attack on cassava.
- ✓ Other nematodes of economic significance on cassava are *P. brachyurus*, *R. reniformis* and *S. bradys*.

#### ii SWEET POTATO (*Ipomea batatas*)

- ✓ Sweet potato is grown throughout the humid tropics and many sub-tropical regions. *Meloidogyne spp.*, *R. reniformis*, *Pratylenchus spp.* and *Ditylenchus spp.* are parasitic on sweet potato causing economic losses of high magnitude.

- ✓ *M. incognita* and *M. javanica* induce galls on sweet potato as the case with other susceptible crops.
- ✓ *R. Reniformis*, *D. destructor*, *D. dispaci*, *R. reniformis*, *P. coffeae*. *P. brachyurus*, *P. zae* and *P. penetrans* are species of plant-parasitic nematodes that are well established to be damaging on sweet potatoes.

**iv CARROT (*Daucus carota sativa*)**

- ✓ Carrot is an important root crop that plays major economic and nutritional roles in the lives and living of people throughout the world. It contains large amount of sugar, carotene and other important vitamins.
- ✓ Up to 38% yield loss results from attack by *M. incognita*. The nematode causes reduced top growth, retarded tap root growth, alterations in tuber shape, galling of tubers and outright death of the plant.

**3. PLANTATION/HORTICULTURAL/TREE CROPS.**

**i BANANA/PLANTAIN (*Musa spp*)**

- ✓ *Musa spp.* are grown in large quantities all over the world. A 20% yield loss estimate results from plant-parasitic nematode attack on banana and plantain around the world. *Radopholus similis* (burrowing nematode) is the most important nematode pest of banana and plantain in the tropics. Obvious problem of *R. similis* attack is the toppling disease of the growing crop. Currently *R. similis* is of great economic concern in Nigeria.

**ii CITRUS (*Citrus spp.*)**

- ✓ Major plant-parasitic nematodes responsible for severe damage and economic loss to citrus include *R. similis*, *Pratylenchus spp.*, *Meloidogyne spp.*, *Trichodorus spp.*, *Paratrichodorus spp.*, *Xiphinema spp.*, *Hemicycliophora spp.*, and *T. semipenetrans* (citrus nematodes)

**iii COCOA (*Theobroma cacao*).**

- ✓ Forty-seven species of various nematodes belonging to twenty-seven genera associates with cocoa roots worldwide. In Nigeria, 24 of these have been



found on cocoa. Important plant-parasitic nematodes include *M. incognita*, *Pratylenchus* spp., *Helicotylenchus cavenessi*, *Xiphinema ifacolum*, and *X.nigeriense Meloidogyne* often produce conspicuous galls roots of cocoa.

- ✓ It poses a serious constraint to the establishment of new cocoa on old cocoa land. Slow growth rate of cocoa and failure of young seedling to get established in the field have been associated with soils heavily infested with *Meloidogyne javanica*.
- ✓ *Meloidogyne incognita* associates with the roots of cacao trees showing symptoms of 'Morte subita' disease in Bahia, Brazil.
- ✓ *Meloidogyne* has also been implicated to cause die-back disease of cocoa caused.

**iv TOMATO (*Lycopersicon esculentum*)**

- ✓ Tomato is an important fruit vegetable in tropical crop production and utilization. Several nematode pest associates with the crop. However, prominent economically important nematode parasites of tomato are *M. incognita* and *Pratylenchus* spp.

**v EGG PLANT (*Solanum* spp.)**

- ✓ *S. melongena* and *S. macrocarpon* are moderate to efficient host of *M. arenaria* *H. cavenessi*, *H. Pseudorobustus*. *M. javanica* and *Scutellonema* spp.

**EVALUATION OF NEMATODE PROBLEMS (NEMATODE DISEASE DIAGNOSIS).**

- ✓ Systematic surveys a soil & various crop types using suitable sampling and array techniques are necessary to determine the general census of plant-parasite nematode communities in an area;
- ✓ It is very essential for nematologists to spend most time in the field to learn which crops are showing symptoms of nematode attack and how they are being damaged.
- ✓ The objective of the survey must be clearly defined before the survey. Generally it is very important to conduct a pilot survey for nematode problem

that is regional. Seek the assistance of statistician who would tour the diseased area.

- ✓ In ranking nematode problems according to the economic importance of the crops & yield reduction due to the pathogen you should:
  - Consider field and lab works necessary to identify the disease agents and the degree of crop infection
  - Identify and qualify losses including yield reduction, loss of crop quality and detrimental residual effects in soil or seed. Economic thresholds have to be determined for each crop.
  - Conversion of losses into economic terms
  - Consider available mgt options and their degrees of effectiveness.
- Estimate costs & benefits.
- Compare costs & benefits with those incurred under alternative management strategies

## 2. Vectors of plant pathogens

- ✓ Up to 6% of plant viruses are transmitted by plant-parasitic nematodes particularly those belonging to the order Dorylaimida.
- ✓ For example Tobravirus are naturally transmitted by plant-parasitic nematodes in the genera *Trichodorus* and *Paratrichodorus*. This group of nematodes possesses long stylets and is ectoparasites.
- ✓ During their feeding activities of these nematodes, they acquire virus particles from the sap of virus-infected root cells.
- ✓ Upon withdrawal of the stylet from root cells, the viruses are retained on the cuticle lining of the nematode Pharyngeal wall. Subsequently upon salivation of pharyngeal secretion the nematode releases the virus particles unto new cells or plant.
- ✓ Other important genera of nematode vectors of soil-borne plant viruses include *Xiphinema Longidorus* and *Paralongidorus*. *X. index* is suspected to be responsible for the transmission of Grapevine fan leaf virus disease

while *X. basiri* appears to be a possible vector of cowpea mosaic virus in Nigeria.

- ✓ *Anguina tritici* are involved in the transportation of spores of *Dilophospora alopecuri* (fungus) on cereals.
- ✓ Nematodes can also interact with other pathogens to cause mirage of untold damages and severe loses to crops.

#### **Bio-control agents**

- ✓ Some nematodes are useful in biological control of insect pests and other pathogens affecting crop production and food supply.
- ✓ The use of entomophagus nematode to control insects in agriculture is well known throughout the world.
- ✓ E.g. *Aphelenchus avenae* feed extensively on several fungi associated with diseased root.

### **3. Interactions with other plant pathogens**

#### **SYNERGISM.**

- Synergism is a phenomenon, which refers to a combined infection being more serious than individual infection. *Fusarium* wilt is caused by *Fusarium spp.* However, in association with *Meloidogyne spp.* it results in infection more severe than either *Fusarium spp* or *Meloidogyne spp* can cause. Plant-parasitic nematodes may serve as mechanical wound agents or breaker of disease resistance sometime they provide necrotic infection court.
- During penetration, plant-parasitic nematode provides entry point on intact surfaces by forth and backward thrusting of the stylet.
- This entry point aids the entrance of other plant pathogens already present. *Pseudomonas solanacearum* are often assisted by *M. incognita* to gain entrance to cause vascular wilt of tomato.
- ✓ Other examples are: *Pratylenchus penetrans* assists *Verticillium albo-atrum* to enter and to proliferate the roots of eggplants.

- ✓ *S. bradys* predisposes yam tuber to *Aspergillus niger* which has no potential for self-establishment.
- ✓ Vascular wilt of tobacco caused by *Pseudomonas* and *Fusarium* wilt of tomato are assisted by *Meloidogyne spp.*
- Nematode-plant-pathogen interaction may also be deterrent to plant disease. Stem rot of rice caused by *Leptosphaeria salvicnii* is restricted by *Aphelenchoides besseyi*.
- Sometimes the interaction may be detrimental to the nematodes. Fungal hyphae have been associated with the destruction of giant cell preventing developing female juvenile from attaining full adult stage.

### Terminologies in Nematology

- 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
- Pathogenicity** – Ability to cause disease
- Perineal pattern** – cuticular folds and annules around the tail, anus, phasmids and vulva in *Meloidogyne* females
- Annulation** - series of transverse 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
- Pathogenicity** – Ability to cause disease
- Perineal pattern** – cuticular folds and annules around the tail, anus, phasmids and vulva in *Meloidogyne* females
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- Cuticle** – membraneous on outer/external wall of epidermis made up of wax or cutins for protection of nematodes against chemical and physical dangers
- 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 all living organisms
- Pasteurisation** – Process of selectively killing specific organism leaving others alive

### LIFE CYCLE OF PLANT-PARASITIC NEMATODES

Three basic types of reproduction are distinguishable viz;

- (1) **Amphimixis** – This involve cross-fertilization between male and female.

- (2) **Parthenogenesis** : Non-sexual reproduction where male is not required for reproduction. Most plant-parasitic nematodes exhibit this phenomenon.
- (3) **Hermaphroditism** – male and female organs are both present in an individual.
- Plant-parasitic nematodes have a simple life cycle of six basic stages.
  - The life cycle of plant-parasitic nematode begins with egg, followed by four larval or juvenile stages, and an adult.
  - Usually the embryo develops within the egg to produce the first juvenile, which upon first molt produces the invasive (infective) second stage juvenile before hatching. Four molts, one each accompany each juvenile stage.
  - The nematode is bigger in each successive stage than the preceding stage (Fig. 1.)

Egg    J1    M1    J2 (hatch)    M2    J3    M3    J4    M4    Adult

Where;  
 J1 - J4 = Second-stage to 4<sup>th</sup> stage juveniles  
 M1 - M4 = 1<sup>st</sup> molt to 4<sup>th</sup> molt.

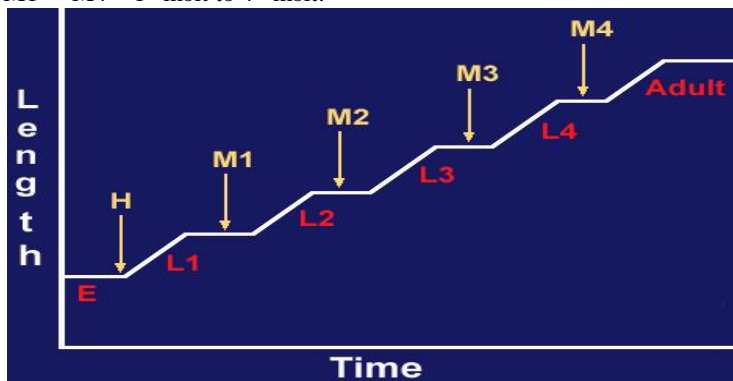


Fig. 1. Life cycle of a typical plant-parasitic nematode.

L1 – L4 = Larval stages 1 to 4 (synonymous with juvenile stages 1 to 4)

- However depending on the host parasite relationship (secondary endoparasite, migratory endoparasite and migratory ectoparasites) there may be possible modifications to the typical life cycle demonstrated above.

### 1. SEDENTARY ENDOPARASITES.

- Sedentary endoparasitic phytonematodes include *Anguina tritici* *Tylenchulus semipenetrans* *Heterodera* spp. and *Meloidogyne* spp.
- Life cycle of *Meloidogyne* spp. reveals that infective second stage juvenile hatches from the egg and find feeding site within the root. J2 will moult to J3, then to J4 and finally adult.

- As the nematode become sessile, plant cells around the head of the invading nematode enlarge to form nurse or giant cells.
- Adult females will begin to lay eggs which will be held in gelatinous matrix at the posterior end of the body. 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.
- 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. Life cycle of a typical sedentary plant-parasitic nematode is as shown on page 18. Note *Meloidogyne* spp. exhibits sexual dimorphism i.e. adult female are permanently immobile and sacchate in shape while adult males are temporally sedentary and vermiform

## **2. 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.  
*Pratylenchus* reproduces by mitotic parthenogenesis. Female usually lay 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. The entire life cycle can occur in root.
- ✓ There may be modifications in some migratory endoparasites where eggs may be laid only in the soil. Since most stages are migratory, it implies that second stage juvenile (J2) to adult can emerge and re-infect the root at any point.

## **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.
- ✓ 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 endoparasites.

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

- ❑ Farmers need to know the risk or otherwise of nematodes to their crops. Will low population result in small (or insignificant crop loss) or high (dangerous loss?)
- ❑ Pathogenicity –damage caused by nematode while population growth refers to rate of increase. What factor could cause or influence nematode population growth? Seasonal growth?
- ❑ 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. Nematodes play a significant part in the web of energy transfer both as consumers of living plant cytoplasm and as consumers of fungi, bacteria, mites, insects, and nematodes themselves (each other) and will in turn be consumed by other decomposers and predators.
- ❑ Therefore, they not only are pests but importantly are consumers of fungi and bacteria
- ❑ 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
- ❑ **Populations** - Communities are usually complex in nature. However, populations of each species of the interacting organisms behave in a predictable manner. Similarly, nematode population responds to the same forces or organisms. Sometimes 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. Similarly, nematode population responds to the same forces or organisms. Sometimes it rises other times it reduces

## **NEMATODE DISTRIBUTION**

### **IN SPACE (spatial distn) -** Over the area/field

- ❑ Nematodes are never uniformly distributed in the field but occur in clusters. Several generations occur per growing season and each new generation remains close to the point of origin because of limited movement. They tend to be more in the uppermost layer of the soil except for *Trichodorus* spp.

### **IN TIME – Seasonal Cycles**

- ❑ Soil conditions vary from season to season
- ❑ Temperature, moisture, hosts (roots) changes seasonally
- ❑ Nematodes respond to the changing conditions
- ❑ Nematodes are more in rainy season than dry spells

## **NEMATODE-HOST INTERACTIONS**

- ❑ 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. The exact equilibrium point is dictated by the host, the nematode, and the environment. Different population levels of PPN have different effects on crop growth



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

**Attributes of host plants:**

- ❑ Susceptibility to injury
- ❑ Efficiency in raising and supporting nematode population